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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	87104

Acknowledgement of Change to Small Entity Status

The entity status change request below filed through Private PAIR on 05/02/2019 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant asserting small entity status. See 37 CFR 1.27.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/Louis Wu/
Name:	Louis Wu
Registration Number:	44413

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	11/03/2015	9178369	AFPA-01032US0	4453

133328 7590 10/14/2015

Mojo Mobility (c/o Louis Wu)
PO Box 10074
Oakland, CA 94610

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Afshin Partovi, Sunnyvale, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Filing Date	2012-01-17	
	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	9	6636017		2003-10-21	Zink et al.	
	10	6586909		2003-07-01	Trepka	
	11	6462509		2002-10-08	Abe	
	12	7042196		2006-05-09	~~Cheng~~	Ka-Lai, et al.
	13	6184651		2001-02-06	Fernandez	
	14	6016046		2000-01-18	Kaite	
	15	7164255		2007-01-16	Hui	
	16	6756765		2004-06-29	Bruning	
	17	6917182		2005-07-12	Burton	
	18	6741064		2004-05-25	Liu	
	19	6650088		2003-11-18	Webb	

Change(s) applied to document, /D.D./ 7/21/2015

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

Examiner Initials

Receipt date: 06/27/2014	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	11	20070178945		2007-08-02	Cook	
Change(s) applied to document; /D.D./ 7/21/2015	12	20050007067		~~2007-02-08~~	Baarman	January 13, 2005
	13	20100007307		2010-01-14	Baarman	
	14	20080272889		2008-11-06	Symons	
	15	20100277121		2010-11-04	Hall	
	16	20100127660		2010-05-27	Cook	
	17	20110012556		2011-01-20	Lai	
	18	20100081473		2010-04-01	Chatterjee	
	19	20090284227		2009-11-19	Mohammadian	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

EFS Web 2.1.17

Receipt date: 03/06/2014	Application Number	13709937 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Not for submission under 37 CFR 1.99)**	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	1	20070178945		2007-08-02	Cook	
	2	20050007067		~~2007-02-08~~	Baarman	January 13, 2005
	3	20100007307		2010-01-14	Baarman	
	4	20080272889		2008-11-06	Symons	
	5	20100277121		2010-11-04	Hall	
	6	20100127660		2010-05-27	Cook	
	7	20110012556		2011-01-20	Lai	
	8	20100081473		2010-04-01	Chatterjee	
	9	20090284227		2009-11-19	Mohammadian	
	10	20090049554		2009-02-19	Vuong	
	11	20060106965		2006-05-18	Falcon	

Change(s) applied to document, /D.D./ 7/21/2015

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EFS Web 2.1.17

Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	51	20090267710		2009-10-29	Joannopoulos et al.	
	52	20090267709		2009-10-29	Joannopoulos et al.	
	53	20090224856		2009-09-10	Karalis et al.	
	54	20090195333		2009-08-06	Joannopoulos et al.	
	55	20090195332		2009-08-06	Joannopoulos et al.	
	56	20080278264		2008-11-13	Karalis et al.	
	57	20110266878		~~2008-11-13~~	Cook et al.	November 3, 2011
	58	20100038970		2010-02-18	Cook et al.	
	59	20090243397		2009-10-01	Cook et al.	
	60	20090224609		2009-09-10	Cook et al.	
	61	20090224608		2009-09-10	Cook et al.	

Change(s) applied to document,
/D.D./
7/21/2015

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

Change(s) applied to document, /D.D./ 7/21/2015	1	20060202665		~~2011-03-18~~	Hsu	September 14, 2006	
	2	20060108977		2006-05-25	Kagermeier et al.		
	3	20100081473		2010-04-01	Chatterjee et al.		

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	European Search Report and Search Opinion in connection with Europe Application 08747863.2 (European National Stage application of PCT/US2008/063084) dated April 2, 2013, 7 pages.	☐
	2	Office Action in connection with Chinese Application 200880023854.4 (Chinese National Stage application of PCT/US2008/063084) dated August 28, 2012, 18 pages.	☐
	3	Office Action in connection with Application No. 12/769,586 dated August 27, 2013, 15 pages.	☐

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

133328 7590 10/07/2015

Mojo Mobility (c/o Louis Wu)
PO Box 10074
Oakland, CA 94610

EXAMINER	
FANTU, YALKEW	

ART UNIT	PAPER NUMBER
2859	

MAIL DATE	DELIVERY MODE
10/07/2015	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Corrected ***Notice of Allowability***	**Application No.** 13/352,096	**Applicant(s)** PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	**Art Unit** 2859	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *09/21/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-37*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 09/21/2015
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Afshin PARTOVI
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	8234189	B2	2012-07-31	Taylor et al.	
	2	8069100	B2	2011-11-29	Taylor et al.	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20140339916	A1	2014-11-14	Fells et al.	
	2	20120259735	A1	2012-10-11	Taylor et al.	
	3	20120150670	A1	2012-06-14	Taylor et al.	
	4	20120119588	A1	2012-05-17	Baarman et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

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Receipt date: 09/21/2015	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17
(Not for submission under 37 CFR 1.99)	First Named Inventor	Afshin PARTOVI
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

	5	20120112552	A1	2012-05-10	Baarman et al.	
	6	20120041843	A1	2012-02-16	Taylor et al.	
	7	20100171369	A1	2010-07-08	Taylor et al.	
	8	20090212637	A1	2009-08-27	Baarman et al.	
	9	20090174263	A1	2009-07-09	Baarman et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

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Receipt date: 09/21/2015	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Afshin PARTOVI
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

EXAMINER SIGNATURE			
Examiner Signature	/Yalkew Fantu/	Date Considered	09/29/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

23910 7590 09/23/2015
TUCKER ELLIS LLP
ONE MARKET PLAZA
STEUART TOWER, SUITE 700
SAN FRANCISCO, CA 94105

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

TITLE OF INVENTION: SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/23/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
FANTU, YALKEW	2859	320-108000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Louis Wu
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Mojo Mobility, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Santa Clara, CA

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☐ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Louis Wu/ Date September 23, 2015
Typed or printed name Louis Wu Registration No. 44413

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Louis L. Wu
Attorney Docket Number:	AFPA-01032US0

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt	
EFS ID:	23574796
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	133328
Filer:	Louis L. Wu
Filer Authorized By:	
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	23-SEP-2015
Filing Date:	17-JAN-2012
Time Stamp:	08:45:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$960
RAM confirmation Number	7367
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	IssueFeePayment.pdf	274617 15168dfa0a5d290bb860bfcfc8910a74b7bfa355	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30645 e12cedd1adef7c07fa3f081d7db8e08b15a1dd8e	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	305262		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Afshin PARTOVI
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	8234189	B2	2012-07-31	Taylor et al.	
	2	8069100	B2	2011-11-29	Taylor et al.	
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20140339916	A1	2014-11-14	Fells et al.	
	2	20120259735	A1	2012-10-11	Taylor et al.	
	3	20120150670	A1	2012-06-14	Taylor et al.	
	4	20120119588	A1	2012-05-17	Baarman et al.	

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	Attorney Docket Number	AFPA-01032US0

	5	20120112552	A1	2012-05-10	Baarman et al.	
	6	20120041843	A1	2012-02-16	Taylor et al.	
	7	20100171369	A1	2010-07-08	Taylor et al.	
	8	20090212637	A1	2009-08-27	Baarman et al.	
	9	20090174263	A1	2009-07-09	Baarman et al.	

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
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	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Louis Wu/	Date (YYYY-MM-DD)	2015-09-20
Name/Print	Louis Wu	Registration Number	44413

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Louis L. Wu
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	
Filing Fees for **Utility under 35 USC 111(a)**	

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	23545667
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	133328
Filer:	Louis L. Wu
Filer Authorized By:	
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	21-SEP-2015
Filing Date:	17-JAN-2012
Time Stamp:	02:53:50
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
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Payment was successfully received in RAM	$180
RAM confirmation Number	8225
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	20150920IDS.pdf	612294 9453f6f829088da229f50c2c5b2cb74f1cd8d04b	no	5
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30856 144f12dd96d4e2ce0d968ac79448b12717c2fb1a	no	2
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

133328 7590 07/15/2015

Mojo Mobility (c/o Louis Wu)
PO Box 10074
Oakland, CA 94610

EXAMINER	
FANTU, YALKEW	

ART UNIT	PAPER NUMBER
2859	

MAIL DATE	DELIVERY MODE
07/15/2015	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Corrected ***Notice of Allowability***	**Application No.** 13/352,096	**Applicant(s)** PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	**Art Unit** 2859	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *07/08/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-37*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 10/30/2013
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US0

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6906495		2005-06-14	Cheng	
	2	5959433		1999-09-28	Rohde	
	3	6208115		2001-03-27	Binder	
	4	5952814		1999-09-14	Van Lerbergne	
	5	6489745		2002-12-03	Koreis	
	6	6331744		2001-12-18	Chen	
	7	6040680		2000-03-21	Toya	
	8	5734254		1998-03-31	Stephens	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17	
	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	9	6636017		2003-10-21	Zink et al.	
	10	6586909		2003-07-01	Trepka	
	11	6462509		2002-10-08	Abe	
	12	7042196		2006-05-09	Cheng	
	13	6184651		2001-02-06	Fernandez	
	14	6016046		2000-01-18	Kaite	
	15	7164255		2007-01-16	Hui	
	16	6756765		2004-06-29	Bruning	
	17	6917182		2005-07-12	Burton	
	18	6741064		2004-05-25	Liu	
	19	6650088		2003-11-18	Webb	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
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	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	20	6697272		2004-02-24	Nanbu	
	21	6008622		1999-12-28	Nakawatase	
	22	6625477		2003-09-23	Wakefield	
	23	6436299		2002-08-20	Baarman	
	24	6673250		2004-01-06	Kuennen	
	25	6731071		2004-05-04	Baarman	
	26	6806649		2004-10-19	Mollema	
	27	6812645		2004-11-02	Baarman	
	28	6825620		2004-11-30	Kuennen	
	29	6831417		2004-12-14	Baarman	
	30	6917163		2005-07-12	Baarman	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17	
	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	31	6943733		2005-09-13	Vance	
	32	6975198		2005-12-13	Baarman	
	33	7031662		2006-04-18	Suzuki	
	34	7116200		2006-10-03	Baarman	
	35	7118240		2006-10-10	Baarman	
	36	7126450		2006-10-24	Baarman	
	37	7132918		2006-11-07	Baarman	
	38	7162264		2007-01-09	Vance	
	39	7183870		2007-02-27	Takagi	
	40	7184706		2007-02-27	Someya	
	41	7209084		2007-04-24	Lindell	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17	
	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	42	7221919		2007-05-22	Takagi	
	43	7305258		2007-12-04	Rydgren	
	44	7324051		2008-01-29	Hayes	
	45	7342539		2008-03-11	Rosenberg	
	46	7352567		2008-04-01	Hotelling	
	47	7376408		2008-05-20	Hayes	
	48	7382636		2008-06-03	Baarman	
	49	7385357		2008-06-10	Kuennen	
	50	7388543		2008-06-17	Vance	
	51	7415248		2008-08-19	Andersson	
	52	7462951		2008-12-09	Baarman	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
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	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	53	7477195		2009-01-13	Vance	
	54	7487921		2009-02-10	Takahashi	
	55	7498871		2009-03-03	Ruuswik	
	56	7211986		2007-05-01	Flowerdew et al.	
	57	6803774		2004-10-12	Park	
	58	7378817		2008-05-27	Calhoon et al.	
	59	4311853		1982-01-19	Cree	
	60	6798716		2004-09-28	Charych	
	61	5543702		1996-08-06	Pfeiffer	
	62	5991665		1999-11-23	Wang et al.	
	63	6498455		2002-12-24	Zink et al.	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
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(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	64	6803744		2004-10-12	Sabo	
	65	6906495		2005-06-14	Cheng et al.	
	66	6972543		2005-12-06	Wells	
	67	7042196		2006-05-09	Ka-Lai et al.	
	68	7239110		2007-07-07	Cheng et al.	
	69	7248017		2007-07-24	Cheng et al.	
	70	7525283		2009-04-28	Cheng et al.	
	71	7576514		2009-08-18	Hui	
	72	5237257		1993-08-17	Johnson et al.	
	73	5656917		1997-08-12	Theobald	
	74	5696433		1997-12-09	Patino	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17	
	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	75	6016046		2000-01-18	Kaite et al.	
	76	6094119		2000-07-25	Reznik et al.	
	77	6573817		2003-06-03	Gottschalk	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20030210106		2003-11-13	Cheng	
	2	20050116683		2005-06-02	Cheng	
	3	20050162125		2005-07-28	Yu	
	4	20050140482		2005-06-30	Cheng	
	5	20050017677		2005-01-27	Burton	
	6	20050189910		2005-09-01	Hui	

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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	7	20050135122		2005-06-23	Cheng	
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	10	20060284593		2006-12-21	Nagy	
	11	20020004167		2002-01-10	Jenson et al.	
	12	20020067238		2002-06-06	Leu	
	13	20050127869		2005-06-16	Calhoon et al.	
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	16	20030214255		2003-11-20	Baarman	
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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	18	20040130916		2004-07-08	Baarman	
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	20	20040222751		2004-11-11	Mollema	
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	28	20050127850		2005-06-16	Baarman	

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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]

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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	1	WO2005109597	WO		2005-11-17	Splashpower Limited		☐
	2	WO2005024865	WO		2005-03-17	Splashpower Limited		☐
	3	WO2004055654	WO		2004-07-01	Splashpower Limited		☐
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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	12	2000341885	JP		2000-08-12	Matsushita Electric Works Ltd		☐
	13	2003045731	JP		2003-02-14	NEC Tokin Corp.		☐

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	1	SAKAMOTO, et al., "A Novel Circuit for Non-Contact Charging Through Electro-Magnetic Coupling", 1992, IEEE, pp. 165-174.	☐
	2	ABE, et al., "A Non-Contact Charger Using a Resonant Converter with Parallel Capacitor of the Secondary Coil", April 2000, IEEE, Vo.l. 36, No. 2, pp. 444-451.	☐
	3	SAKAMOTO, et al. "Large Air-Gap Coupler for Inductive Charger", September 1999, IEEE, Vol. 35, No. 5, pp. 3526-3528.	☐
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	7	HUI, et al. "Optimal Operation of Coreless PCB Transformer-Isolated Gate Drive Circuits with Wide Switching Frequency Range", May 1999, IEEE Transactions of Power Electronics, Vol. 14, No. 3, pp. 506-514	☐

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Receipt date: 10/30/2013	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	8	TANG, et al. "Characterization of Coreless Printed Circuit Board (PCB) Transformers", November 2000, IEEE Transactions of Power Electronics, Vol. 15, No. 6, pp. 1275-1282	☐
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	17	Economist.com Science Technology Quarterly, "Wireless Charging", http://www.economist.com/science/tq/PrinterFriendly.cfm?story_id=13174387, 4/15/2009, 4 pages.	☐
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Receipt date: 10/30/2013	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

EXAMINER SIGNATURE			
Examiner Signature	/Yalkew Fantu/	Date Considered	07/10/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0

CONFIRMATION NO. 4453

133328
Mojo Mobility (c/o Louis Wu)
PO Box 10074
Oakland, CA 94610

POA ACCEPTANCE LETTER

OC000000076005351

Date Mailed: 06/29/2015

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 06/23/2015.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/cnguyen/

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NOTICE OF ALLOWANCE AND FEE(S) DUE

23910 7590 06/23/2015

TUCKER ELLIS LLP
ONE MARKET PLAZA
STEUART TOWER, SUITE 700
SAN FRANCISCO, CA 94105

EXAMINER	
FANTU, YALKEW	
ART UNIT	PAPER NUMBER
2859	

DATE MAILED: 06/23/2015

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

TITLE OF INVENTION: SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/23/2015

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

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ONE MARKET PLAZA
STEUART TOWER, SUITE 700
SAN FRANCISCO, CA 94105

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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

TITLE OF INVENTION: SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/23/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
FANTU, YALKEW	2859	320-108000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
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3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
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- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
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- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
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NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

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13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

23910 7590 06/23/2015

TUCKER ELLIS LLP
ONE MARKET PLAZA
STEUART TOWER, SUITE 700
SAN FRANCISCO, CA 94105

EXAMINER	
FANTU, YALKEW	
ART UNIT	**PAPER NUMBER**
2859	

DATE MAILED: 06/23/2015

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

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The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 13/352,096	Applicant(s) PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	Art Unit 2859	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *02/18/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-37*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 4/29/15,3/11/15,6/27/14
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☒ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

DETAILED ACTION

The present application is being examined under the pre-AIA first to invent provisions. As per applicant's remarks of 02/18/2015, claims 38-39 are cancelled. A **terminal disclaimer has been filed** on the previously co-pending application number 13/709,937, which is currently allowed. Therefore, the double patenting rejection has been withdrawn since a terminal disclaimer was previously field with the co-pending application. Independent claims 1 and 29 are currently amended. Applicant's argument that the reference Partovi does not **disclose a switching layer layered either between the receiver coil and the surface of the receiver, or between the charge coil and the surface o the charger; where one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil** as claimed in claims 1 and 29 is persuasive; therefore claims 1 and 29 are allowed. Claims 2-28 and 30-37 are dependent on claims 1 and 29 respectively; therefore claims 1-37 are allowed.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to YALKEW FANTU whose telephone number is (571)272-8928. The examiner can normally be reached on M-F: 7 - 4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, DREW A. DUNN can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed
PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13709937
Filing Date	2012-12-10
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US1

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7915858		2011-03-29	Liu	
	2	8169185		2012-05-01	Partovi	
	3	4800328		1989-01-24	Bolger	
	4	5367242		1994-11-22	Hulman	
	5	7554316		2009-06-30	Stevens	
	6	7151357		2006-12-19	Xian	

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Receipt date: 03/06/2014	Application Number	13709937 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	1	20070178945		2007-08-02	Cook	
	2	20050007067		2007-02-08	Baarman	
	3	20100007307		2010-01-14	Baarman	
	4	20080272889		2008-11-06	Symons	
	5	20100277121		2010-11-04	Hall	
	6	20100127660		2010-05-27	Cook	
	7	20110012556		2011-01-20	Lai	
	8	20100081473		2010-04-01	Chatterjee	
	9	20090284227		2009-11-19	Mohammadian	
	10	20090049554		2009-02-19	Vuong	
	11	20060106965		2006-05-18	Falcon	

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	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	12	20100081473		2010-04-01	Chatterjee		

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	1	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,548, November 20, 2013, 5 pages.	☐
	2	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/115,811, September 23, 2013, 17 pages.	☐
	3	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,584, September 13, 2013, 16 pages.	☐
	4	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/158,134 January 22, 2014, 43 pages.	☐
	5	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,827 February 5, 2014, 28 pages.	☐

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	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	6	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,520 February 5, 2014, 8 pages.	☐
	7	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/710,062, February 27, 2014, 9 pages.	☐
	8	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/710,017, February 27, 2014, 11 pages.	☐
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	10	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/115,811, March 4, 2014, 15 pages.	☐
	11	UNKNOWN AUTHOR, System Description Wireless Power Transfer, Volume 1: Low Power Part 1: Interface Definition, Version 1.0, July 2010, 83 pages.	☐
	12	THE PATENT OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA, 2nd Office Action for Chinese Patent Application No. 200880023854.4, April 15, 2013, 4 pages.	☐

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Examiner Signature	/Yalkew Fantu/	Date Considered	06/18/2015

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	FANTU, YALKEW
Attorney Docket Number	AFPA-01032US0

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7733215		2010-06-08	Kozuma	

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	1	20040145343		2004-07-29	Naskali	
	2	20070236174		2007-10-11	Kaye	
	3	20090212639		2009-08-27	Johnson	
	4	20100235006		2010-09-16	Brown	
	5	20100314946		2010-12-16	Budde	

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Receipt date: 03/11/2015	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	FANTU, YALKEW	
	Attorney Docket Number	AFPA-01032US0	

	6	20110115430		2011-05-19	Saunamäki		
	7	20120049991		2012-03-01	Baarman		

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	1	2009200174	JP		2009-09-03	Panasonic Electric Works Co., Ltd.		☐
	2	100836634	KR		2008-04-29	Hanrim Postech Co., Ltd.		☐
	3	2000341885	JP		2000-12-08	Matsushita Electric Works Ltd.		☐
	4	2003045731	JP		2003-02-04	NEC Tokin Corp.		☐

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	1	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/829,346, February 12, 2015, 10 pages.	☐

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Receipt date: 03/11/2015	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

	2	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/829,186, January 23, 2015, 12 pages.	☐
	3	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/828,933, February 5, 2015, 11 pages.	☐
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

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Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	FANTU, YALKEW
Attorney Docket Number	AFPA-01032US0

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Receipt date: 04/29/2015	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

	1	JAPANESE PATENT OFFICE, Office Action for Japanese Patent Application No. 2010-507666, March 9, 2015, 8 pages.	☐
	2	JAPANESE PATENT OFFICE, Office Action for Japanese Patent Application No. 2014-104181, March 23, 2015, 14 pages.	☐

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Examiner Signature	/Yalkew Fantu/	Date Considered	06/13/2015

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5311973		1994-05-17	Tseng	
	2	7915858		2011-03-29	Liu	
	3	8169185		2012-05-01	Partovi	
	4	4800328		1989-01-24	Bolger	
	5	5367242		1994-11-22	Hulman	
	6	7554316		2009-06-30	Sevens	
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Receipt date: 06/27/2014	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
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	1	20120126745		2012-05-24	Partovi	
	2	20110222493		2011-09-15	Mangold	
	3	20120146576		2012-06-14	Partovi	
	4	20060105718		2006-05-18	Ozluturk	
	5	20110162035		2011-06-30	King	
	6	20120235636		2012-09-20	Partovi	
	7	20110193520		2011-08-11	Yamazaki	
	8	20100117596		2010-05-13	Cook	
	9	20090049554		2009-02-19	Vuong	
	10	20060106965		2006-05-18	Falcon	

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Receipt date: 06/27/2014	Application Number	13352096	13352096 - GAU: 2859
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	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	11	20070178945		2007-08-02	Cook	
	12	20050007067		2007-02-08	Baarman	
	13	20100007307		2010-01-14	Baarman	
	14	20080272889		2008-11-06	Symons	
	15	20100277121		2010-11-04	Hall	
	16	20100127660		2010-05-27	Cook	
	17	20110012556		2011-01-20	Lai	
	18	20100081473		2010-04-01	Chatterjee	
	19	20090284227		2009-11-19	Mohammadian	

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EFS Web 2.1.17

Receipt date: 06/27/2014	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	1	2006115368	WO		2006-11-02	Kang		☐
	2	2006001557	WO		2006-01-05	Jung		☐
	3	2012116054	WO		2012-08-30	Steele		☐

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	1	INTERNATIONAL SEARCHING AUTHORITY AT THE U. S. PATENT AND TRADEMARK OFFICE, International Search Report and Written Opinion for PCT International Patent Application No. PCT/US2013/078534, May 13, 2014, 11 pages.	☐
	2	INTERNATIONAL SEARCHING AUTHORITY AND WRITTEN OPINION FROM THE U. S. PATENT AND TRADEMARK OFFICE, International Search Report and Written Opinion for PCT International Application No. PCT/ US2013/069270, April 4, 2014, 9 pages.	☐
	3	EUROPEAN PATENT OFFICE, Office Action for European Patent Publication Application No. EP2151037, April 9, 2014, 5 pages.	☐

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Examiner Signature	/Yalkew Fantu/	Date Considered	06/13/2015

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	YALKEW FANTU	2859

CPC						
Symbol					**Type**	**Version**
H02J		7	/	0042	F	2013-01-01
H02J		7	/	025	I	2013-01-01
H02J		17	/	00	I	2013-01-01
H01F		38	/	14	I	2013-01-01
H02J		5	/	005	I	2013-01-01
H04B		5	/	0037	I	2013-01-01
H04B		5	/	0081	I	2013-01-01
H04B		5	/	0093	I	2013-01-01
B60L		11	/	182	I	2013-01-01
H02J		7	/	0013	I	2013-01-01
H02J		7	/	0052	I	2013-01-01
H02M		1	/	40	A	2013-01-01
H02M		3	/	3376	A	2013-01-01
Y02T		90	/	127	A	2013-01-01
Y02T		90	/	122	A	2013-01-01
B60L		2210	/	30	A	2013-01-01
B60L		2240	/	547	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
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NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/YALKEW FANTU/ Primary Examiner.Art Unit 2859	06/12/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No. 20150613

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	YALKEW FANTU	2859

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
320	108	H	0	2	J	7 / 00 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
320	109	139	150		

NONE		Total Claims Allowed: 37	
(Assistant Examiner)	(Date)		
/YALKEW FANTU/ Primary Examiner.Art Unit 2859	06/12/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	YALKEW FANTU	2859

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	3	17	33	33										
2	2	4	18	34	34										
9	3	5	19	35	35										
10	4	6	20	36	36										
15	5	7	21	37	37										
11	6	8	22		38										
12	7	23	23		39										
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14	9	25	25												
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17	11	27	27												
18	12	28	28												
19	13	29	29												
20	14	30	30												
21	15	31	31												
22	16	32	32												

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 37	
/YALKEW FANTU/ Primary Examiner.Art Unit 2859 (Primary Examiner)	06/12/2015 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office

Part of Paper No. 20150613

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S129	0	((charg$3 or power$3)(wireless or inductive)(receiver near coil)(battery)(switch$3 near layer)(cover$3 or protect$3)(modify or change)(magnitude or phase)(electromagnet$2 near field)(electromagnet$2 near shield$3)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 14:27
S130	0	((charg$3 or power$3)(wireless or inductive)(receiver coil)(battery)(switch$3 near layer)(cover$3 or protect$3)(modify or change)(magnitude or phase)(electromagnet$2 near field)(electromagnet$2 near shield$3)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:36
S136	1	((charg$3 or power$3)(wireless or inductive)(receiver coil)(batter$3 or device$1)(ferrite)(ferromagnetic near material)(switch$3 near layer)(cover$3 or protect$3)(modify or change)(magnitude or phase)(electromagnet$2 near field)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:42
S137	1	((charg$3 or power$3)(wireless or inductive)(batter$3 or device$1)(ferromagnetic near material)(switch$3 near layer)(cover$3 or protect$3)(modify or change)(magnitude or phase)(electromagnet$2 near field)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:42
S140	11	((charg$3 or power$3)(wireless or inductive)(batter$3 or device$1)(ferromagnetic material)(switch$3)(cover$3 or protect$3)(electromagnet$2 field)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:43
S141	37	((charg$3 or power$3)(wireless or inductive)(batter$3 or device$1)(magnetic material)(switch$3)(cover$3 or protect$3)(electromagnet$2 field)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:44
S145	41	((charg$3 or power$3)(wireless or inductive)(magnetic material)(switch$3)(cover$3 or protect$3)(electromagnet$2 field)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:45
S147	59	((charg$3 or power$3)(wireless or inductive)(magnetic material)(switch$3)(cover$3 or protect$3)(electromagnet$2)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:46
S157	88	((charg$3 or power$3)(wireless or inductive)(magnetic near material)(switch$3 or transistor or control)(electromagnet$2)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:51
S158	105	((charg$3 or power$3)(wireless or inductive)(magnetic)(switch$3)(cover$3 or protect$3)(electromagnet$2)).clm.	US-PGPUB; USPAT; UPAD	AND	ON	2015/06/13 18:52

6/13/2015 7:56:39 PM
C:\Users\yfantu1\Documents\EAST\Workspaces\13352096.inductive.charge.wsp

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

CPC- SEARCHED		
Symbol	Date	Examiner
H02J	06/12/2015	YF

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner
H02J7/025	06/12/2015	YF

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320	108,139,150	9/5/2013	YF
455	all	9/5/2013	

SEARCH NOTES		
Search Notes	Date	Examiner
320/109,139,150;455/all with text search was conducted	9/5/2013	YF
Inventor's search in PALM and eDAN was conducted	9/5/2013	YF
EAST Search (See Printout)	9/5/2013	YF
Related applications search was conducted	9/5/2013	YF
an updsated search was conducted	3/03/2014	YF
an updated search was coducted	8/9/2014	YF
search update with interference search was condcuted	06/12/2015	YF

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
320 / H02J	108 / 7/025	06/12/2015	YF

	/YALKEW FANTU/ Primary Examiner.Art Unit 2859

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I hereby appoint:

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OR

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OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
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Assignee Name and Address:

Mojo Mobility Inc.
3350 Scott Blvd., Bldg. 37A
Santa Clara, CA 95054

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	/Afshin Partovi/	Date	June 22, 2015
Name	Afshin Partovi	Telephone	(650) 446-0004
Title	CEO Mojo Mobility		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Mojo Mobility Inc.

Application No./Patent No.: 13/352,096 Filed/Issue Date: January 17, 2012

Titled: SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Mojo Mobility Inc. , a Corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is _____ %); or

3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 28656, Frame 459, or for which a copy therefore is attached.

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The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Afshin Partovi/ June 22, 2015
Signature Date

Afshin Partovi CEO, Mojo Mobility Inc.
Printed or Typed Name Title

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Electronic Acknowledgement Receipt	
EFS ID:	22718569
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Louis L. Wu
Filer Authorized By:	
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	23-JUN-2015
Filing Date:	17-JAN-2012
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Application Type:	Utility under 35 USC 111(a)

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File Listing:

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2	Assignee showing of ownership per 37 CFR 3.73	POAChange25.pdf	426615 8e4bebc03305656de9c96860b804a29441cc66dd	no	2

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

	1	JAPANESE PATENT OFFICE, Office Action for Japanese Patent Application No. 2010-507666, March 9, 2015, 8 pages.	☐
	2	JAPANESE PATENT OFFICE, Office Action for Japanese Patent Application No. 2014-104181, March 23, 2015, 14 pages.	☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl Kenna/	Date (YYYY-MM-DD)	2015-04-29
Name/Print	Karl Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION	
Inventor(s):	Partovi, Afshin		
Appl. No.:	13/352,096	Art Unit:	2859
Confirm. No.:	4453	Examiner:	Fantu, Yalkew
Filed:	January 17, 2012		
Title:	SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**	

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

✓ A copy of an Examination Report for Japanese Patent Application No. 2010-507666 dated March 9, 2015.

✓ A copy of an Examination Report for Japanese Patent Application No. 2014-104181 dated March 23, 2015.

This statement should be considered because:

___ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);
-- OR --
(2) It is being filed within 3 months of entry of a national stage;
-- OR --
(3) It is being filed before the mailing date of the first Office Action on the merits,
-- OR --
(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.
-- AND *(check at least one of the following)* --
___ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).
-- OR --
✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

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-- AND --
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✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

TUCKER ELLIS LLP

Date: April 29, 2015

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

Customer No. 23910
TUCKER ELLIS LLP
One Market Plaza, Suite 700
San Francisco, California 94105
Telephone: (415) 362-3800

Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	
Filing Fees for **Utility under 35 USC 111(a)**	

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	22203522
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	29-APR-2015
Filing Date:	17-JAN-2012
Time Stamp:	16:21:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	3265
Deposit Account	061325
Authorized User	KENNA, KARL
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

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Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Other Reference-Patent/App/Search documents	afpa_1013jp0_OA.pdf	321416 b460ccf3515a4f6acd1d62a8577c5034b4163e47	no	8
Warnings:					
Information:					
2	Other Reference-Patent/App/Search documents	afpa_1013jp1_OA.pdf	620769 5517edd2a5b8d4895f8a1dd86875a9e19431d6a7	no	14
Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	afpa_1038us1_041615_oa.pdf	925220 2894a84c4c952ea531b9ea83b7f61a84b8f4737a	no	24
Warnings:					
Information:					
4	Foreign Reference	JP2006246633.pdf	63872 902f72760058951 3f4b4b21325deec8ab9d04fcc	no	1
Warnings:					
Information:					
5	Information Disclosure Statement (IDS) Form (SB08)	afpa_1032us0_IDS.pdf	612078 195d25998bf7b74dd2713cfd33e412220a85f646	no	4
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6	Transmittal Letter	afpa_1032us0_042915_IDS_Transmittal.pdf	117073 dc208a5ccb6a481370b7ffea73a44d585508675e	no	2
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	30866 768b2ef4aabab13c6b8abaaaa844330aa8fb278c	no	2

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Total Files Size (in bytes):	2691294

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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Ref. 1

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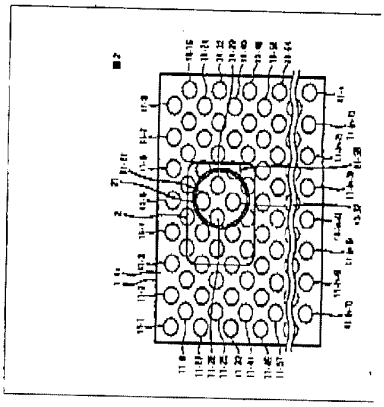
Selected Gazette

JP,2006-246633,A

Previous Document 1/1 Next Doc

PAJ Detail Image

(11)Publication number	2006-246633
(43)Date of publication of application	14.09.2006
(51)Int.Cl.	H02J 7/00 (2006.01) H02J 17/00 (2006.01)
(21)Application number	2005-059747
(22)Date of filing	03.03.2005
(71)Applicant	SONY CORP
(72)Inventor	KAMITSUMA YDSUKE NISHIKAWA SHINPEI KIMURA SHINJI HORI YUSUKE SANKEGANO GORO IWASAKI YUKI ONITSUKA SHIGETOSHI



(54)SYSTEM, DEVICE AND METHOD FOR SUPPLYING POWER, POWER-RECEIVING DEVICE/METHOD, RECORDING MEDIUM AND PROGRAM

(57)Abstract

PROBLEM TO BE SOLVED: To more speedily supply power to a power-receiving device.
SOLUTION: In a power supply device 1 having power supplies 11-1 to 11-n supplying power by electromagnetic induction, the power supply device 1 selects the power supplies 11-21, the power supplies 11-28, the power supplies 11-29 and the power supplies 11-37, which are placed on an installation face 1a of the power supply device 1 and correspond to positions of a power receiver 21 of the power-receiving device 2 from the power supplies 11-1 to 11-n. The selected power supplies 11-21, the power supplies 11-28, the power supplies 11-29, and the power supplies 11-37 supply power to the power receiver 21 of the power-receiving device 2 through electromagnetic induction. The system, the device and the method can be applied to the power supply device, supplying power to a portable telephone set and the like.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	FANTU, YALKEW
Attorney Docket Number	AFPA-01032US0

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7733215		2010-06-08	Kozuma	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040145343		2004-07-29	Naskali	
	2	20070236174		2007-10-11	Kaye	
	3	20090212639		2009-08-27	Johnson	
	4	20100235006		2010-09-16	Brown	
	5	20100314946		2010-12-16	Budde	

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	Attorney Docket Number	AFPA-01032US0

	6	20110115430		2011-05-19	Saunamäki	
	7	20120049991		2012-03-01	Baarman	

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	1	2009200174	JP		2009-09-03	Panasonic Electric Works Co., Ltd.		☐
	2	100836634	KR		2008-04-29	Hanrim Postech Co., Ltd.		☐
	3	2000341885	JP		2000-12-08	Matsushita Electric Works Ltd.		☐
	4	2003045731	JP		2003-02-04	NEC Tokin Corp.		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/829,346, February 12, 2015, 10 pages.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

	2	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/829,186, January 23, 2015, 12 pages.	☐
	3	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/828,933, February 5, 2015, 11 pages.	☐
	4	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/352,096, August 18, 2014, 14 pages.	☐
	5	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/708,584, January 23, 2015, 25 pages.	☐
	6	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 12/769,586, June 2, 2014, 23 pages.	☐
	7	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/708,520, August 14, 2014, 9 pages.	☐
	8	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/115,811, August 20, 2014, 20 pages.	☐
	9	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 14/135,082, December 5, 2014, 14 pages.	☐
	10	JAPANESE PATENT OFFICE, Examiner's Reconsideration Report for Japanese Patent Application No. 2010-507666, July 17, 2014, 1 page.	☐
	11	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/708,520, March 11, 2015, 10 pages.	☐
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	FANTU, YALKEW
	Attorney Docket Number	AFPA-01032US0

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl Kenna/	Date (YYYY-MM-DD)	2015-03-11
Name/Print	Karl Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	
Filing Fees for **Utility under 35 USC 111(a)**	

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	21735661
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	11-MAR-2015
Filing Date:	17-JAN-2012
Time Stamp:	19:33:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	5481
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

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Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	afpa_1032us0_IDS_Trans_031115.pdf	111246 e7bd239dae9c3422d0853bee2175ddaa5ba193b0	no	2
Warnings:					
Information:					
2	Other Reference-Patent/App/Search documents	Office_Action_12769586_060214.pdf	781937 bfdf60acb68c515c66862e5c66522a33b3f3fa02	no	23
Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	Office_Action_13115811_082014.pdf	480993 ac36fb33bdb82ead9b739a9211027190420a714a	no	14
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4	Other Reference-Patent/App/Search documents	Office_Action_13352096_081414.pdf	557142 5ad68cacff174ddb76cbb52c5c381142119e304b	no	14
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5	Other Reference-Patent/App/Search documents	Office_Action_14135082_120514.pdf	422576 c6a9e8116472aef0bad77bdf743d67917763830a	no	14
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12	Foreign Reference	JP2009200174_Translation.pdf	305285 81004351c0ca4beca31391db925839a057cfdc26	no	7
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Information:					

17	Information Disclosure Statement (IDS) Form (SB08)	afpa_1032us0_IDS.pdf	613001 7d0766c37d00fa2e63229732c649e38c9f114e76	no	6
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18	Fee Worksheet (SB06)	fee-info.pdf	30866 23a6c29fc47dbed6256dc585f76f8db0aae21203	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	10274504		

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION
Inventor(s):	Partovi, Afshin et al.	
Appl. No.:	13/352,096	Art Unit: 2859
Confirm. No.:	4453	Examiner: Fantu, Yalkew
Filed:	January 17, 2012	
Title:	SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

This statement should be considered because:

__ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.

-- AND *(check at least one of the following)* --

__ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

MEYER IP LAW GROUP

Date: March 11, 2015

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

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410 Pacific Avenue
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Telephone: (415) 362-3800

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **2009-200174**
(43)Date of publication of application : **03.09.2009**

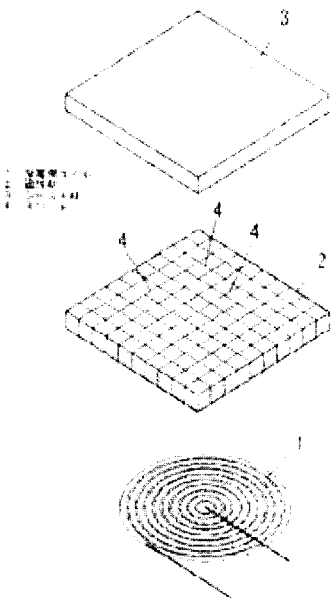
(51)Int.Cl. *H01F 38/14 (2006.01)*
H02J 17/00 (2006.01)

(21)Application number : **2008-039209**
(22)Date of filing : **20.02.2008**

(71)Applicant : **PANASONIC ELECTRIC WORKS CO LTD**
(72)Inventor : **KITAMURA KOTA**
SUZUKI MASAYUKI
YABUUCHI HIDEKAZU

(54) NON-CONTACT POWER TRANSMISSION APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To increase power transmission efficiency by suppressing generation of an eddy current in a magnetic material.
SOLUTION: This non-contact power transmission apparatus is provided with a secondary power-receiving coil 1 for receiving power from a primary power transmitting coil, and a magnetic material 2 is arranged at least on one surface of the coil 1. The magnetic material 2 has slits 4 formed on a surface parallel to facing surfaces of both the coils. The slits formed on the magnetic material for improving power transmission efficiency suppresses an eddy current generated by passage of magnetic flux through the magnetic material, whereby heat loss is reduced.



* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]
While it is non-contact transfer-of-power apparatus provided with a coil for downstream power receiving for receiving electric power from a coil for primary side power transmission and a magnetic material is arranged by at least one side of the above-mentioned coil for downstream power receiving, Non-contact transfer-of-power apparatus, wherein a slit is formed in a surface where the above-mentioned magnetic material is parallel to an opposed face of both the above-mentioned coils.
[Claim 2]
The non-contact transfer-of-power apparatus according to claim 1, wherein the above-mentioned slit is formed in a surface by the side of a coil for downstream power receiving of a magnetic material as what does not penetrate a magnetic material.
[Claim 3]
The non-contact transfer-of-power apparatus according to claim 1 or 2, wherein the above-mentioned slit is the thing of a direction which was along in the direction of magnetic flux which flows through inside of a magnetic material.
[Claim 4]
Non-contact transfer-of-power apparatus of a description in any 1 item of Claims 1-3, wherein the above-mentioned slit is densely provided by portion with high density of magnetic flux which flows through inside of a magnetic material.

[Translation done.]

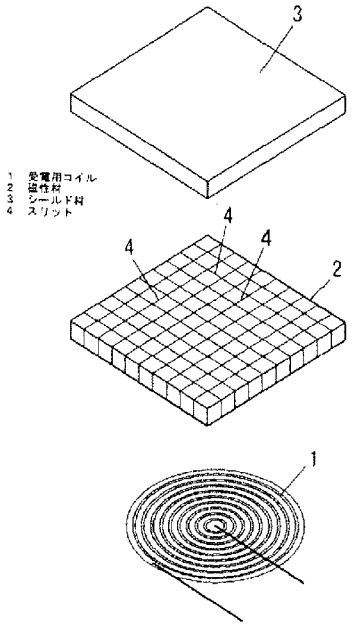
* NOTICES *

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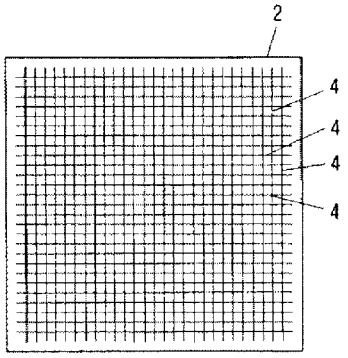
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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

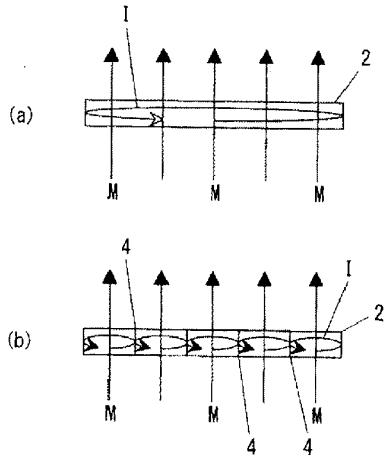
[Drawing 1]



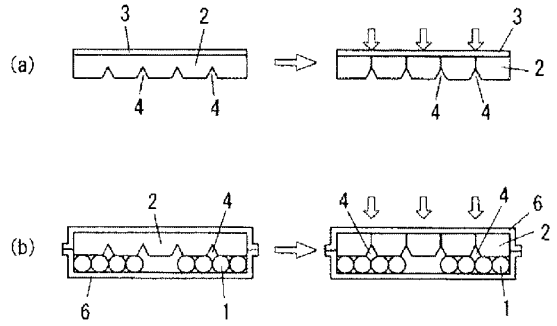
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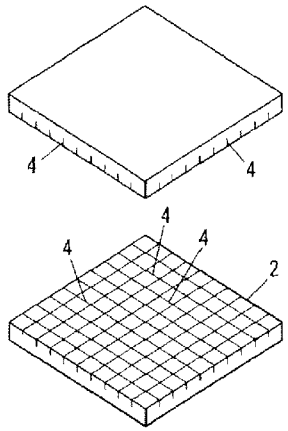
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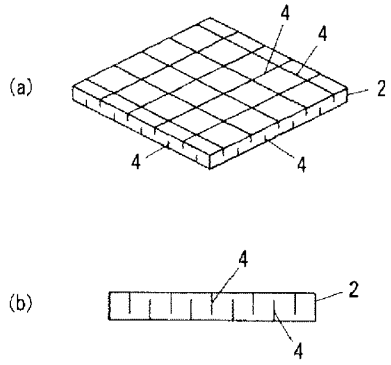
[Drawing 4]



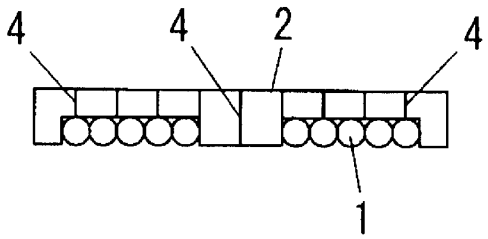
[Drawing 5]



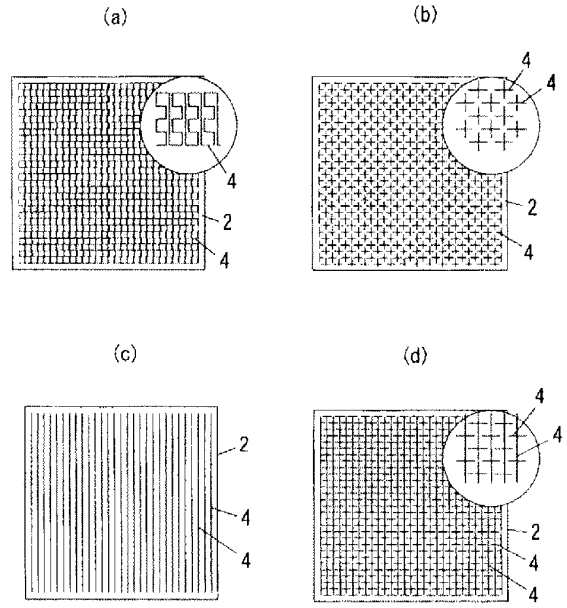
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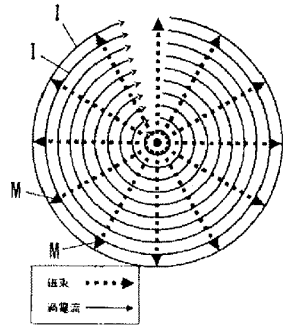
[Drawing 7]



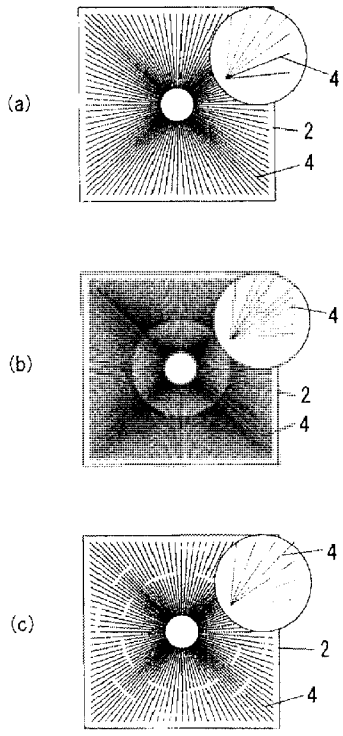
[Drawing 8]



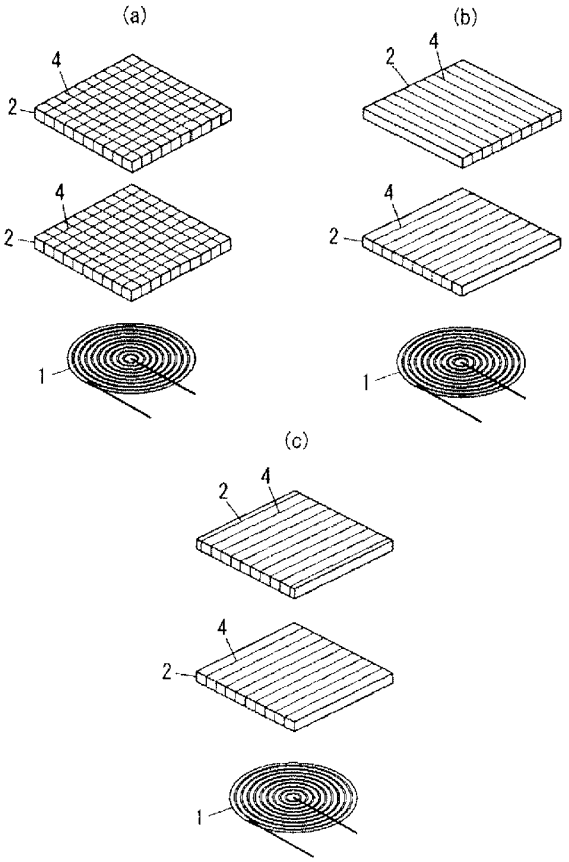
[Drawing 9]



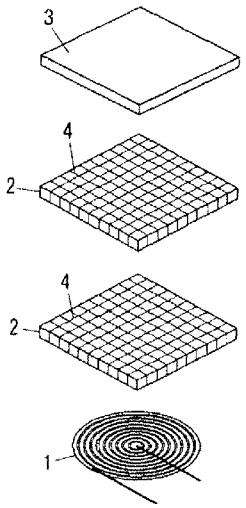
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]

(19) KOREAN INTELLECTUAL PROPERTY OFFICE

KOREAN PATENT ABSTRACTS

(11) Publication number: 1020080036702 A
(43) Publication date: 29.04.2008

(21) Application number: 1020060103254
(22) Application date: 24.10.2006

(51) Int. Cl: H02J 17/00

(71) Applicant: • HANRIM POSTECH CO., LTD.
(72) Inventor: • KOOK, YOON SANG

(54) NON-CONTACT CHARGER PERFORMING WIRELESS DATA COMMUNICATION AND POWER TRANSMISSION, A CHARGING BATTERY-PACK, AND A MOBILE DEVICE USING NON-CONTACT CHARGER, CAPABLE OF RECOGNIZING A CHARGING STATE BY THE BATTERY-PACK OF THE MOBILE DEVICE

(57) Abstract:

PURPOSE: A non-contact charger performing wireless data communication and power transmission, a charging battery-pack, and a mobile device using the non-contact charger are provided to supply power while stably transmitting and receiving data.

CONSTITUTION: A non-contact charger performing wireless data communication and power transmission includes a USB(Universal Serial Bus) connector(10), a USB driver block(20), and an MPU (Micro processor Unit) block(30), and a primary coil. The MPU block controls a serial resonant connector(50), a current sensing block (60), and a power supplying member. The serial resonant converter converts and aggregates a data signal transmitted and received between the USB driver block and the mobile device, and a power signal supplied from the USB connector to the mobile device. The current sensing block analyzes a signal of a secondary coil transmitted from the primary coil sensing a load modulation signal by the secondary coil at the side of the mobile device which corresponds to the primary coil and recognizes the mobile device, monitors the primary coil and the secondary coil to control a charging voltage with a stable voltage, and transmits the signal to the MPU block.

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No.	Content
1	It is installed to one side of the equipment body (2) of the wearable hull shape and one side is connected to USB port of the computer or the notebook and jack bond and separation is possible connected USB connector (10) ; USB connector (10). In order to transmit and receive the computer or the notebook and data data are connected to USB driver block (20) ; USB connector (10) entrusted by USB protocol. In order that the power supplied from the computer or the notebook is supplied to the portable terminal or data are transmitted and receive in order to wirelessly transmit data signal from the MPU block (30); controlling the series resonance converter (50), and the member for the current sensing block (60) and electric power supply and series resonance converter (50) and electric source signal in the portable terminal the primary coil (70) formed in upper part of the equipment body (2) is included. The supplied electric source signal is configured to be converted into the portable terminal from data signal and USB connector (10) in which series resonance converter (50) is transmitted and received between USB driver block (20) and portable terminal Non-contact charger capable of the wireless data communication and the power deliver noticing load modulation signal by the secondary coil (80) and is configured to transmit the sensed signal with the MPU block (30) and analyzes the sensed signal about the secondary coil (80) transmitted from the MPU block (30) through the primary coil (70) and current sensing block (60) and is configured to recognize the portable terminal and control the charging voltage to the stabilized voltage of the portable terminal corresponding to the current sensing block (60) in the primary coil (70).
2	The non-contact charger in which the wireless data communication and the power deliver which are the LLC full bridge series resonance converter are possible of claim 1, wherein primary coil (70) are series resonance converter (50) is the half-wave type or the full wave type the serial / parallel resonant converter it is formed with the circular form, and the square or the polygon it is comprised of any one of FPCB of decoupling-type transformer, PCB, and the coil and ferrite core.
3	As for claim 1, the non-contact charger capable of the wireless data communication and the power deliver which more includes the display section (3) in which the signal is transmitted from the primary coil (70) and indicating the state of charge of the rechargeable battery (230) with the control of the MPU block (30) sensing the state of battery charging signal among the gate drive block (40), and secondary coil (80) signal that are equipped and include the boots trap gate driver between USB driver block (20) and the MPU block (30) and series resonance converter (50).
4	As for claim 1, the detecting circuit of dust sensor (90), and non-contact charger capable of the wireless data communication and the power deliver which further includes the ion source (91) generating anion and sprays the antiseptic spray for the bacillus extermination the dust of the himetal (71), and equipment body (2) inner portion and circuit wherein the current flowing through the primary coil (70) it is connected to the thermal protect on circuit part (92) which detects the temperature of equipment body (2) inner portion blocks the current it is too much or the inner temperature overheats.

No.	Content
5	Deletion .
6	As for claim 1, the non-contact charger capable of the wireless data communication and the power deliver which more includes the portable terminal ID detection part wherein USB driver block (30) senses and distinguishes the identification of portable terminal the IrDA port (42) is further that sends and receives each other with the portable terminal by the control of the MPU block (30) data signal further includes 1 and being transformed to the IrDA with IrDA signal converter (21) the IrDA signal transducer (31) converted into USB protocol and IrDA.
7	The battery pack for charge in which the charger circuit (220) transmitting the charge electricity among claim 5 to claim 6 and claim 5 with filters body (201) configured in the secondary coil (80) it is contactable with the equipment body (2) one side of the non-contact charger (1) of any one claim from each other and for sending and receives data signal in the primary coil (70) and non contact state with the magnetic field and being transmitted the power signal, is one side, filters control unit (210) in which the primary coil (70) and data signal transmitted and received it transmits in the rechargeable battery (230) the power signal transmitted from the primary coil (70) is processed it is connected to the secondary coil (80) of filters body (201) inner one side are processed, and the control of filters control unit (210) in the rechargeable battery (230) is included and charger circuit (220) is configured to be the power source of the rechargeable battery (230) supplied to the portable terminal.
8	As for claim 7, the battery pack for charge comprising the identification port, and the charging detecting port wherein filters control unit (210) transmits with the non-contact charger (1) through the secondary coil (80) and primary coil (70) the identification on the thing is sensed that is first connected from non-contact charger (1), and the charging detecting part senses the charge degree of rechargeable battery (230) and transmitted with the non-contact charger (1).
9	The battery pack for charge of claim 7, wherein filters body (201) comprises the integrated pack which is composed of the decoupling-type pack formed with the separate body so that portable terminal, the separation and tightening be possible 1 and it is input inside the main case of portable terminal and is or integrally formed, and secondary coil (80) it is comprised of any one of ferrite core 1 and it is formed with the circular form, and the square of the polygon with FPCB of the decoupling-type transformer, FCB, and the coil.
10	As for claim 9, the battery pack for charge wherein the filters body (201) of decoupling-type pack more comprises the terminal block (240) that supplies to the portable terminal the power source of the rechargeable battery (230) by the control of filters control unit (210).

No.	Content
11	As for claim 8, the electricity of being induced from the secondary coil (516) which of charge receive module (517) is wound surrounds the battery cell (512), charged through the wireless power receiving circuit (513) battery cell (512) bottom surface, and up and down four sides The battery pack for charge including the shielding member (501) covering the magnetic field in the wireless power receiving circuit (513) it is equipped between the shielding plate (515) (515-1) (515-2) (515-3) (515-4) which is comprised of the Al, and the Cu or the Ni Alloy metal and protects the battery cell (512) from the magnetic field, and upper shielding board (515) and charge receiver module (517) wireless power receiving circuit (513) are comprised of the Al, and the Cu or the Ni Alloy metal.
12	Portable terminal using the non-contact charger which is provided with the power source from the non-contact charger (1) and transmits and receives data of claim 11.
13	The portable terminal having the battery pack for charge (200) and includes the IrDA port (22) of IrDA controller (302) and non-contact charger (1) and the IrDA port which data communicates including the filler body (201) of the integrated pack of claim 11.
14	Portable terminal using the non-contact charger comprising the charge block (330) filling the terminal block (240) and the electricity of being electrically contacted and being connected to the electricity receiving terminal block (510) provided with the power source and being connected to electricity receiving terminal block (510) and being transformed in the DC/DC converter (320) of converting electricity and DC/DC converter (320) of the battery pack for charge (200) of claim 11.

<13> 도 1은 본 발명의 바람직한 실시예에 따른 휴대용 충전장치의 내부 시스템블록도.

<12> <도면의 주요 부분에 대한 부호의 설명>

<11> 1 : 무접점 충전장치 2 : 충전단자

<14> 10 : USB커넥터 10 : USB드라이버부

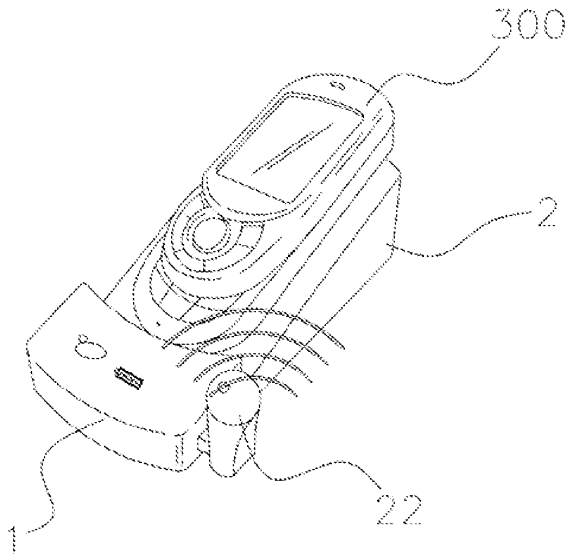
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<16> 60 : 전류증폭부

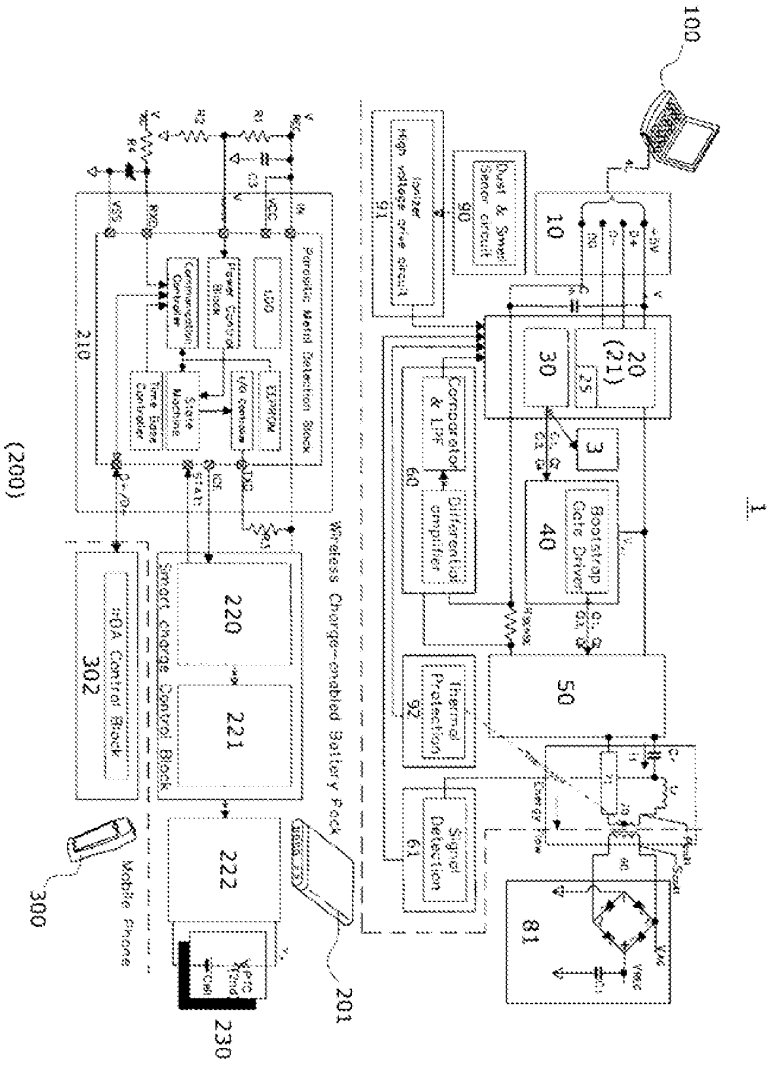
<17> 70 : 1차코일 80 : 2차코일

<18> 200 : 충전용 배터리팩 300 : 충전용 단말기

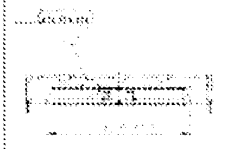
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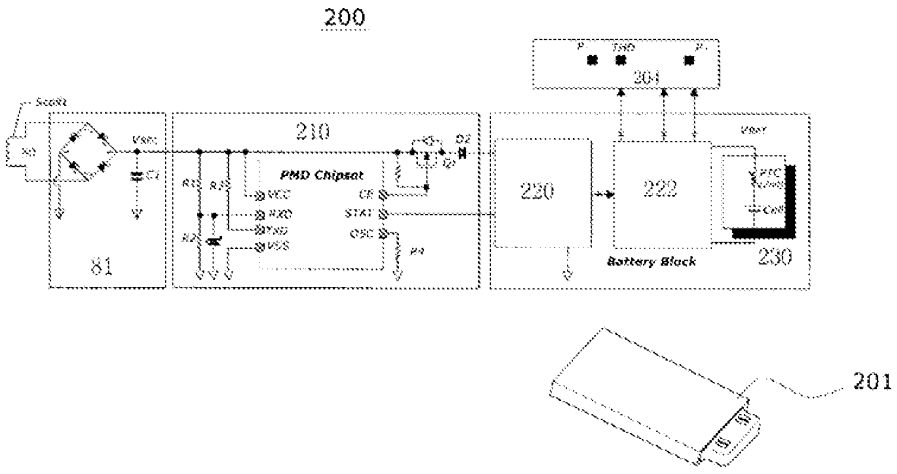
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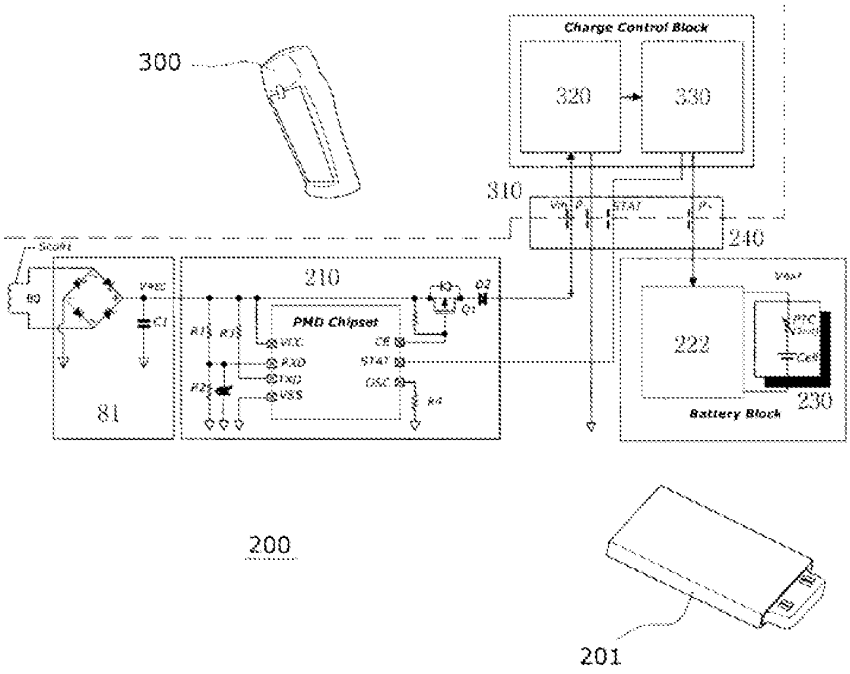
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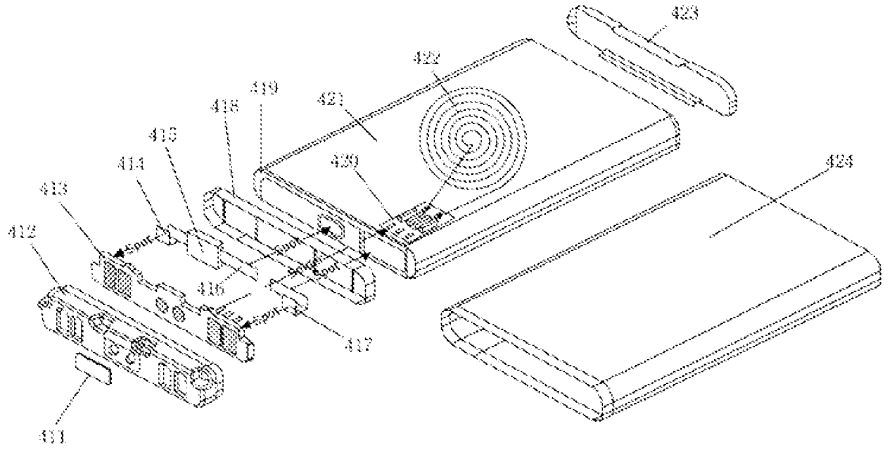
충전부 표면 전압 측정 수치	USB 컨넥터	Cigar 소켓
		

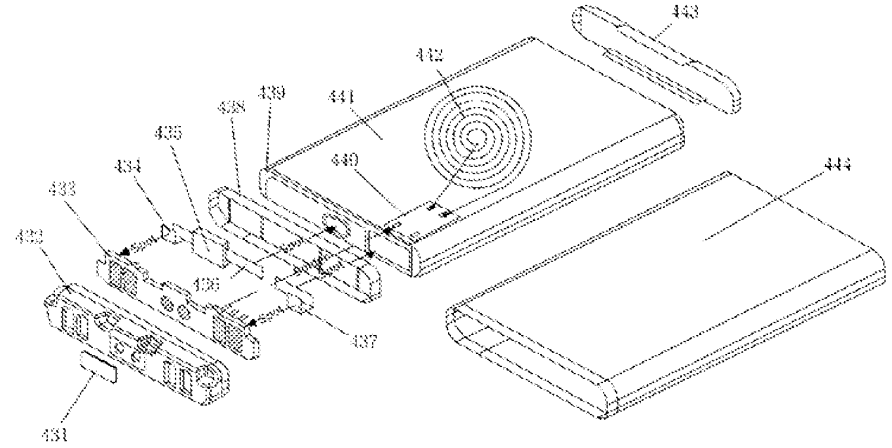
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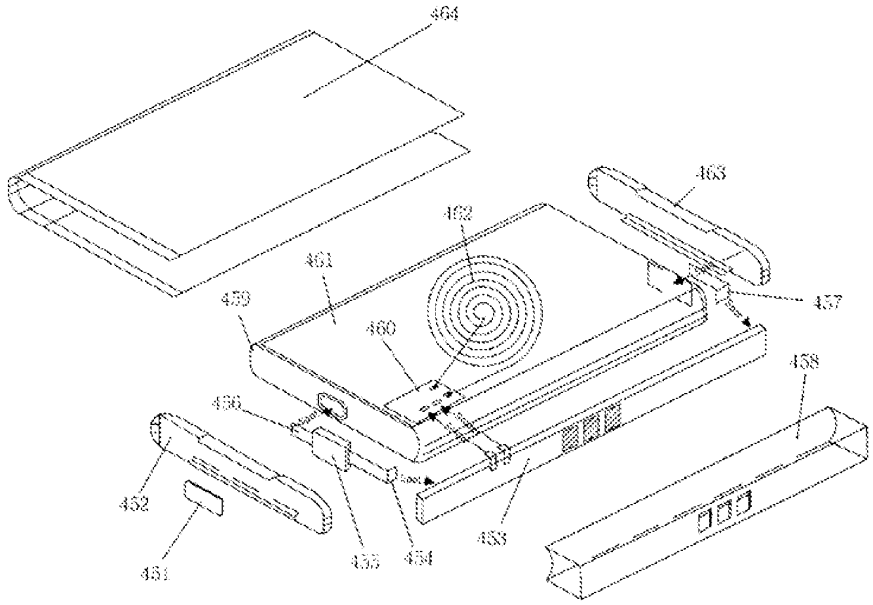

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301
210
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220
222
230
Battery Block
81
201

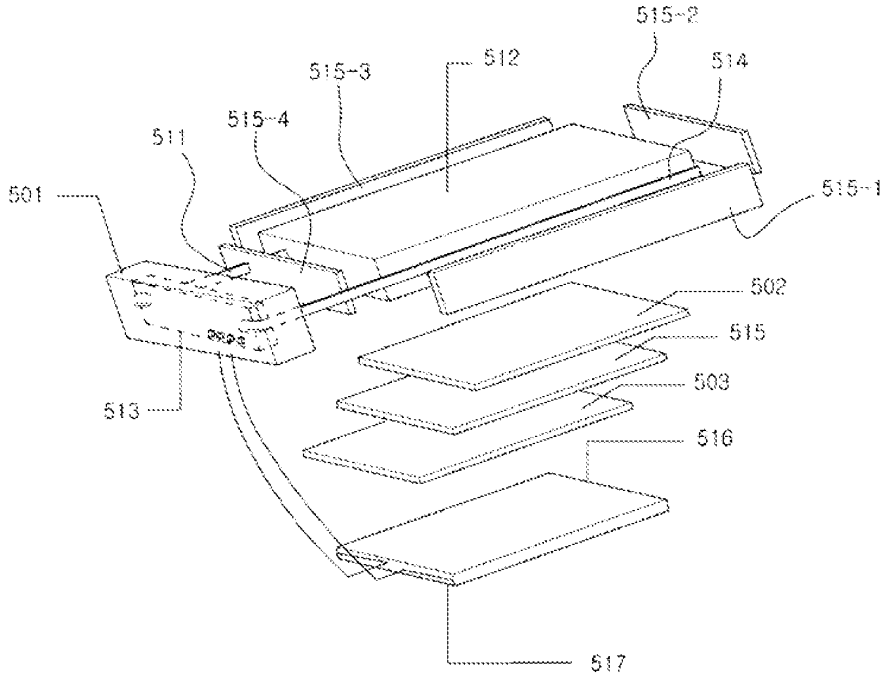
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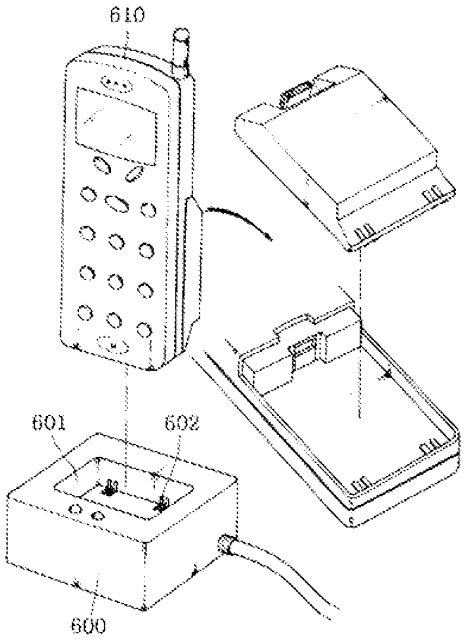

300
Charge Control Block
320
330
310
240
210
PMD Chipset
222
230
Battery Block
81
200
201


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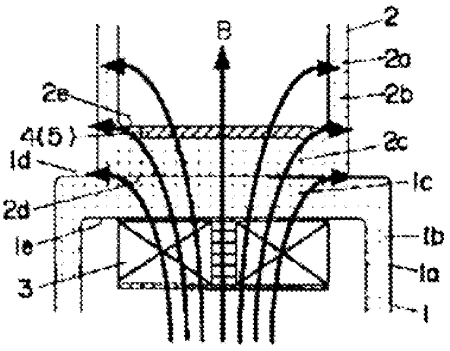
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(54) NONCONTACT POWER TRANSMISSION DEVICE AND MANUFACTURE THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a noncontact transmission device which can reduce the gap between a primary coil and a secondary coil and increase the power transmitted from the primary coil to the secondary coil.
SOLUTION: In a noncontact power transmission device, a primary coil 3 is placed on a power supply device 1 side, a secondary coil 4 is placed on a load apparatus 2 side, and a power is transmitted from the primary coil 3 to the secondary coil 4 through electromagnetic induction. The primary coil 3 or the secondary coil 4 is formed into a flat coil 5, which is attached to the contact wall 1c(2c) of the mutual connection part 1a(2a)



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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]The present invention relates to non-contact power transmission equipment and a manufacturing method for the same.
[0002]
[Description of the Prior Art]Fig.9 shows the power transmission part of conventional non-contact power transmission equipment. The primary side coil 3 in which the principal part of the power transmission part of this equipment is arranged in the interconnecting part 1a of the power supply system 1, It comprises the secondary coil 4 arranged in the interconnecting part 2a of the load apparatus 2, and the electromagnetic induction from the primary side coil 3 to the secondary coil 4 performs power transmission by non-contact (the inside B of a figure expresses magnetic flux). The primary side coil 3 is stuck to the inner surface 1e of the contact wall 1c of the housing 1b of the interconnecting part 1a of the power supply system 1, the secondary coil 4 is stuck to the inner surface 2e of the contact wall 2c of housing 2b of the interconnecting part 2a of the load apparatus 2, respectively, and it has arranged.
[0003]By the way, it is possible to increase the inductor of the primary side coil 3 or the secondary coil 4, or to improve a transmission efficiency by core insertion as a method to which the electric power transmited to the secondary coil 4 is made to increase from the primary side coil 3, etc. Since the number of turns of a coil is increased in order to increase an inductor in the case of the method of increasing the inductor of the primary side coil 3 or the secondary coil 4 first, a coil becomes largely and bars the miniaturization of equipment. In the method of improving a transmission efficiency by core insertion as well as the previous method, the miniaturization of equipment will be barred by core insertion, and also it is connected with cost increase.
[0004]Then, how to make the gap between the primary side coil 3 and the secondary coil 4 as small as possible can be considered as methods other than the above. Namely, the thickness of the contact wall 1c of the housing 1b of the interconnecting part 1a of the power supply system 1 with which the primary side coil 3 is arranged as for this, It is the method of making as thin as possible thickness of the contact wall 2c of housing 2b of the interconnecting part 2a of the load apparatus 2 in which the secondary coil 4 is arranged, and making distance between the primary side coil 3 and the secondary coil 4 as small as possible. However, in this method, there is a limit also in making thin thickness of the housing 1b and the contact walls 1c and 2c of housing 2b by restriction of housing strength, housing molding conditions, the distance for insulation, etc. In the case of this method, as shown in Fig.10, depending on the design of goods, the primary side coil 3 and the secondary coil 4 may have to be arranged to the curved surface part 14. In this case, the gap between the primary side coil 3 and the secondary coil 4 becomes largely, and it becomes difficult to secure from the primary side coil 3 the electric power transmited to the secondary coil 4.
[0005]

[Problem to be solved by the invention]In view of the above-mentioned point, it succeeds in the present invention, the gap between a primary side coil and a secondary coil can be made extremely small, and it aims at providing the non-contact power transmission equipment which can increase the electric power transmited to a secondary coil from a primary side coil.
[0006]
[Means for solving problem]The non-contact power transmission equipment concerning Claim 1 of the present invention, In the non-contact power transmission equipment which arranges the primary side coil 3 to the power supply system 1 side, arranges the secondary coil 4 to the load apparatus 2 side, and carries out power transmission by the electromagnetic induction from the primary side coil 3 to the secondary coil 4, The primary side coil 3 or the secondary coil 4 is formed in the plane coil 5, and this plane coil 5 is arranged in the contact wall 1c (2c) of the interconnecting part 1a (2a) of the power supply system 1 or the load apparatus 2.
[0007]The non-contact power transmission equipment concerning Claim 2 of the present invention, In addition to the composition of Claim 1, either the primary side coil 3 formed in the plane coil 5 or the secondary coil 4 is arranged on 1 d (2d) of outer surfaces of the contact wall 1c (2c) of the interconnecting part 1a (2a) of the power supply system 1 or the load apparatus 2.
[0008]The non-contact power transmission equipment concerning Claim 3 of the present invention, In addition to the composition of Claim 1, either the primary side coil 3 formed in the plane coil 5 or the secondary coil 4 is arranged to 1 d (2d) of outer surfaces of the contact wall 1c (2c) of the interconnecting part 1a (2a) of the power supply system 1 or the load apparatus 2, and both sides of the inner surface 1e (2e), And both the coils 3 and 3 (4, 4) arranged to 1 d (2d) of outer surfaces and both sides of the inner surface 1e (2e) are electrically connected.
[0009]In addition to the composition of Claim 2 or either of 3, the non-contact power transmission equipment concerning Claim 4 of the present invention covers the exposed part 5a of the plane coil 5 with the protection seal 6 for protecting the plane coil 5.
[0010]In addition to the composition of Claim 4, the non-contact power transmission equipment concerning Claim 5 of the present invention provided the magnetic part 7 to the central part of the aforementioned protection seal 6.
[0011]In addition to one composition of the Claims 1-4, the non-contact power transmission equipment concerning Claim 6 of the present invention arranged two or more secondary coils 4 at the place which intersects the magnetic flux B generated from the primary side coil 3.
[0012]The manufacturing method of the non-contact power transmission equipment concerning Claim 7 of the present invention arranges the above-mentioned plane coil 5 by hot stamping in the contact wall 1c (2c) of the interconnecting part 1a (2a) of the power supply system 1 or the load apparatus 2.
[0013]
[Mode for carrying out the invention]An embodiment of the invention is described based on Fig.1 thru/or Fig.8.
[0014]An example of an embodiment of the invention is shown in Fig.1 thru/or Fig.3.Fig.1 shows the power transmission part of the non-contact power transmission equipment of the present invention. The power transmission part of non-contact power transmission equipment comprises the interconnecting part 1a of the power supply system 1, and the interconnecting part 2a of the load apparatus 2. The interconnecting part 1a of the power supply system 1 and the interconnecting part 2a of the load apparatus 2, respectively, A coat is formed with cylinder-like-object-with-base-like the housing 1b and housing 2b, and to the inner surface 1e of the contact wall 1c of the housing 1b the primary side coil 3, The secondary coil 4 is arranged by the inner surface 2e of the contact wall 2c of housing 2b so that the winding axis of a coil may correspond to the medial axis of the housing 1b and housing 2b, respectively. In this example, the plane coil 5 which formed copper foil as shown in Fig.2 spirally is used for one secondary coil 4 using the cylindrical coil generally used for the primary side coil 3. Hot stamping performs arrangement to the inner surface 2e of formation of this

plane coil 5, and the contact wall 2c of housing 2b.
[0015]Next, the description of the non-contact power transmission equipment of the present invention of operation is carried out. Fig.3 shows the circuit diagram of this non-contact power transmission equipment, Fig.3 (a) is a circuit diagram of the power supply system 1, and Fig.3 (b) is a circuit diagram of the load apparatus 2. First, in the power supply system 1, the alternating current supplied from AC power supply 8 is converted to the high frequency current by the high frequency generation circuit 9, the high frequency current is sent through the primary side coil 3 arranged to the inner surface 1e of the contact wall 1c of the housing 1b, and the magnetic flux B as shown in Fig.1 is generated. Next, when the aforementioned magnetic flux B intersects the secondary coil 4 which is the plane coil 5 arranged to the inner surface 2e of the contact wall 2c of housing 2b in the load apparatus 2, After electromotive force occurs in the secondary coil 4 by electromagnetic induction and the rectifier diode 10 rectifies, it charges by supplying current to the cell 11. In this way, the load apparatus 2 to which electric power was supplied can make the load 12 drive by turning ON the electric power switch 13 arranged to the load apparatus 2.
[0016]As mentioned above the non-contact power transmission equipment of the present invention, By forming the secondary coil 4 in the plane coil 5, and arranging the plane coil 5 to the inner surface 2e of the contact wall 2c of housing 2b of the interconnecting part 2a of the load apparatus 2, Since the number of the magnetic flux B which intersects the secondary coil 4 among the magnetic flux B generated from the primary side coil 3 by the distance between the primary side coils 3 of the secondary coil 4 which is the plane coil 5 which are all a part and the other party coil becoming short can be increased, Big electromotive force is acquired and the electric power transmited to the secondary coil 4 from the primary side coil 3 can be increased. Since the inductor of the primary side coil 3 or the secondary coil 4 is small and ends compared with the conventional thing when making fixed electric power profitably like conversely at the load apparatus 2 side, the miniaturization of parts and a cost cut can be aimed at. Since it is the plane coil 5 and space of a longitudinal direction is not taken, equipment can be miniaturized and slimmed down. By arranging the above-mentioned plane coil 5 by hot stamping in the contact wall 2c of housing 2b of the interconnecting part 2a of the load apparatus 2, it becomes possible to manufacture the power transmission part of non-contact power transmission equipment by low cost. By hot stamping, since the plane coil 5 can be arranged also to the curved surface part of a housing, the flexibility of the housing form of goods increases.
[0017]Next, other examples of an embodiment of the invention are shown in Fig.4. Other composition except arrangement of the secondary coil 4 in which this non-contact power transmission equipment is the plane coil 5 is the same as the aforementioned example, and in this example, the secondary coil 4 is embedded so that it may become flat-tapped with 2 d of outer surfaces at the contact wall 2c of housing 2b. Since the gap between the primary side coil 3 and the secondary coil 4 serves as only thickness of the contact wall 1c of the housing 1b and becomes short by having such composition, the electric power transmited to the secondary coil 4 from the primary side coil 3 can be increased more.
[0018]Next, other examples of an embodiment of the invention are shown in Fig.5. Other composition except arrangement of the secondary coil 4 in which this non-contact power transmission equipment is the plane coil 5 is the same as a first example, In this example, both the coils 5 and 5 that arranged the two plane coils 5 and 5 as the secondary coil 4 to 2 d of outer surfaces of the contact wall 2c of housing 2b and both sides of the inner surface 2e, and were arranged to 2 d of outer surfaces and both sides of the inner surface 2e are connected via the electrical connection member 15. Both the coils 5 and 5 arranged to 2 d of outer surfaces and both sides of the inner surface 2e are embedded so that it may become flat-tapped with 2 d of outer surfaces of the contact wall 2c, and the inner surface 2e, respectively. Since the gap between the primary side coil 3 and the secondary coil 4 serves as only thickness of the contact wall 1c of the housing 1b and becomes short by having such composition, By being able to increase the electric

power transmited to the secondary coil 4 from the primary side coil 3, and connecting both the coils 5 and 5 arranged in addition to 2 d of outer surfaces of the contact wall 2c of housing 2b, and both sides of the inner surface 2e. Since the number of turns of a coil increases and an inductor increases, the electric power transmited to the secondary coil 4 from the primary side coil 3 can be increased further.

[0019]Next, other examples of an embodiment of the invention are shown in Fig.6. In the composition of a second example, this non-contact power transmission equipment covers the exposed part 5a of the plane coil 5 with the protection seal 6, in order to protect the plane coil 5 embedded under 2 d of the outer surfaces of the contact wall 2c of housing 2b flat-tapped. By having such composition, the disconnection or degradation of the coil of the secondary coil 4 by fall of the load apparatus 2, a fall, and attachment and detachment with the power supply system 1 can be prevented.

[0020]Next, other examples of an embodiment of the invention are shown in Fig.7. This non-contact power transmission equipment provides the magnetic part 7 to the central part of the protection seal 6 in the composition of the aforementioned example. The center of the magnetic part 7 is placed on the same straight line as the winding axis of the primary side coil 3 and the secondary coil 4. The magnetic flux B converges on the magnetic part 7 of the central part of the protection seal 6, and since the number of the magnetic flux B which crosses the secondary coil 4 increases, the transmission efficiency of the electric power transmited to the secondary coil 4 can be raised by having such composition from the primary side coil 3.

[0021]Next, other examples of an embodiment of the invention are shown in Fig.8. Other composition except arrangement of the secondary coil 4 in which this non-contact power transmission equipment is the plane coil 5 is the same as a second example, and two or more secondary coils 4 are arranged in this example at the place which intersects the magnetic flux B generated from the primary side coil 3. Thus, since the number of the magnetic flux B which intersects the secondary coil 4 by providing more than one can be increased so that the magnetic flux B which does not cross in the case of the one secondary coil 4 may intersect the aforementioned magnetic flux B in the secondary coil 4, Big electromotive force is acquired and the electric power transmited to the secondary coil 4 from the primary side coil 3 can be increased more.

[0022]

[Effect of the Invention]In the non-contact power transmission equipment which arranges a primary side coil to the power supply system side, arranges a secondary coil to the load apparatus side, and carries out power transmission by the electromagnetic induction from a primary side coil to a secondary coil if it is in the invention of the present invention according to claim 1, By forming a primary side coil or a secondary coil in a plane coil, and arranging this plane coil in the contact wall of the interconnecting part of a power supply system or load apparatus, Since the primary side coil or the secondary coil is a plane coil, the distance between all the portions of this plane coil and the other party coil becomes short. Since the number of the magnetic flux which intersects a secondary coil among the magnetic flux generated from a primary side coil can be increased, big electromotive force is acquired and the electric power transmited to a secondary coil from a primary side coil can be increased. Since the inductor of a primary side coil or a secondary coil is small and ends compared with the conventional thing when making fixed electric power profitably like conversely at the load apparatus side, the miniaturization of parts and a cost cut can be aimed at. Since it is a plane coil and space of a longitudinal direction is not taken, equipment can be miniaturized and slimmed down.

[0023]If it is in the invention of the present invention according to claim 2, the effect of the invention according to claim 1 -- in addition, either of the primary side coils or secondary coils which were formed in the plane coil by arranging on the outer surface of the contact wall of the interconnecting part of a power supply system or load apparatus, Since the gap between a primary

side coil and a secondary coil serves as only thickness of the contact wall of the interconnecting part of either a power supply system or load apparatus and becomes short, the electric power transmited to a secondary coil from a primary side coil can be increased more.

[0024]If it is in the invention of the present invention according to claim 3, the effect of the invention according to claim 1 -- in addition, either of the primary side coils or secondary coils which were formed in the plane coil to the outer surface of the contact wall of the interconnecting part of a power supply system or load apparatus, and both sides of an inner surface, [arrange and] By and the thing for which both the coils arranged to an outer surface and both sides of the inner surface are electrically connected, Since the gap between a primary side coil and a secondary coil serves as only thickness of the contact wall of the interconnecting part of either a power supply system or load apparatus and becomes short, By being able to increase the electric power transmited to a secondary coil from a primary side coil, and connecting both the coils arranged in addition to the outer surface of the contact wall of the interconnecting part of a power supply system or load apparatus, and both sides of the inner surface, Since the number of turns of a coil increases and an inductor increases, the electric power transmited to a secondary coil from a primary side coil can be increased further.

[0025]If it is in the invention of the present invention according to claim 4, It is covering the exposed part of a plane coil with the protection seal for protecting a plane coil in addition to the effect of the invention of the description to Claim 2 or either of 3, Disconnection or degradation of the coil of either the primary side coil by fall of load apparatus, a fall, and attachment and detachment with a power supply system or a secondary coil can be prevented.

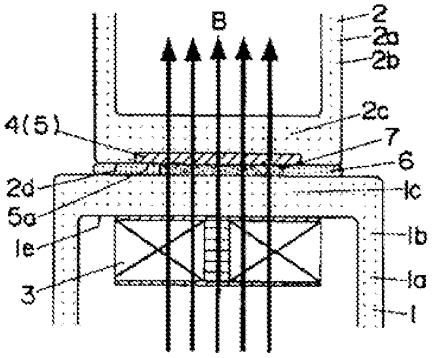
[0026]If it is in the invention of the present invention according to claim 5, the effect of the invention according to claim 4 -- in addition, magnetic flux converges on the magnetic part of the central part of a protection seal, and since the number of the magnetic flux which crosses a secondary coil increases, the transmission efficiency of the electric power transmited to a secondary coil can be raised by having provided the magnetic part to the central part of the aforementioned protection seal from a primary side coil.

[0027]If it is in the invention of the present invention according to claim 6, To the effect of the invention according to any one of claims 1 to 4, a secondary coil by in addition, the thing for which more than one were arranged at the place which intersects the magnetic flux generated from a primary side coil, Since the number of the magnetic flux which intersects a secondary coil by providing more than one can be increased so that the magnetic flux which does not cross in the case of one secondary coil may also intersect the aforementioned magnetic flux in a secondary coil, Big electromotive force is acquired and the electric power transmited to a secondary coil from a primary side coil can be increased more.

[0028]If it is in the invention of the present invention according to claim 7, it is arranging the above-mentioned plane coil by hot stamping in the contact wall of the interconnecting part of a power supply system or load apparatus, and it becomes possible to manufacture the power transmission part of non-contact power transmission equipment by low cost. By hot stamping, since a plane coil can be arranged also to the curved surface part of a housing, the flexibility of the housing form of goods increases.

[Translation done.]

Drawing selection Fig.7



[Translation done.]

PATENT ABSTRACTS OF JAPAN

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(43)Date of publication of application : 14.02.2003

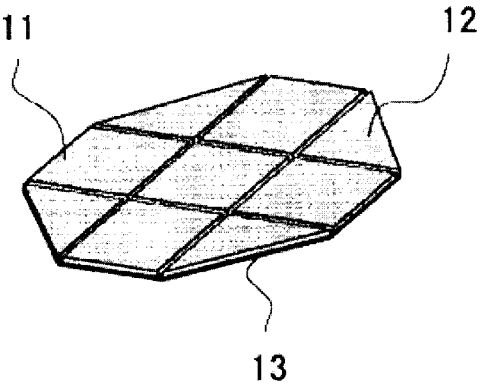
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(21)Application number : 2001-230023
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(71)Applicant : NEC TOKIN CORP
(72)Inventor : SATO TADAKUNI

(54) NON-CONTACT POWER TRANSMISSION APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a non-contact power transmission apparatus, in which a coil loading a ferrite plate is given flexibility under the condition that transmission power be increased fully and conversion efficiency be improved fully.
SOLUTION: This non-contact power transmission apparatus transmits electric power on the non-contact basis, by utilizing electromagnetic induction effect in the coils provided opposed to each other via gaps. This apparatus is also configured by loading a ferrite sheet which is formed, by providing a plurality of soft-magnetic ferrite plates to the external side of the coils which are provided opposed to each other.



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DETAIL JAPANESE LEGAL STATUS

PATENT ABSTRACTS OF JAPAN

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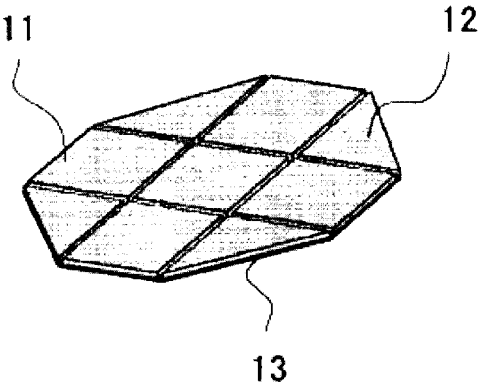
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PROBLEM TO BE SOLVED: To provide a non-contact power transmission apparatus, in which a coil loading a ferrite plate is given flexibility under the condition that transmission power be increased fully and conversion efficiency be improved fully.
SOLUTION: This non-contact power transmission apparatus transmits electric power on the non-contact basis, by utilizing electromagnetic induction effect in the coils provided opposed to each other via gaps. This apparatus is also configured by loading a ferrite sheet which is formed, by providing a plurality of soft-magnetic ferrite plates to the external side of the coils which are provided opposed to each other.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]The present invention relates to the non-contact transfer-of-power equipment which transmits electric power via space by the electromagnetic induction action produced between coils.
[0002]
[Description of the Prior Art]Conventionally, a system which transmits electric power to non-contact using an electromagnetic induction action produced between coils made to oppose via a gap is called cordless Power Station, and is disclosed in Journal of the Maganetics Society of Japan [17,485-488] of publication in the 1993 fiscal year.
If it is considered as the example of use, it is mentioned as an effective power supply means to a driving device of an artificial heart from the ability of non-contact transfer of power to be performed, for example as it discloses in Journal of the Institute of Electrical Engineers of Japan [A of publication in the 1991 fiscal year, 111-A, and 807].

[0003]Incidentally, a pair of coil is used for the transformer for artificial hearts of a perfect flush type, and slimming down is demanded of the transformer. Although the thickness is about 3 mm in the transformer using the amorphous magnetic material as a magnetic material for energy transmission of the driving device of an artificial heart, the thickness of the transformer is about 15 mm in the pot-cores type thing using a ferrite. The inventors have realized slimming down of a transformer by the transformer which used the ferrite plate.
[0004]Such cordless Power Station is applicable also to the electric power supply to portable home electronics etc., or battery charge besides the power supply means to the driving device of an artificial heart.
[0005]
[Problem to be solved by the invention]However, by the transformer formed using the amorphous magnetic material mentioned above, although slimming down is realized, at the time of transfer of power, generation of heat by a high-frequency field arises, and when it is prolonged use, with the amorphous magnetic material, it has the fault of carrying out a temperature rise by the time it produces the low temperature burns in a human body.
[0006]When using it for a human body etc., it becomes in many cases that it is more convenient to form coil shape with a certain amount of curvature. Therefore, it becomes useful practically to have a certain amount of [a magnetic body and the arranged coil] flexibility.
[0007]Good flexibility is obtained in the coil equipped with the above-mentioned amorphous magnetic material.
[0008]On the other hand, in the coil equipped with a ferrite plate, generation of heat by the ferrite section at the time of transfer of power is hardly produced, and problems, such as a burn to a living

body, do not occur. On the other hand, since a ferrite plate is hard and it is weak, there is no flexibility of the coil equipped with a ferrite plate.
[0009]It was made that the present invention should solve this problem, and the technical problem is in the state which could aim at sufficiently increase of transmission power, and improvement in conversion efficiency, and there is in giving flexibility to the coil equipped with a ferrite plate.
[0010]
[Means for solving problem]According to the present invention, in the equipment which transmits electric power to non-contact, the non-contact transfer-of-power equipment which equipped the lateral part of the aforementioned coil which counters with the ferrite sheet which lays two or more soft magnetism ferrite plates is obtained using the electromagnetic induction action in the coil which opposes via a gap.
[0011]
[Function]In the present invention, a ferrite sheet provided so that a lateral part of a plane swirl type coil which opposed might be covered with a soft magnetism ferrite chip is arranged. Therefore, non-contact transfer of power is good, there is almost no generation of heat, and a transformer section which has flexibility can be realized.

[0012]Non-contact transfer of power becomes good in a ferrite sheet part because prehension of magnetic flux and magnetic flux combination of a primary side and a secondary improve. Since the electrical resistance of a ferrite is high, generation of heat hardly arises because there is very little eddy current generation of heat by an electromagnetic induction action. By sticking a ferrite chip on a plastic sheet etc. and forming in a ferrite sheet shaped, the flexibility of a ferrite section is that a certain amount of deformation becomes possible, and is given.
[0013]
[Working example]Hereafter, it describes about an working example.
[0014](Working example 1) Fig.1 is a perspective view showing the ferrite sheet used in working example 1 of the present invention.
[0015]First, saturation magnetization used about 0.5 T (5000G) Mn-Zn system spinel ferrite sintered body by about 2500, and amplitude permeability cut this to the diagonal direction with the square-like corner guard 11 of 11 mm of side length who consists of 1 mm in thickness, and produced the isosceles triangle board 12 used as the 2 equilateral length of 10 mm each.
[0016]As a plane spiral coil, carried out 5 turn winding of what bundled 100 copper wire 100 micrometers in diameter, produced in the outer diameter of 30 mm, 15 mm in inner diameter, and thickness of 1.5 mm, these were made to oppose, and the direction where the output of a primary side (input side) generates the direction connected to a power supply in electromagnetic induction was made into the secondary (output side).
[0017]Next, give a 1-mm gap, these plane spiral coil was made to oppose, one pair of plane spiral coils were constituted, and secondary output (maximum transmission power) P_2 and the conversion efficiency eta were searched for under the frequency of 100 kHz, primary side voltage, and the conditions of 4V. However, it is eta=(output power/input power) x100 (%).
[0018](1) The composition of the electromagnetic induction part in measurement In the case only of the coil which opposes. (2) Leave about 0.5-mm gap for five sheets and 4 of the isosceles triangle boards 12 of a Mn-Zn system spinel ferrite sintered body, and stick on the polyester film 13 the square-like corner guard 11 of the Mn-Zn system spinel ferrite sintered body mentioned above, It has measured about two kinds at the time of equipping the both-outsides part of the coil which opposes with the ferrite sheet produced in the shape of a regular octagon. The result is shown in Table 1.
[0019]
[Table 1]

構成 / 特性	フェライトシートの装着	
	なし	あり
2次側出力P_2 (W)	1.4	8.3
変換効率η (%)	8	82

[0020]By equipping with a ferrite sheet shows that secondary output P_2 and the conversion efficiency eta improve remarkably.
[0021]The coil part equipped with a ferrite sheet held flexibility, and has reached easily to the curvature radius of about 50 mm.
[0022](Working example 2) Fig.2 is a perspective view showing the ferrite sheet used in working example 2 of the present invention.
[0023]First, saturation magnetization used about 0.35 T (3500G) nickel-Cu-Zn system spinel ferrite sintered body by about 800, and amplitude permeability produced the square-like corner guard 21 of 5 mm of side length who comprises 0.5 mm in thickness, and the isosceles triangle board 22 which cuts this to a diagonal direction and serves as 2 equilateral length of 4 mm each.
[0024]About 0.5-mm gap was left, these 24 square templates and eight triangle boards were stuck on the silicon rubber sheet 23, and the ferrite sheet was produced in the shape of a regular octagon.

[0025]About the effect which uses this, it measured like the working example 1. The result is shown in Table 2.
[0026]
[Table 2]

構成 / 特性	フェライトシートの装着	
	なし	あり
2次側出力P_2 (W)	1.4	7.9
変換効率η (%)	8	80

[0027]By equipping with a ferrite sheet shows that secondary output P_2 and the conversion efficiency eta improve remarkably.
[0028]The coil part equipped with a ferrite sheet held flexibility, and has reached easily to the curvature radius of about 30 mm.
[0029]
[Effect of the Invention]It comprises the present invention, as described above.
Therefore, according to the present invention, non-contact transfer-of-power equipment which gave flexibility to a coil equipped with a ferrite plate where increase of transmission power and improvement in conversion efficiency can be aimed at sufficiently can be provided.

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1]Non-contact transfer-of-power equipment characterized by equipping with a ferrite sheet which lays two or more soft magnetism ferrite plates to a lateral part of the aforementioned coil which counters in equipment which transmits electric power to non-contact using an electromagnetic induction action in a coil which opposes via a gap.

[Translation done.]

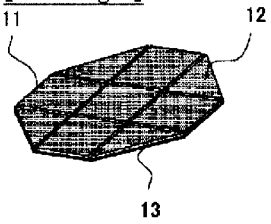
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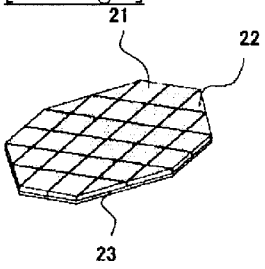
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DRAWINGS

[Drawing 1]



[Drawing 2]



[Translation done.]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION	
Inventor(s):	Partovi, Afshin		
Appln. No.:	13/352,096	Art Unit:	2859
Confirm. No.:	4453	Examiner:	Fantu, Yalkew
Filed:	January 17, 2012		
Title:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**	

REPLY TO OFFICE ACTION UNDER 37 C.F.R. §1.111

Mail Stop AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This REPLY is in response to the Office Action mailed August 18, 2014.

Amendments

Please amend the above-identified application as follows:

Amendments to the Claims begin on Page 2.

Remarks begin on Page 10.

In the Claims:

Please amend Claims 1 and 29, as shown below. Applicant respectfully reserves the right to prosecute any originally presented claims in a continuing or future application.

1. (Currently Amended) A system for use in charging or powering one or more devices or batteries by wireless power, comprising:

one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from a charger coil placed close to the receiver coil and configured to provide power thereto, and

a charger coil, provided within a charger, which transmits inductive power to a receiver coil placed close to the charger coil and configured to receive power therefrom;

a switching layer having magnetic properties and covering the one or more receiver coil or charger coil, so that, during charging or powering of a device or battery, the switching layer is layered either

between the receiver coil and a surface of the receiver, or

between the charger coil and a surface of the charger; and

wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to ~~affect passage of~~ control magnetic flux within a particular region of the switching layer, including

guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within [[a]] the particular region of the switching layer that is generally aligned both with the receiver coil and the charger coil, while

providing electromagnetic shielding in regions of the switching layer other than the particular region.

2. (Previously Presented) The system of claim 1, wherein the switching layer is provided within

one or more wireless chargers or power supplies or the electronics, coils, magnetic material, or magnets therein, or

one or more wireless power receivers or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices or batteries.

3. (Previously Presented) The system of claim 1, wherein the one or more components and the switching layer is used to provide a degree of position independence in charging or powering the one or more devices or batteries.

4. (Previously Presented) The system of claim 1, wherein the modifying the magnitude or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the switching layer so that it allows a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

5. (Previously Presented) The system of claim 1, wherein the switching layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron, carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof.

6. (Previously Presented) The system of claim 4, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the switching layer locally on or near where the receiver coil is placed.

7. (Previously Presented) The system of claim 6, wherein the saturating or altering the magnetization curve of the switching layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

8. (Previously Presented) The system of claim 7, wherein the permanent magnet or electromagnet is incorporated behind, in front, around or at the center of the receiver or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the switching layer locally on or near where the receiver coil is placed.

9. (Previously Presented) The system of claim 7, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

10. (Previously Presented) The system of claim 1, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices or batteries by wireless power.

11. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices or the batteries.

12. (Original) The system of claim 11, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof.

13. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

14. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

15. (Previously Presented) The system of claim 1, wherein the wireless power transmitted to the devices or batteries charged or powered wirelessly is transmitted at substantially the same

or similar frequencies.

16. (Previously Presented) The system of claim 1, wherein the wireless power transmitted to the devices or batteries charged or powered wirelessly is transmitted at different frequencies.

17. (Previously Presented) The system of claim 2, wherein the chargers or receivers include one or more microcontrollers or programmable parts or memory.

18. (Previously Presented) The system of claim 2, wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil or load modulation or through an RF or optical link or through one or more RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof.

19. (Previously Presented) The system of claim 2, wherein the presence of the one or more receivers is detected by the one or more chargers or power supplies or causes a change in the operating behavior or characteristics of the chargers or power supplies.

20. (Previously Presented) The system of claim 2, wherein the chargers or receivers may consist of one set of electronics or coils or several sets of similar or dissimilar electronics or coils to provide flexibility in wirelessly charging devices or batteries at different voltages, powers, current levels, geometries or functions or communication and regulation or detection protocols.

21. (Previously Presented) The system of claim 2, wherein the chargers or receivers may include shielding materials such as ferromagnetic or other magnetic materials or metal or other conductive layers, or thin metal layers covering a portion or all of the charger or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system.

22. (Original) The system of claim 2, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system.

23. (Previously Presented) The system of claim 1, wherein one or more repeater antennas or coils or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

24. (Previously Presented) The system of claim 1, wherein the system includes one or more metal layers included on the top of the receiver shield or the bottom of the charger / transmitter shield to provide further shielding from the magnetic field.

25. (Previously Presented) The system of claim 1, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system.

26. (Previously Presented) The system of claim 1, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary or rechargeable battery, solar cell, fuel cell, mechanical, nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities / functions can be added as needed.

27. (Original) The system of claim 1, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or

email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products.

28. (Previously Presented) The system of claim 1, wherein the receiver or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate.

29. (Currently Amended) A method of charging or powering one or more devices or batteries by wireless power, comprising the steps of:

providing one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from a charger coil placed close to the receiver coil and configured to provide power thereto, and

a charger coil, provided within a charger, which transmits inductive power to a receiver coil placed close to the charger coil and configured to receive power therefrom;

using a switching layer having magnetic properties and covering the one or more receiver coil or charger coil, so that, during charging or powering of a device or battery, the switching layer is layered either

between the receiver coil and a surface of the receiver, or

between the charger coil and a surface of the charger,

to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including

wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to ~~affect passage of a~~ control magnetic flux within a particular region of the switching layer, including

guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within [[a]] the particular region of the switching layer that is generally aligned both with the receiver coil and the charger coil, while

providing electromagnetic shielding in regions of the switching layer other than the particular region.

30. (Previously Presented) The method of claim 29, wherein the switching layer is provided within

one or more wireless chargers or power supplies or the electronics, coils, magnetic material, or magnets therein, or

one or more wireless power receivers or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices or batteries.

31. (Previously Presented) The method of claim 29, wherein the one or more components and the witching layer is used to provide a degree of position independence in charging or powering the one or more devices or batteries.

32. (Previously Presented) The method of claim 29, wherein the modifying the magnitude or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the switching layer so that it allows a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

33. (Previously Presented) The method of claim 32, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the switching layer locally on or near where the receiver coil is placed.

34. (Previously Presented) The method of claim 33, wherein the saturating or altering the magnetization curve of the switching layer locally is provided by saturating or modifying the

permeability of the layer through application of one or more DC or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

35. (Previously Presented) The method of claim 34, wherein the permanent magnet or electromagnet is incorporated behind, in front, around or at the center of the receiver or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the switching layer locally on or near where the receiver coil is placed.

36. (Previously Presented) The method of claim 34, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

37. (Previously Presented) The method of claim 29, further comprising using one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices or batteries by wireless power.

38-39. (Canceled).

Remarks

This REPLY is in response to the Office Action mailed August 18, 2014.

I. Request for Interview

In the event the amendments and remarks provided herein fail to place the application in condition for allowance, Applicant respectfully requests the opportunity to interview with the Examiner, at the Examiner's convenience, and prior to issuance of a subsequent Office Action, to assist in expediting prosecution.

II. Summary of Examiner's Rejections

Prior to the Office Action mailed August 18, 2014, Claims 1-37 were pending in the application. In the Office Action, Claims 1-37 were rejected on the grounds of nonstatutory obviousness-type double patenting as being unpatentable over the claims of co-pending Application No. 13/709,937. Claims 1-37 were also rejected under 35 U.S.C. 102(b) as being anticipated by Partovi et al (U.S. Publication No. 2007/0182367, hereinafter Partovi).

III. Summary of Applicant's Amendment

The present Reply amends Claims 1 and 29, leaving for the Examiner's present consideration Claims 1-37.

IV. Claim Rejections under Double Patenting

In the Office Action, Claims 1-37 were rejected on the grounds of nonstatutory obviousness-type double patenting as being unpatentable over the claims of co-pending Application No. 13/709,937.

Co-pending Application No. 13/709,937 is currently pending, and has not yet issued as a patent. Additionally, a Terminal Disclaimer has previously been filed in Application No. 13/709,937 with regard to the instant application. As such, Applicant respectfully requests that the rejection of the claims on the grounds of nonstatutory obviousness-type double patenting be held in abeyance pending issuance of a patent, at which point this rejection can be further addressed, including if necessary the filing of an appropriate Terminal Disclaimer.

V. Claim Rejections under 35 U.S.C. §102(b)

In the Office Action, Claims 1-37 were rejected under 35 U.S.C. 102(b) as being

anticipated by Partovi (U.S. Publication No. 2007/0182367).

Claim 1

Claim 1 has been amended to recite:

1. (Currently Amended) A system for use in charging or powering one or more devices or batteries by wireless power, comprising:

one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from a charger coil placed close to the receiver coil and configured to provide power thereto, and

a charger coil, provided within a charger, which transmits inductive power to a receiver coil placed close to the charger coil and configured to receive power therefrom;

a switching layer having magnetic properties and covering the one or more receiver coil or charger coil, so that, during charging or powering of a device or battery, the switching layer is layered either

between the receiver coil and a surface of the receiver, or

between the charger coil and a surface of the charger; and

wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to control magnetic flux within a particular region of the switching layer, including

guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within the particular region of the switching layer that is generally aligned both with the receiver coil and the charger coil, while

providing electromagnetic shielding in regions of the switching layer other than the particular region.

Partovi describes a portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices is disclosed herein. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of

applying an alternating current to a winding, coil, or any type of current carrying wire. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device. In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device, or to communicate information or data to and from the pad. (Abstract).

In the Office Action, it was asserted that Partovi discloses a system generally as claimed. However, Applicant respectfully submits that Partovi does not disclose a switching layer layered either between the receiver coil and a surface of the receiver, or between the charger coil and a surface of the charger; wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to affect passage of a magnetic flux within a particular region of the switching layer, including guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within a particular region of the switching layer generally aligned both with the receiver coil and the charger coil, while providing electromagnetic shielding in regions of the switching layer other than the particular region.

To more clearly recite the embodiment therein, Claim 1 has been amended to recite that, in accordance with an embodiment, the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to control magnetic flux within a particular region of the switching layer, including guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within the particular region of the switching layer that is generally aligned both with the receiver coil and the charger coil, while providing electromagnetic shielding in regions of the switching layer other than the particular region.

In view of the above remarks, Applicant respectfully submits that Claim 1, as currently amended, is neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claim 29

The remarks provided above with regard to Claim 1 are herein incorporated by reference. Claim 29 has been amended similarly to Claim 1 to more clearly recite the embodiment therein. For similar reasons as provided above, Applicant respectfully submits that Claim 29, as currently amended, is likewise neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claims 2-28 and 30-39

Claims 38 and 39 have been canceled, rendering moot the rejection of these claims. Claims 2-28 and 30-37 depend from and include all of the features of one of Claims 1 or 29. Claims 2-28 and 30-37 are not addressed separately herein. However, Applicant respectfully submits that these claims are allowable at least as depending from an allowable independent claim, and further in view of the amendments to the independent claims, and the remarks provided above. Reconsideration thereof is respectfully requested.

VI. Conclusion

In view of the above amendments and remarks, it is respectfully submitted that all of the claims now pending in the subject patent application should be allowable, and reconsideration thereof is respectfully requested. The Examiner is respectfully requested to telephone the undersigned if he can assist in any way in expediting issuance of a patent.

The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 06-1325 for any matter in connection with this response, including any fee for extension of time, which may be required.

Respectfully submitted,

Date: February 18, 2015

By: /Karl F. Kenna /
Karl F. Kenna
Reg. No. 45445

Customer No.: 23910
MEYER IP LAW GROUP
410 Pacific Avenue
San Francisco, California 94133
Telephone: (415) 362-3800
Fax: (415) 362-2928

Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna/Christopher Burnharte
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	
Filing Fees for **Utility under 35 USC 111(a)**	

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 3 months with $0 paid	1253	1	1400	1400
Miscellaneous:				
			Total in USD ($)	**1400**

Electronic Acknowledgement Receipt	
EFS ID:	21532881
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	18-FEB-2015
Filing Date:	17-JAN-2012
Time Stamp:	18:52:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1400
RAM confirmation Number	14277
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Extension of Time	afpa_1032us0_EOT.pdf	186627 900b89eaaea5a6b8842f8c8700690ffc3617f302	no	2
Warnings:					
Information:					
2		afpa_1032us0_reply_081814.pdf	108975 787a1359ac15db0f0e28340026d5c7cc75e5db91	yes	13

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	9
Applicant Arguments/Remarks Made in an Amendment	10	13

Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	31188 d11b498cfe7e9e2de29500750012b09e6cc13c22	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	326790		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/22 (03-13)
Approved for use through 3/31/2013. OMB 0651-0031
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): AFPA-01032US0

Application Number	Filed
13/352,096	1/17/2012

For: SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Art Unit	Examiner
2859	FANTU, YALKEW

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$
☐ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☑ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$ 1400
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 061325.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71. 37 CFR 3.73(b) statement is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration number 45445.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Karl Kenna/ — Signature

February 18, 2015 — Date

Karl Kenna — Typed or printed name

415-362-3800 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☐ * Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/352,096	Filing Date 01/17/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	02/18/2015	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 37	Minus	** 39	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/TRINA STEPTOE/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

23910 7590 08/18/2014

MEYER IP LAW GROUP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

EXAMINER	
FANTU, YALKEW	
ART UNIT	**PAPER NUMBER**
2859	

NOTIFICATION DATE	DELIVERY MODE
08/18/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

officeactions@meyerip.com
pctoa@meyerip.com

Office Action Summary	Application No. 13/352,096	Applicant(s) PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	Art Unit 2859	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *06/27/2014*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-37* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-37* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 06/27/2014 has been entered.

As per applicant amendments and remarks filed on 06/27/2014, claim 38-39 were previously cancelled; claims 1-9 and 29-36 are amended. Claims 1-17 are pending.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*,

686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO internet Web site contains terminal disclaimer forms which may be used. Please visit http://www.uspto.gov/forms/. The filing date of the application will determine what form should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission.

Claim 1 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the co-pending application number 13/709,937. Although the claims at issue are not identical, they are not patentably distinct from each other because they both deal with powering and charging a mobile device or battery wirelessly or in a non-conductive way.

1. The examined claim 1 of the instant application is anticipated by the co-pending application of 13/709,937.

Claim 1 of the co-pending application No. **13/709,937**	Claim 1 of the instant application **13/352,096**
1. A system for providing positioning freedom, and support of different voltages, protocols, and power levels in a	**1.** A system for use in charging or powering one or more devices or batteries by wireless power, comprising: one or

wireless power system, comprising: a base unit having one or more transmitter coils which transmit inductive power to a receiver coil placed close to the one or more transmitter coils and configured to receive power therefrom; one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more transmitter coils, so that, during charging or powering of a device or battery having the receiver coil, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more transmitter coils and the receiver coil, that modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the device or battery having the receiver coil is placed close to the base unit having the one or more transmitter coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux and allow power transfer within a particular region, generally aligned with the one or more transmitter coils and the receiver coil; and one or more components within the base unit or a mobile device for positioning freedom, and support of different voltages, protocols, and power levels including determining by the base unit, for the mobile device to be powered, a power protocol to be used and one or more voltage and power level requirements for the mobile device, and regulating, by the mobile device, power received at the receiver coil; wherein multiple mobile devices, batteries or receivers with different voltage or power level requirements can be simultaneously powered by the base unit.	more of a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom, one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, which wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including to allow power transfer in a particular region, generally aligned both with the other coil and the one or more receiver or charger coils, while providing an amount of electromagnetic shielding in regions other than the particular region.

Claim 29 of the instant application is also similar to claim 1 of the co-pending application; claims 2-28 and 30-37 are dependent on the rejected claims of 1 and 29; therefore rejected on the ground of nonstatutory double patenting.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-39 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Partovi (US 2007/0182367).

2. **With respect to claims 1, 29 and 38**, Partovi discloses a system for use in charging or powering one or more devices or batteries by wireless power **(Figs. 1-26)**, comprising: one or more of a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from a charger coil placed close to the receiver coil and configured to provide power thereto **(Fig. 2, 114 and 160; figs. 1-4 and 15)**, and a charger coil, provided within a charger, which transmits inductive power to a receiver coil placed close to the charger coil and configured to receive power therefrom **(Fig. 2, 112)**, a switching (Para. # 0037) layer having magnetic properties and covering the one or more receiver coil or charger coil, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or switching layer is layered either between the one or more receiver coil and a surface of the receiver, or between the charger coil and a surface of charger and wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil in one or multiple dimensions **(Para. # 0074)**, including wherein, when the receiver coil is placed close to

the or charger coil switching layer's magnetic properties are locally modified by one or more of a magnetic field of he receiver coil or charger coil, or by another magnetic component, to affect passage of a magnetic flux within a particular region of the switching layer, including **(Para. # 0051 and 0073)** to guiding the magnetic flux to provide localized power transfer from the charger coil to receiver coil within in a particular region of the switching layer generally aligned both with receiver coil and the charger coil, while providing electromagnetic shielding in regions of the switching layer other than the particular region **(Para. # 0040-0041)**

3. **With respect to claims 2 and 30,** Partovi discloses wherein switching layer is provided within one or more wireless chargers or power supplies and/or the electronics, coils, magnetic material, or magnets therein **(Figs. 2, 112)**, and/or one or more wireless power receivers and/or the electronics, coils, magnetic materials, or magnets therein **(Fig. 2, 114)**; and used in charging or powering the one or more devices and/or batteries **(Para. # 0050 and 0051)**.

4. **With respect to claims 3 and 31,** Partovi discloses wherein the one or more components including the switching layer is used to provide a degree of position independence in charging or powering the one or more devices and/or batteries **(Para. # 0060)**.

5. **With respect to claims 4 and 32,** Partovi discloses wherein the modifying the magnitude and/or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of and the switching layer so that it acts as a

switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area **(Para. # 0058 and 0059)**.

6. **With respect to claim 5,** Partovi discloses wherein the switching layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron), carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof **(Para. # 0013)**.

7. **With respect to claims 6 and 33,** Partovi discloses , wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed **(Fig. 10, SW 268; Para. # 0110-0117)**.

8. **With respect to claims 7 and 34,** Partovi discloses wherein the saturating or altering the magnetization curve of switching layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC and/or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof **(Para. # 0096)**.

9. **With respect to claims 8 and 35,** Partovi discloses wherein the permanent magnet and/or electromagnet is incorporated behind, in front, around or at the center of the receiver and/or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite,

or other magnetic material or layer locally on or near where the receiver coil is placed **(See Figs, 1, and 3-4)**.

10. **With respect to claims 9 and 36,** Partovi discloses, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC and/or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer **(Para. # 0013; Figs. 11 and 17)**.

11. **With respect to claims 10, 11 and 37,** Partovi discloses, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices and/or batteries by wireless power **(Para. # 0096);** the power at the devices and/or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices and/or the batteries **(Para. # 0081 and 0082)**.

12. **With respect to claim 12,** Partovi discloses, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof **(Para. # 0081; see also Fig. 11)**.

13. **With respect to claims 13 -16** Partovi discloses, wherein the power at the devices and/or batteries charged or powered by wireless power is regulated by varying

the frequency, duty cycle, and power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters **(Para. # 0070)**.

14. **With respect to claim 17** Partovi discloses, wherein the chargers and/or receivers include one or more microcontrollers or programmable parts and/or memory **(Fig. 11, 204 (MCU2); Para. # 0125)**.

15. **With respect to claim 18,** Partovi discloses wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil and/or load modulation or through an RF or optical link or through RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), etc. or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof **(Para. # 0125)**.

16. **With respect to claim 19,** Partovi discloses wherein the presence of the one or more receivers is detected by the one or more chargers and/or power supplies and/or causes a change in the operating behavior or characteristics of the chargers and/or power supplies **(Para. # 0049)**.

17. **With respect to claim 20,** Partovi discloses wherein, the chargers and/or receivers may consist of one set of electronics and/or coils or several sets of similar or dissimilar electronics and/or coils to provide flexibility in wirelessly charging devices

and/or batteries at different voltages, powers, current levels, geometries or functions and/or communication and regulation or detection protocols **(See Figs. 2-5; Para. # 0060)**.

18. **With respect to claim 21,** Partovi discloses wherein, the chargers and/or receivers may include shielding materials such as ferromagnetic or other magnetic materials and/or metal or other conductive layers, and/or thin metal layers covering a portion or all of the charger and/or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system **(Para. # 0040 and 0086)**.

19. **With respect to claims 22-24 and 39,** Partovi discloses, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system and wherein one or more repeater antennas or coils and/or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets and/or electromagnets are used to extend the range between the charger and receiver while controlling the emissions **(Para. # 0080)**.

20. **With respect to claim 25,** Partovi discloses, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, etc., airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor

storage or playback device such as hard drive, optical players, etc., cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, etc., industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system **(Para. # 0096)**.

21. **With respect to claim 26,** Partovi discloses, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary (non-rechargeable) or rechargeable battery, solar cell, fuel cell, mechanical (hand crank, wind source, etc.), nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities/functions can be added as needed **(Para. # 0014; Fig. 18, 356)**.

22. **With respect to claim 27,** Partovi discloses, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or

robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products **(Para. # 0096)**.

23. **With respect to claim 28,** Partovi discloses, wherein the receiver and/or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device etc. to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate **(Para. # 0061)**.

RESPONSE TO ARGUMENTS

24. Applicant's arguments filed on 06/27/2014 have been considered but are ineffective to overcome the reference mentioned in the office action (See rejection above).

25. Applicant generally describes or argues that Partovi "…as currently amended, is neither anticipated nor obvious in view of the cited references … " As disclosed in Partovi's reference, the newly amended limitation is also disclosed as indicated in the office action above. **Conclusion**

Any inquiry concerning this communication or earlier communications from the examiner should be directed to YALKEW FANTU whose telephone number is (571)272-8928. The examiner can normally be reached on M-F: 7 - 4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, DREW A. DUNN can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320	108,139,150	9/5/2013	YF
455	all	9/5/2013	

SEARCH NOTES		
Search Notes	Date	Examiner
320/109,139,150;455/all with text search was conducted	9/5/2013	YF
Inventor's search in PALM and eDAN was conducted	9/5/2013	YF
EAST Search (See Printout)	9/5/2013	YF
Related applications search was conducted	9/5/2013	YF
an updsated search was conducted	3/03/2014	YF
an updated search was coducted	8/9/2014	YF

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/YALKEW FANTU/ Primary Examiner.Art Unit 2859

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/05/2013	08/09/2014							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
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	31	✓	✓							
	32	✓	✓							
	33	✓	✓							
	34	✓	✓							
	35	✓	✓							
	36	✓	✓							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/05/2013	08/09/2014							
	37	✓	✓							
	38	✓	-							
	39	✓	-							

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	13/352,096	Filing Date	2012-01-17	Docket Number (if applicable)	AFPA-01032US0	Art Unit	2859
First Named Inventor	Partovi, Afshin			Examiner Name	Fantu, Yalkew		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☐ Other _____

☒ Enclosed

☒ Amendment/Reply

☒ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☒ Other
Petition for Extension of Time

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 061325

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/Karl F. Kenna/	Date (YYYY-MM-DD)	2014-06-27
Name	Karl F. Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	1251	1	200	200

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for Continued Examination	1801	1	1200	1200
		Total in USD ($)		**1400**

Electronic Acknowledgement Receipt	
EFS ID:	19435135
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	27-JUN-2014
Filing Date:	17-JAN-2012
Time Stamp:	19:01:16
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1400
RAM confirmation Number	6336
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	afpa_1032us0_IDS.pdf	615574 e6c1dc449751fc9b3fd76fbfcb075cb29cbc0196	no	6
Warnings:					
Information:					
2	Transmittal Letter	afpa_1032us0_IDS_Trans_062714.pdf	111613 183c9e24370d250bdb8433705129d43744ba3fb1	no	2
Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	afpa_1013ep0_OA.pdf	204706 8870edf98230f93667f6db23d5ac1540896f4a48	no	5
Warnings:					
Information:					
4	Other Reference-Patent/App/Search documents	afpa_1037wo0_ISR.pdf	700602 17a2205574a4280bfab9af99e1ec770fefb521ac	no	9
Warnings:					
Information:					
5	Other Reference-Patent/App/Search documents	afpa_1038wo0_ISR.pdf	1083962 925348c837136b1e64318d27dcd331034e30f291	no	11
Warnings:					
Information:					
6	Foreign Reference	WO2006001557.pdf	2051730 9dd6f714c71d865ce234606f98b8ab314825d83e	no	73
Warnings:					
Information:					
7	Foreign Reference	WO2006115368.pdf	2596077 20e3c40ad05cadfaa0c62e311076fa76ecd5e093	no	52
Warnings:					
Information:					
8	Foreign Reference	WO2012116054.pdf	6780712 7aa034e1228c80cd34779743a61a8c79467946f6	no	111

Warnings:					
Information:					
9	Extension of Time	afpa_1032us0_EOT.pdf	183174 4d522e3fbb7961204113379dad90506ed7823b99	no	2
Warnings:					
Information:					
10		afpa_1032us0_RCE_031214.pdf	120779 65adbbac3e146958cc5967a0eebbace2b0b79bb9	yes	14
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment Submitted/Entered with Filing of CPA/RCE		1	1	
	Claims		2	9	
	Applicant Arguments/Remarks Made in an Amendment		10	14	
Warnings:					
Information:					
11	Request for Continued Examination (RCE)	afpa_1032us0_RCE.pdf	699823 192854c9a854479247fa3a5df7d32a6d31e648a8	no	3
Warnings:					
Information:					
12	Fee Worksheet (SB06)	fee-info.pdf	32468 54ccd14a3bfc12bef571eacccd56782a380a643c	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	15181220		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US0

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5311973		1994-05-17	Tseng	
	2	7915858		2011-03-29	Liu	
	3	8169185		2012-05-01	Partovi	
	4	4800328		1989-01-24	Bolger	
	5	5367242		1994-11-22	Hulman	
	6	7554316		2009-06-30	Sevens	
	7	7151357		2006-12-19	Xian	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20120126745		2012-05-24	Partovi	
	2	20110222493		2011-09-15	Mangold	
	3	20120146576		2012-06-14	Partovi	
	4	20060105718		2006-05-18	Ozluturk	
	5	20110162035		2011-06-30	King	
	6	20120235636		2012-09-20	Partovi	
	7	20110193520		2011-08-11	Yamazaki	
	8	20100117596		2010-05-13	Cook	
	9	20090049554		2009-02-19	Vuong	
	10	20060106965		2006-05-18	Falcon	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	11	20070178945		2007-08-02	Cook	
	12	20050007067		2007-02-08	Baarman	
	13	20100007307		2010-01-14	Baarman	
	14	20080272889		2008-11-06	Symons	
	15	20100277121		2010-11-04	Hall	
	16	20100127660		2010-05-27	Cook	
	17	20110012556		2011-01-20	Lai	
	18	20100081473		2010-04-01	Chatterjee	
	19	20090284227		2009-11-19	Mohammadian	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	1	2006115368	WO		2006-11-02	Kang		☐
	2	2006001557	WO		2006-01-05	Jung		☐
	3	2012116054	WO		2012-08-30	Steele		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	INTERNATIONAL SEARCHING AUTHORITY AT THE U. S. PATENT AND TRADEMARK OFFICE, International Search Report and Written Opinion for PCT International Patent Application No. PCT/US2013/078534, May 13, 2014, 11 pages.	☐
	2	INTERNATIONAL SEARCHING AUTHORITY AND WRITTEN OPINION FROM THE U. S. PATENT AND TRADEMARK OFFICE, International Search Report and Written Opinion for PCT International Application No. PCT/ US2013/069270, April 4, 2014, 9 pages.	☐
	3	EUROPEAN PATENT OFFICE, Office Action for European Patent Publication Application No. EP2151037, April 9, 2014, 5 pages.	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl F. Kenna/	Date (YYYY-MM-DD)	2014-06-27
Name/Print	Karl F. Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION
Inventor(s):	Partovi, Afshin et al.	
Appl. No.:	13/352,096	Art Unit: 2859
Confirm. No.:	4453	Examiner: Fantu, Yalkew
Filed:	January 17, 2012	
Title:	SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

✓ A copy of an International Search Report and Written Opinion dated May 13, 2014 for International Patent Application No. PCT/US2013/078534.

✓ A copy of an International Search Report and Written Opinion dated April 4, 2014 for International Patent Application No. PCT/US2013/069270.

This statement should be considered because:

✓ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

___ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.

-- AND *(check at least one of the following)* --

___ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

___ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

MEYER IP LAW GROUP

Date: June 27, 2014

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

Customer No. 23910
MEYER IP LAW GROUP
410 Pacific Avenue
San Francisco, California 94133
Telephone: (415) 362-3800

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APR 07 2014
MEYER IP

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: KARL F. KENNA
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

MEYER IP
File: AFPA-01013US2
Action Item: ISR-IDS
Date Due: May 7, 2014
Critical Date: July 4, 2014
Atty Path: KFK
Docketed By: MMR
Verified By: MMR

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference: AFPA1037WO0	Date of mailing (day/month/year): 04 APR 2014
	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No.: PCT/US2013/069270	International filing date (day/month/year): 08 November 2013
Applicant: MOJO MOBILITY, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300
Facsimile No. 571-273-3201	Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2010)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference AFPA1037WO0	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2013/069270	International filing date *(day/month/year)* 08 November 2013	(Earliest) Priority Date *(day/month/year)* 13 November 2012
Applicant MOJO MOBILITY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 1

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/069270

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/00 (2014.01)
USPC - 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B60L11/18, H02J7/00, H02J7/02, H02J7/04, H02J17/00, H01M10/44 (2014.01)
USPC - 320/101, 104, 108, 109, 137

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - B60L11/1816, H02J7/025, Y02E60/12, Y02T10/7005 Y02T90/163, Y02T90/14 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2012/0235636 A1 (PARTOVI) 20 September 2012 (20.09.2012) entire document	1-5, 7-13, 15, 17, 18, 20 --- 6, 14, 16, 19
Y	WO 2012/116054 A2 (STEELE) 30 August 2012 (30.08.2012) entire document	6, 14, 16, 19
A	US 2011/0193520 A1 (YAMAZAKI et al) 11 August 2011 (11.08.2011) entire document	1-20
A	US 2010/0117596 A1 (COOK et al) 13 May 2010 (13.05.2010) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 March 2014	04 APR 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: KARL F. KENNA
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	04 APR 2014
Applicant's or agent's file reference AFPA1037WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/069270	08 November 2013	13 November 2012

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H02J 7/00 (2014.01)
USPC - 320/108

Applicant MOJO MOBILITY, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	16 March 2014	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/069270

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/069270

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	6, 14, 16, 19	YES
	Claims	1-5, 7-13, 15, 17, 18, 20	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-5, 7-13, 15, 17, 18, and 20 lack novelty under PCT Article 33(2) as being anticipated by Partovi et al. (hereinafter Partovi).

Regarding claim 1, Partovi discloses a system for enabling efficient wireless power transfer and charging of devices and/or batteries (para. [0003]), comprising: means, including a charger coil and a receiver coil (para. [0006], Fig. 1 shows a charger coil and a receiver coil), for inductively charging one or more mobile, electronic, electric, lighting, batteries, power tools, kitchen, military, medical, industrial tools or systems, robots, trains, buses, trucks and/or vehicles, or other devices (para. [0231], "The same surface can also power or charge multiple devices including lamps, kitchen appliances, laptops, keyboards, computer mice, mobile phones, power tools, batteries, etc. as needed by simple placement on or near the surface.").

Regarding claim 20, Partovi discloses a method for enabling efficient wireless power transfer and charging of devices and/or batteries (para. [0003]), comprising the steps of: providing means, including a charger coil and a receiver coil (para. [0006], Fig. 1 shows a charger coil and a receiver coil), for inductively charging one or more mobile, electronic, electric, lighting, batteries, power tools, kitchen, military, medical, industrial tools or systems, robots, trains, buses, trucks and/or vehicles, or other devices (para. [0231], "The same surface can also power or charge multiple devices including lamps, kitchen appliances, laptops, keyboards, computer mice, mobile phones, power tools, batteries, etc. as needed by simple placement on or near the surface.").

Regarding claim 2, Partovi discloses wherein the charger coil and receiver coil and magnetics axes are crossed to provide overlap of some portion of the charger and receiver coil and magnetics over a wide range of x and y axes (para. [0129], "This type of system is characterized by coils that are typically similar in size and/or spatially close together in distance (z axis) and with good lateral (x,y) overlap."), allowing for a degree of positioning tolerance (para. [0129], "This so called tightly coupled system is typically associated with high power transfer efficiencies defined here as the ratio of output power from the receiver coil to input power to transmitter coil. The methods described above for position independent operation (array of transmitter coils and moving coils), typically may use tightly coupled coils.").

Regarding claim 3, Partovi discloses wherein the electromagnetic emission from the charger is generally contained to the location where the receiver is in alignment with (Fig. 34; para. [0245], "a layer comprising magnetic or ferrite or other material is added to the charger to limit the emission from the charger into space.").

Regarding claim 4, Partovi discloses wherein the system includes one or more magnetic guiding layer(s) that extends beyond one or more of the charger coil and/or receiver coil dimensions (para. [0173], "In accordance with another embodiment, the charger/transmitter also includes magnetic flux guide layer/shield at the bottom of the charger as shown in FIGS. 20 and 21..."; Fig. 21, charger shield is shown to extend beyond the receiver coil), to provide a low reluctance path for the magnetic field and improved power transfer efficiency (para. [0170], "Choosing the appropriate magnetic layer and receiver shield/guide layer permeabilities and thicknesses is important to provide a low reluctance path for the magnetic flux to allow higher power transfer and efficiencies while achieving sufficient field shielding at other locations of the charger.").

Regarding claim 5, Partovi discloses wherein the system allows power transfer to one or more devices being charged at a variety of positions on the charger (Fig. 46(a); para. [0286], "FIG. 46(a) shows a charger which broadcasts power to a number of receivers placed anywhere on its surface.").

Regarding claim 7, Partovi discloses wherein a build-up of magnetic field between the coils at any particular location allows a change in the properties of a magnetic material to allow more efficient of power transfer from the charger to one or more receivers (para. [0170], "Significant power transfer was achieved with receiver coil at distances of several mm to 2-3 cm from the charger surface. The power transfer and efficiency increased with introduction of a 0.5 mm thick ferrite magnetic material or layer above the coil to guide and shield the flux as shown in FIG. 20.").

Regarding claim 8, Partovi discloses wherein the device is one or more of a mobile, electronic, electric, lighting, battery, power tool, kitchen, military, medical, industrial tools or other device (para. [0058], "The term device, product, or battery is used herein to include any electrical, electronic, mobile, lighting, or other product, batteries, power tools, industrial, kitchen, military or medical products...").

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/069270

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding claim 9, Partovi discloses wherein the device is one or more electric vehicle, robot, train, bus, truck, electric bicycle, motorcycle, Segway type of device and/or other electric vehicles or other moving equipment (para. [0058], "The term device, product, or battery is used herein to include...vehicles or movable machines such as robots whereby the product, part, or component is powered by electricity or an internal or external battery.").

Regarding claim 10, Partovi discloses wherein a communication between the charger and the receiver can follow one or a number of protocols, including in the case of an electric vehicle such as a wireless charging specific or automotive-specific procedures or protocols including DSRC (para. [0064], "The receiver may also include optional additional features such as including Near Field Communication, Bluetooth, WiFi, RFID or other communication and/or verification technology;" para. [0084], "As an example, FIG. 3 shows a system 130 in accordance with an embodiment, wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes.").

Regarding claim 11, Partovi discloses wherein the approach of a device including a receiver, such as a vehicle or system or robot to be charged, has been detected and verified through a communication such as RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), WPC, A4WP, DSRC, or a ping or other communication (para. [0064], "The receiver may also include optional additional features such as including Near Field Communication, Bluetooth, WiFi, RFID or other communication and/or verification technology.") is communicated from the charger to energize and power the receiver circuit (para. [0072], "the charger can periodically be turned on to be driven with a periodic pattern (a ping process) and if a receiver in proximity begins to draw power from it, the charger can detect power being drawn from it and would stay in a transmitting state.").

Regarding claim 12, Partovi discloses wherein the charger and receiver can communicate information such as one or more output voltage, current, power, device or battery status, validation ID for receiver, end of charge or various charge status information, receiver battery, device, or coil temperature, and/or user data such as information about the user, verification of ability to account and charge a customer for a charging/power service, or other data that can be used to perform system or firmware updates, diagnostics, or other tasks (para. [0064], "Additionally, the receiver may include a method for the receiver to communicate with the charger;" para. [0069], "The communicated information can be the output voltage, current, power, device or battery status, validation ID for receiver, end of charge or various charge status information, receiver battery, device, or coil temperature, and/or user data such as music, email, voice, photos or video, or other form of digital or analog data used in a device.").

Regarding claim 13, Partovi discloses wherein initiation of wireless charging can be signaled to the device, such as a vehicle, to provide visual and/or auditory signal to the user, disable the device or vehicle movement during charge, or other actions (para. [0076], "In addition, MCU1 is responsible for processes such as periodic start of the charger to seek a receiver at the start of charge...providing audio or visual indications to the user on the status of charging or power process, etc.").

Regarding claim 15, Partovi discloses wherein the charger, receiver or the device or vehicle connected to the receiver communicates with the owner or a designated person by text, email, telephone message, custom application or other means of communication about the state of charging of the device or vehicle, error conditions or other important information (para. [0076], "For example, the charger can be built into a car, and when a valid receiver and/or an NFC, RFID or other ID mechanism integrated into or on a mobile device, its case or skin, dongle or battery is found, the charger may activate some other functions such as Bluetooth connectivity to the device, displaying the device identity or its status or state of charge on a display, etc.").

Regarding claim 17, Partovi discloses wherein a communication such as RFID or NFC, Bluetooth, or other wireless detection between the charger and receiver can be used to indicate approach of a valid device (para. [0064], "The receiver may also include optional additional features such as including Near Field Communication, Bluetooth, WiFi, RFID or other communication and/or verification technology;" para. [0072], "the charger can periodically be turned on to be driven with a periodic pattern (a ping process) and if a receiver in proximity begins to draw power from it, the charger can detect power being drawn from it and would stay in a transmitting state.") such as a vehicle (para. [0224], "In yet another embodiment to allow for charging an automobile or other vehicle or movable system such as a robot, etc., the coil on the stationary part (the road or the floor) or alternately the moving part (car, robot, etc.), can be made to be much longer and/or wider than the other coil to avoid the need for precise alignment. For example a charger coil on a floor or road can be in a rectangular or oval shape while the receiver coil in a car is circular and placed at any location at the bottom center line of the car. In this way, the driver does not have to precisely align the coils in the front and back direction to use the charger. Similarly, different cars with the receiver coils placed at different locations in the car can use the same charger.").

Regarding claim 18, Partovi discloses wherein once a rough or approximate alignment is reached a wireless communication link between the charger and receiver and the battery and its charging system can be established and diagnostic tests, verification or other actions performed (para. [0283], "It may be therefore advantageous to subdivide a large area charger into smaller sections and by detecting the receiver's placement on this section through in coil or separate coil communication, RF, mechanical, optical, magnetic or weight detection, etc. and only activate the section where a receiver is placed to enable higher efficiencies or output powers. Of course this can be combined with verification, etc. to provide further security and safety in these conditions.").

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/069270

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Claims 6, 14, 16, and 19 lack an inventive step under PCT Article 33(3) as being obvious over Partovi in view of Steele.

Regarding claim 6, Partovi teaches a system enabling power transfer to a device (para. [0003]). Partovi also teaches that the system includes the use of one or more charger coils along a length upon which the device to power powered or charged moves (para. [0224], "In yet another embodiment to allow for charging an automobile or other vehicle or movable system such as a robot, etc., the coil on the stationary part (the road or the floor) or alternately the moving part (car, robot, etc.), can be made to be much longer and/or wider than the other coil to avoid the need for precise alignment. For example a charger coil on a floor or road can be in a rectangular or oval shape while the receiver coil in a car is circular and placed at any location at the bottom center line of the car. In this way, the driver does not have to precisely align the coils in the front and back direction to use the charger. Similarly, different cars with the receiver coils placed at different locations in the car can use the same charger.").

Partovi does not explicitly teach that the system enables power transfer to and/or charging of a moving device.

Steele, also in the field of wireless charging (para. [0002]), teaches a system enabling power transfer to and/or charging of a moving device (para. [0063], "Figure 1 depicts a means for seamlessly charging batteries of all-electric or plug-in hybrid electric vehicles under a variety of conditions, both statically while a vehicle is parked or otherwise stationary and dynamically while a vehicle is in motion"), including use of one or more charger coils along a length upon which the device to power powered or charged moves (para. [0081], "As seen in Figure 2, a typical WAVES 10 system for roadway 36 is composed of continuous chains of PTMs 14 forming PTM lanes 40, with each PTM 14 containing many individual PTM coils and their associated PTM-CES units 34.").

At the time of the invention, it would have been obvious to one skilled in the art to allow the system and device taught by Partovi to charge the device while the device is in motion, as taught by Steele as a move towards near-and long term elimination of battery technology limitations regarding range, charging time and associated lifetime cost and real-time performance trades (Steele, para. [0061]).

Regarding claim 14, Partovi does not teach wherein initiation of wireless charging of the device, such as a vehicle can include billing/tolling of the electricity used during charging in public locations such as public or office parking, hotel, restaurant, roadway or other structures.

Steele teaches wherein initiation of wireless charging of the device, such as a vehicle can include billing/tolling of the electricity used during charging in public locations such as public or office parking, hotel, restaurant, roadway or other structures (para. [0066], "In either stationary or mobile mode, the driver can be automatically charged for energy use (and tolls as they may apply), such as in a manner directly analogous to the current EZ Pass system where a credit card account is periodically charged for usage fees.").

At the time of the invention, it would have been obvious to one skilled in the art to apply the billing capabilities taught by Steele to the invention taught by Partovi to provide a return on the long term investment infrastructure required to put the system in place on a given highway as well as shorter term maintenance costs (Steele, para. [0099]).

Regarding claim 16, Partovi does not teach wherein the charger and/or the receiver or the vehicle can also be programmed to contact utility service providers and optimize the charge commencement and/or termination time or charge rate for optimum network load, minimum electricity cost or other desirable performance attributes.

Steel teaches wherein the charger and/or the receiver or the vehicle can also be programmed to contact utility service providers and optimize the charge commencement and/or termination time or charge rate for optimum network load, minimum electricity cost or other desirable performance attributes (para. [0098], "Grid energy has a cost that varies with the type and location of power sources which in turn can vary throughout the day and days of the week. The instantaneous cost of energy to the driver can and should be adjusted both to provide fair price to the grid but also as a way to provide adaptive choices that drivers can use to minimize their driving expenses while at the same time providing the power grid with greater capacity margins. Thus at peak driving times such as early morning, noontime and early evening, the cost per kilowatt-hour passed to the driver may be substantially greater than at other times of the day. The driver may in turn choose other commute times or avoid engagement the PRM during these times;" see also paras. [0099]-[00100]).

At the time of the invention, it would have been obvious to one skilled in the art to allow the system taught by Partovi to contact the utility service providers to contact utility service providers and optimize the charge commencement and/or termination time or charge rate for optimum network load, minimum electricity cost or other desirable performance attributes as taught by Steele to reduce the probability of having to increase existing capacity or of over-stressing existing power generation and distribution equipments (Steele, para. [0098]).

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/069270

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding claim 19, Partovi does not teach wherein a proximity sensor such as a capacitive, resistive, laser or diode or rangefinder, optical, thermal, photocell, radar, sonar, ultrasonic, weight or cameras or infrared sensors or other method of detection can be used to determine the presence of a live animal or person in a region of high magnetic field close to the charger or between the charger and receiver coils and take appropriate action.

Steele teaches a proximity sensor such as a capacitive, resistive, laser or diode or rangefinder, optical, thermal, photocell, radar, sonar, ultrasonic, weight or cameras or infrared sensors or other method of detection can be used to determine the presence of a live animal or person in a region of high magnetic field close to the charger or between the charger and receiver coils and take appropriate action (para. [00135], "In either MPIU 96 or 60Hz configurations, a ground fault circuit interrupter can be utilized that provides immediate power shutdown and safety protection in the circumstance that an environmental breech has occurred either along/within the power distribution cable or PTM-CES 34.").

At the time of the invention, it would have been obvious to one of ordinary skill to include the ground fault circuit interrupter taught by Steele with the invention of Partovi to provide safety protection (Steele, para. [00135]).

Claims 1-20 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

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PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: Karl F. Kenna
410 Pacific Avenue
San Francisco, California 94133
United States of America

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference AFPA1038WO0 ✓	Date of mailing *(day/month/year)* 13 MAY 2014 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US13/78534 ✓	International filing date *(day/month/year)* 31 December 2013 (31.12.2013) ✓
Applicant MOJO MOBILITY, INC. ✓	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2010)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
AFPA1038WO0		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US13/78534	31 December 2013 (31.12.2013)	04 January 2013 (04.01.2013)
Applicant MOJO MOBILITY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

   ☐ the text is approved as submitted by the applicant.

   ☒ the text has been established by this Authority to read as follows:

CHARGING MULTIPLE RECEIVERS WIRELESSLY WITH POWER TRANSMITTER

5. With regard to the **abstract**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

   a. the figure of the **drawings** to be published with the abstract is Figure No. 1

   ☒ as suggested by the applicant.

   ☐ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US13/78534

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/04, 17/00; H05B 6/36 (2014.01)
USPC - 320/106, 108; 335/285
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): H02J 7/04, 17/00; H05B 6/36 (2014.01)
USPC: 320/106, 108; 335/285

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); Google; Google Scholar; ProQuest; KEYWORDS: inductive charge portable mobile device coil degrees of freedom movable communicate identify sensor voltage magnet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2012/0126745 A1 (PARTOVI, A. et al.) May 24, 2012; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0148, 0178-0179].	1-4, 6-16, 18-21, 23-33 --- 5, 17, 22, 34
Y	US 2011/0222493 A1 (MANGOLD, S. et al.) September 15, 2011; figure 4; paragraphs [0057-0059].	5, 22
Y	US 5,311,973 A (TSENG, D. et al.) May 17, 1994; abstract; column 1, lines 45-65.	17, 34
A	US 2012/0146576 A1 (PARTOVI, A.) June 14, 2012; entire document.	1-34

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2014 (16.04.2014)	13 MAY 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: Karl F. Kenna
410 Pacific Avenue
San Francisco, California 94133
United States of America

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	13 MAY 2014
Applicant's or agent's file reference AFPA1038WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US13/78534	31 December 2013 (31.12.2013)	04 January 2013 (04.01.2013)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H02J 7/04, 17/00; H05B 6/36 (2014.01)
USPC - 320/106, 108; 335/285

Applicant MOJO MOBILITY, INC.

1. This opinion contains indications relating to the following items:

- [X] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [X] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [X] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1 *bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	16 April 2014 (16.04.2014)	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US13/78534

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US13/78534

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	5, 17, 22, 34	YES
	Claims	1-4, 6-16, 18-21, 23-33	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-34	NO
Industrial applicability (IA)	Claims	1-34	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 1-4, 6-16, 18-21 and 23-33 lack novelty under PCT Article 33(2) as being anticipated by US 2012/0126745 A1 to PARTOVI, A. et al. (hereinafter 'Partovi').

As per claim 1, Partovi discloses a system for powering or charging multiple receivers wirelessly with a power transmitter (power source, charging system, and inductive receiver for mobile devices [system]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]) comprising: a base unit having one or more transmitter coils (pad 100 (base unit) comprises multiple coils or sets of wires 104 [base unit]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]); and one or more components within the base unit and/or a mobile device to be charged by the base unit, including a degree of positioning freedom (the coils are mounted such that they can move laterally within the pad, such that the pad senses the position of a secondary coil (component within base unit or mobile device) and moves the coils to the right position to optimize power transfer [degree of freedom]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), and support for different voltages, wireless power protocols, and/or power levels, for powering or charging multiple receivers wirelessly (receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile devices [support for different voltages], and may support multiple mobile devices; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 2, Partovi discloses the system of claim 1. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger include a coil and/or magnetic material and/or structure system that allows position free multi-charging, including one or more magnetic resonance or loosely coupled systems, flux guide structures, Magnetic Coupling, Magnetic Aperture coil and/or other coil and/or magnetic material and structures (the coils are mounted such that they can move laterally within the pad, such that the pad senses the position of a secondary coil (component within base unit or mobile device) and moves the coils to the right position to optimize power transfer [coil for position free multi-charging]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 3, Partovi discloses the system of claim 1. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger include a receiver having an output regulator stage with a large acceptable operating input voltage range (regulator can be placed between the output of the receiver and the battery, where regulator can sense the appropriate parameters of the battery (voltage, current, capacity), and regulate the current drawn from the receiver appropriately and set the voltage and current to the appropriate levels required by the mobile device [output regulator stage]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 4, Partovi discloses the system of claim 1. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger operate a communication method that allows multiple receivers to communicate with a single charger and avoid message collision (receiver may in some instances contain a means of synchronizing communication of information and data from the mobile device to the pad, where unique RFID tags, including those using Felicia or NFC protocols, are used to communicate charging information between devices and pad [communication method]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 6, Partovi discloses the system of claim 1. Partovi further discloses wherein the system uses a control algorithm for power transfer to the multiple receivers, which attempts to keep all of the receivers operating simultaneously such that the range of each particular receiver's voltage at its output stage regulator input is within the acceptable operating range for that particular receiver (Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior to the regulator, where Zener can be chosen to have an appropriate value (5 V) and clamp the voltage at this value at the input to the battery charger unit while the coils are centered or mis-aligned, such that once the battery charger starts operation after detection of the appropriate voltage at the input, the battery charger circuitry would pull the voltage at this point to the pre-programmed voltage or voltage of the battery [control algorithm]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0148, 0178-0179]).

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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/US13/78534

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

Claims 10, 13, 27, and 30 are objected to under PCT Rule 66.2(a)(iii) as containing the following defect in the form or contents thereof:

Claims 10 and 27 contain a typographical error in the phrase "the WPT" in line 3 of each claim. For the purposes of this opinion, the phrase "the WPT" shall be interpreted to read "a wireless power system" in accordance with the specification of the instant application and PCT Rules regarding claim clarity and proper antecedent basis.

Claims 13 and 30 contain a typographical error in the phrases "the charger coil area" and "the charger magnetic area" in line 2 of each claim. For the purposes of this opinion, the phrases "the charger coil area" and "the charger magnetic area" shall be interpreted to read "a charger coil area" and "a charger magnetic area" in accordance with PCT Rules regarding proper antecedent basis.

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
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-***-Continued from Box V: Citations and Explanations-***-

As per claim 7, Partovi discloses the system of claim 1. Partovi further discloses wherein the system includes components for use in powering the multiple receivers from the same charger, including support for one or more of the following features: standby and initial set up/ping or identification of receivers; changes to number of receivers due to introduction or removal of a receiver during operation; handling of changes to power requirement of one or more receivers due to movement of the receiver in an X, Y, or Z direction or change in their load; end of charge at one or more receivers; foreign object or metal detection; and/or over temperature and/or other fault handling in the system (unique RFID tags are used to communicate charging information between devices and pad, including device identification information [ID of receivers]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 8, Partovi discloses the system of claim 1. Partovi further discloses wherein the system includes a combination of physical power layer (PPL) (pad 100 comprises multiple coils or sets of wires 104 for charging a plurality of receivers within the base unit and external to it [PPL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), physical communication and control layer (PCCL) (printed circuit board used as hardware for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [PCCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), command and control layer (CCL) (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [CCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]), and user application layer (UAL) components, for use in powering or charging the multiple receivers wirelessly (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of a mobile device to determine position of the device and arrange coils 104 of the pad 100 accordingly [UAL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

As per claim 9, Partovi discloses the system of claim 8. Partovi further discloses wherein the PPL comprises the mobile device, coil, magnetic and other hardware components, systems and specifications in the base unit transmitter, or chargers and receivers that allow power to be transmitted from one or more transmitters to one or more receivers (pad 100 comprises multiple coils or sets of wires 104 for inductively charging a plurality of receivers within the base unit or external to it [chargers and receivers]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 10, Partovi discloses the system of claim 8. Partovi further discloses wherein the PCCL comprises components, hardware, systems and specifications that allow device identification, communication and control of a wireless power system, and components used to detect and interrupt power flow, such as interlock switches, temperature or magnetic field detectors, and charging flags (printed circuit board used as hardware for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [PCCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 11, Partovi discloses the system of claim 8. Partovi further discloses wherein the CCL comprises a firmware and/or software and associated protocols and specifications in transmitters and/or chargers and receivers that control the charger and receiver operations and allow detection and/or identification of the receivers, control of power transmission, power regulation, end of charge actions and/or handling of any extraordinary or fault conditions (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [CCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

As per claim 12, Partovi discloses the system of claim 8. Partovi further discloses wherein the UAL comprises physical, software and hardware connections, communications, control, protocols and specifications for connectivity and display or execution of additional functionality between transmitters or chargers and/or receivers and devices, systems, environments or vehicles where they are integrated or attached to (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of a mobile device to determine position of the device and arrange coils 104 of the pad 100 accordingly [UAL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

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As per claim 13, Partovi discloses the system of claim 1. Partovi further discloses wherein the base unit uses a saturable magnetic layer placed above a charger coil area to shield a charger magnetic layer from the surrounding area for use with a Magnetic Aperture (MA) or Magnetic Coupling (MC) receiver (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to each of the coils 104 in the pad 100 (collectively saturable magnetic layer), where a matching magnet at the center of the receiver coil attracts the nearby primary magnet in the pad 100 and centers it automatically with respect to the secondary (MC) receiver magnet [saturable magnetic layer, MC]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 14, Partovi discloses the system of claim 1. Partovi further discloses wherein the base unit uses a magnetic layer that extends beyond the physical dimensions of the base unit coil or coils on the side opposing the receiver or receivers and provides a flux return path to allow better guiding of the electromagnetic power flux and some degree of positioning freedom and efficient power transfer to one or more receivers (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to the bottom center (beyond physical dimensions of base unit coils) each coil in the pad, where a matching magnet at the center of the receiver coil attracts the primary magnet nearby and centers it (positioning freedom) automatically with respect to the secondary (allowing guiding of EM flux) [magnetic layer beyond coil dimensions]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 15, Partovi discloses the system of claim 1. Partovi further discloses wherein the receiver or receivers use magnetic layer(s) that extends beyond the physical dimensions of the receiver coil or coils on the side opposing the base unit and provide a flux return path to allow some degree of positioning freedom and efficient power transfer from the base unit to one or more receivers (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to the bottom center (beyond physical dimensions of base unit coils) each coil in the pad, where a matching magnet at the center of the receiver coil attracts the primary magnet nearby and centers it (positioning freedom) automatically with respect to the secondary (efficient power transfer) [magnetic layer beyond coil dimensions]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 16, Partovi discloses the system of claim 1. Partovi further discloses wherein the base unit is provided within an automobile, train, bus or other vehicle, for use in charging or powering one or more mobile devices each having receivers, within the vehicle (an after market inductive or wire free charger for a car where the inductive or wire free charger or pad including a solar cell on the pad or in another area and connected to the pad by wires is used to charge mobile devices [automobile]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 18, Partovi discloses a method for powering or charging multiple receivers wirelessly with a power transmitter (power source, charging system, and inductive receiver for mobile devices [system]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]) comprising: providing a system including a base unit having one or more transmitter coils (pad 100 (base unit) comprises multiple coils or sets of wires 104 [base unit]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]); and providing one or more components within the base unit and/or a mobile device to be charged by the base unit, including a degree of positioning freedom (the coils are mounted such that they can move laterally within the pad, such that the pad senses the position of a secondary coil (component within base unit or mobile device) and moves the coils to the right position to optimize power transfer [degree of freedom]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), and support for different voltages, wireless power protocols, and/or power levels, for powering or charging multiple receivers wirelessly (receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile devices [support for different voltages]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 19, Partovi discloses the method of claim 18. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger include a coil and appropriate magnetic material and structure system that allows position free multi-charging, including one or more magnetic resonance or loosely coupled systems, flux guide structures, Magnetic Coupling, Magnetic Aperture coil and/or other magnetic material and structures (the coils are mounted such that they can move laterally within the pad, such that the pad senses the position of a secondary coil (component within base unit or mobile device) and moves the coils to the right position to optimize power transfer [coil for position free multi-charging]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 20, Partovi discloses the method of claim 18. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger includes a receiver having an output regulator stage with a large acceptable operating input voltage range (regulator can be placed between the output of the receiver and the battery, where regulator can sense the appropriate parameters of the battery (voltage, current, capacity), and regulate the current drawn from the receiver appropriately and set the voltage and current to the appropriate levels required by the mobile device [output regulator stage]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 21, Partovi discloses the method of claim 18. Partovi further discloses wherein the components for use in powering the multiple receivers from the same charger operate a communication method that allows multiple receivers to communicate with a single charger and avoid message collision (receiver may in some instances contain a means of synchronizing communication of information and data from the mobile device to the pad, where unique RFID tags, including those using Felicia or NFC protocols, are used to communicate charging information between devices and pad [communication method]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

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As per claim 23, Partovi discloses the method of claim 18. Partovi further discloses wherein the system uses a control algorithm for power transfer to the multiple receivers, which attempts to keep all of the receivers operating simultaneously such that the range of each particular receiver's voltage at its output stage regulator input is within the acceptable operating range for that particular receiver (Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior to the regulator, where Zener can be chosen to have an appropriate value (5 V) and clamp the voltage at this value at the input to the battery charger unit while the coils are centered or mis-aligned, such that once the battery charger starts operation after detection of the appropriate voltage at the input, the battery charger circuitry would pull the voltage at this point to the pre-programmed voltage or voltage of the battery [control algorithm]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0148, 0178-0179]).

As per claim 24, Partovi discloses the method of claim 18. Partovi further discloses wherein the system includes components for use in powering the multiple receivers from the same charger, including support for one or more of the following features: standby and initial set up I ping or identification of receivers; changes to number of receivers due to introduction or removal of a receiver during operation; handling of changes to power requirement of one or more receivers due to movement of the receiver in an X, Y, or Z direction or change in their load; end of charge at one or more receivers; foreign object or metal detection; and/or over temperature and/or other fault handling in the system (unique RFID tags are used to communicate charging information between devices and pad, including device identification information [ID of receivers]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 25, Partovi discloses the method of claim 18. Partovi further discloses wherein the system includes a combination of physical power layer (PPL) (pad 100 comprises multiple coils or sets of wires 104 for charging a plurality of receivers within the base unit and external to it [PPL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), physical communication and control layer (PCCL) (printed circuit board used as hardware for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [PCCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]), command and control layer (CCL) (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [CCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]), and user application layer (UAL) components, for use in powering or charging the multiple receivers wirelessly (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of a mobile device to determine position of the device and arrange coils 104 of the pad 100 accordingly [UAL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

As per claim 26, Partovi discloses the method of claim 25. Partovi further discloses wherein the PPL comprises the mobile device, coil, magnetic and other hardware components, systems and specifications in the base unit transmitter, or chargers and receivers that allow power to be transmitted from one or more transmitters to one or more receivers (pad 100 comprises multiple coils or sets of wires 104 for inductively charging a plurality of receivers within the base unit or external to it [chargers and receivers]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 27, Partovi discloses the method of claim 25. Partovi further discloses wherein the PCCL comprises components, hardware, systems and specifications that allow device identification, communication and control of of a wireless power system, and components used to detect and interrupt power flow, such as interlock switches, temperature or magnetic field detectors, and charging flags (printed circuit board used as hardware for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [PCCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

As per claim 28, Partovi discloses the method of claim 25. Partovi further discloses wherein the CCL comprises a firmware and/or software and associated protocols and specifications in transmitters and/or chargers and receivers that control the charger and receiver operations and allow detection and/or identification of the receivers, control of power transmission, power regulation, end of charge actions and/or handling of any extraordinary or fault conditions (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of circuit and antenna in the device to be charged, such that the information on the tag can be detected to identify the voltage in the device to be charged required and to authenticate the circuit to be genuine or under license [CCL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

As per claim 29, Partovi discloses the method of claim 25. Partovi further discloses wherein the UAL comprises physical, software and hardware connections, communications, control, protocols and specifications for connectivity and display or execution of additional functionality between transmitters or chargers and/or receivers and devices, systems, environments or vehicles where they are integrated or attached to (software code instructions stored on a storage medium executed by printed circuit board, where software instructions include a process for RFID communication between mobile device and charger device, where RFID reader 280 can detect an RFID tag of a mobile device to determine position of the device and arrange coils 104 of the pad 100 accordingly [UAL]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147, 0178-0179]).

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As per claim 30, Partovi discloses the method of claim 25. Partovi further discloses wherein the base unit uses a saturable magnetic layer placed above a charger coil area to shield a charger magnetic layer from the surrounding area for use with a Magnetic Aperture (MA) or Magnetic Coupling (MC) receiver (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to each of the coils 104 in the pad 100 (collectively saturable magnetic layer), where a matching magnet at the center of the receiver coil attracts the nearby primary magnet in the pad 100 and centers it automatically with respect to the secondary (MC) receiver magnet [saturable magnetic layer, MC]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 31, Partovi discloses the method of claim 18. Partovi further discloses wherein the base unit uses a magnetic layer that extends beyond the physical dimensions of the base unit coil or coils on the side opposing the receiver or receivers and provides a flux return path to allow better guiding of the electromagnetic power flux and some degree of positioning freedom and efficient power transfer to one or more receivers (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to the bottom center (beyond physical dimensions of base unit coils) each coil in the pad, where a matching magnet at the center of the receiver coil attracts the primary magnet nearby and centers it (positioning freedom) automatically with respect to the secondary (allowing guiding of EM flux) [magnetic layer beyond coil dimensions]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 32, Partovi discloses the method of claim 18. Partovi further discloses wherein the receiver or receivers use magnetic layer(s) that extends beyond the physical dimensions of the receiver coil or coils on the side opposing the base unit and provide a flux return path to allow some degree of positioning freedom and efficient power transfer from the base unit to one or more receivers (coils 104 of pad 100 are arranged in an overlapping layered manner, where a magnet is attached to the bottom center (beyond physical dimensions of base unit coils) each coil in the pad, where a matching magnet at the center of the receiver coil attracts the primary magnet nearby and centers it (positioning freedom) automatically with respect to the secondary (efficient power transfer) [magnetic layer beyond coil dimensions]; figures 1, 6, 10-11, 14-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0135-0147]).

As per claim 33, Partovi discloses the method of claim 18. Partovi further discloses wherein the base unit is provided within an automobile, train, bus or other vehicle, for use in charging or powering one or more mobile devices each having receivers, within the vehicle (an after market inductive or wire free charger for a car where the inductive or wire free charger or pad including a solar cell on the pad or in another area and connected to the pad by wires is used to charge mobile devices [automobile]; figures 1, 6, 10-11, and 16-17; paragraphs [0013-0014, 0037-0056, 0068-0082, 0124-0131, 0137-0147]).

Claims 5 and 22 lack an inventive step under PCT Article 33(3) as being obvious over Partovi in view of US 2011/0222493 A1 to MANGOLD, S. et al. (hereinafter 'Mangold').

As per claims 5 and 22, Partovi discloses the system and method of claims 4 and 21, respectively. However, Partovi fails to disclose wherein, to avoid message collisions, each receiver is configured to send messages at time intervals which are random or different from other receivers, such that if a collision occurs with a particular message, the charger can ignore that particular message, or reset the communication. However, Mangold discloses wherein, to avoid message collisions, each receiver is configured to send messages at time intervals which are random or different from other receivers, such that if a collision occurs with a particular message, the charger can ignore that particular message, or reset the communication (time division multiplexing (differing time intervals) can still include data collisions, where, in the event of a collision, traditional collision recovery can be used including sending resend (reset communication) requests [sending message at time intervals]; figure 4; paragraphs [0057-0059]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the system and method of Partovi to include wherein, to avoid message collisions, each receiver is configured to send messages at time intervals which are random or different from other receivers, such that if a collision occurs with a particular message, the charger can ignore that particular message, or reset the communication, as taught by Mangold, because it is advantageous to utilize a time randomization communication involving time dividing messages, ignoring collision messages, and resending the given communication in the event of collision, such as the time division multiplexed method of Mangold, for the purpose or mitigating the occurrence of message collision while still successfully completing message transmission even in the event of a collision (see Mangold, paragraph [0059]).

Claims 17 and 34 lack an inventive step under PCT Article 33(3) as being obvious over Partovi in view of US 5,311,973 A to TSENG, D. et al. (hereinafter 'Tseng').

As per claims 17 and 34, Partovi discloses the system and method of claims 1 and 18, respectively. However, Partovi fails to disclose wherein the receiver is incorporated within or otherwise coupled to an electric train, bus, automobile or other vehicle, and the base unit is used to charge the electric train, bus, automobile or other vehicle. However, Tseng discloses wherein the receiver is incorporated within or otherwise coupled to an electric train, bus, automobile or other vehicle, and the base unit is used to charge the electric train, bus, automobile or other vehicle (battery of an electric vehicle is inductively charged while the electrical vehicle is moving, using a magnetic field along different portions of an extended linear distance and an inductive coil mounted on an electric vehicle [base unit charging automobile]; abstract; column 1, lines 45-65). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the system and method of Partovi to include wherein the receiver is incorporated within or otherwise coupled to an electric train, bus, automobile or other vehicle, and the base unit is used to charge the electric train, bus, automobile or other vehicle, as taught by Tseng, because it is well known in the relevant art to utilize a inductive car battery charging device, such as the inductive car charger of Tseng, for the purpose of utilizing inductive electric energy that may be generated by the movement of the vehicle itself (see Tseng, column 1, lines 45-65).

Claims 1-34 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

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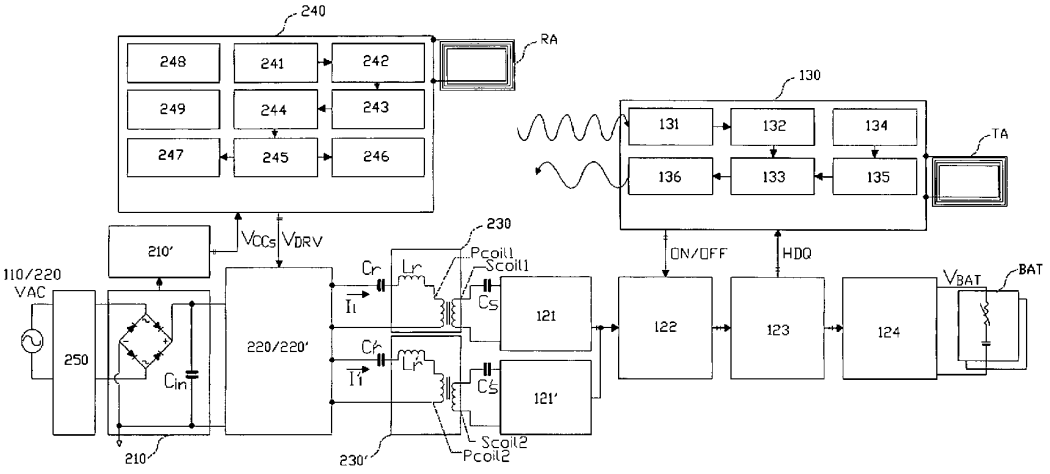
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(54) Title: WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY



(57) Abstract: The present invention relates to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad. Thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

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DESCRIPTION

WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY

Technical Field

The present invention relates, in general, to a wireless charging pad and a battery pack to which a radio frequency identification technology is applied and, more particularly, to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Background Art

Recently, with the development of communication and information processing technologies, the use of portable devices that are convenient to carry, such as a mobile phone, is increasing, and with the development of technologies, new model terminals having improved efficiency are continuously popularized. To charge such portable devices, a contact type charging method is used,

or a non-contact type charging method in which a battery is charged using magnetic coupling without electrical contact is used so as to overcome the problem of the contact type charging method that is attributable to the exposure of contact terminals to an outside.

As for technology corresponding to a non-contact charger, a method of charging a battery through wireless communication between a battery pack and a charging device using magnetic cores is disclosed in Korean Unexamined Pat. Pub. No. 2002-0035242 entitled "Non-contact Charging Device for Battery of Portable Device using Inductive Coupling," and a method of solving a problem of a magnetic core using a transformer formed in such a way that coils are wound on a Printed Circuit Board (PCB) is disclosed in Korean Unexamined Pat. Pub. No. 2002-0057469 entitled "Thin PCB Transformer without Core and Non-contact Battery Charger using PCB Transformer."

The present applicant proposed the technology in which a wireless charging pad for functioning as a wireless charger was constructed and the battery pack of a portable device was charged in a non-contact manner by placing the battery pack on the wireless charging pad through "Non-contact Battery Charging System capable of Multi-Charging and Method of Designing Core Block" (Korean Pat. application No. 2004-21335).

However, in the prior art, the wireless charging pad

could not detect the charged status of the battery pack in real time and a means for detecting devices placed on the wireless charging pad was not implemented, so that a problem arises in that the prior art is difficult to cope with the case where a plurality of battery packs, or an object that cannot be charged, is placed on a wireless charging pad.

Description of Drawings

FIG. 1 is a view showing the construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention;

FIG. 2 is a view showing the entire construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIGS. 3 to 5 are views illustrating the components of the wireless charging pad or battery pack, according to the present invention;

FIG. 6 is a view showing a method of generating a magnetic field based on the switching patterns of the wireless charging pad, according to the present invention;

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention;

FIG. 8 is a view showing the detailed construction of

the non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIG. 9 is a flowchart showing a method of charging a battery using the wireless charging pad of FIG. 8;

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters, respectively, provided to the wireless charging pad of the present invention;

FIGS. 12 to 17 are views showing the operation of a half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIG. 18 is a view showing the voltage and current waveforms of a transformer according to the gate signal of the half-bridge series resonant converter provided to the wireless charging pad of the present invention;

FIG. 19 is a view showing the rotating directions of a magnetic field according to the operation of the half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIGS. 20 to 23 are views showing the rectifying circuits of a charging receiver module according to the present invention;

FIG. 24 is a view showing the construction of a controller provided to the wireless charging pad of the

present invention; and

FIG. 25 is a view showing the flow of an RF signal between the wireless charging pad and the battery pack according to the present invention.

Disclosure

Technical Problem

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Technical Solution

In order to accomplish the above objects, the present invention provides a wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, including a controller (240) for switching to an active mode and

controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed; the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

Preferably, the controller (240) may read wireless identification information and charged status information of each of battery packs (100) in order in which the battery packs (100) are placed, indicate charged status of

each battery pack (100), and switch to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status may be established.

Preferably, the controller (240) may include an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

Preferably, the drive circuits (220 and 220') may

include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

Preferably, the wireless charging pad may further include an electromagnetic wave filter (250) combined with a power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

Preferably, the wireless charging pad (200) may include input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a

cigar lighter jack for a vehicle.

The present invention provides a battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, including a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200); a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an Radio Frequency Identification (RFID) tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT); the RFID tag (130) combined with the charging protection circuit module (120) to store wireless identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted

from the wireless charging pad (200) through a tag antenna (TA); and the battery (BAT) to be charged under control of the protection circuit (124).

Preferably, the wireless charging pad may further include an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

Preferably, the wireless charging pad may further include a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

Preferably, the charging protection circuit module (120) may include rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for

supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

Preferably, the rectifying circuits (121 and 121') may be series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

Preferably, the RFID tag (130) may include a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the

control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

Preferably, the wireless identification information may correspond to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

Preferably, the RF carrier signal may be a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz)

bands.

Advantageous Effects

As described above, the present invention is advantageous in that there is provided a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Best Mode

Preferred embodiments of the present invention are described in detail with reference to the attached drawings below, but detailed descriptions of related well-known functions and construction may be omitted if the detailed descriptions are determined to make the gist of the present invention unclear.

FIG. 1 is a view showing the entire construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention.

Referring to FIG. 1, a battery pack 100 includes a charging receiver module 110 provided with secondary coils Scoil1 and Scoil2 to receive induced electromotive force

from a primary-side wireless charging pad 200 (refer to FIG. 2), a charging protection circuit module 120 and a battery BAT having fuel gauge and charging functions, an RFID tag 130 (refer to FIG. 2) and a tag antenna TA adapted to transmit and receive radio signals, and an electromagnetic protector 140 that is an amorphous metal-based electromagnetic interference shield for magnetically isolating the battery BAT and the charging receiver module 110 so that the battery BAT does not affect the inductive coupling between the receiver module 110 and the wireless charging pad 200 (refer to FIG. 2).

The electromagnetic protector 140 is made of an amorphous metal-based magnetic material to remove frequency interference in a magnetic field attributable to radio signals and induced electromotive force, and generally functions to minimize a rise in temperature of the battery BAT in a magnetic field attributable to inductive heating caused by a metallic battery casing, so that the electromagnetic protector 140 must be inserted.

The battery pack 100 may further include the battery casing 150 for surrounding all the components, such as the charging receiver module 110, the charging protection circuit module 120, the battery BAT and the electromagnetic protector 140, combined into a single structure. In this case, the battery casing 150 is manufactured using a cool polymer material, such as cobalt or nickel, so that the

battery casing 150 functions to pass the induced electromotive force or electromagnetic waves, and emit heat generated inside the battery casing 150 due to charging.

FIG. 2 is a view showing the construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention.

Referring to FIG. 2, the non-contact battery charging system composed of the wireless charging pad and the battery pack separately comprises the wireless charging pad 200 adapted to function as a non-contact charger and the battery pack 100 charged with power provided by the wireless charging pad 200. A separative transformer is provided between the wireless charging pad 200 and the battery pack 100 so that a primary side of the transformer is provided in the wireless charging pad 200 and a secondary side of the transformer is provided in the battery pack 100.

The battery pack 100 includes the charging receiver module 110, the charging protection circuit module 120, the RFID tag 130, the tag antenna TA and the battery BAT that constitute the secondary side of the transformer.

The charging receiver module 110 receives the power induced from the wireless charging pad 200 and supplies the power to the charging protection circuit module 120.

The charging protection circuit module 120 having

fuel gauge and charging functions includes rectifying circuits 121 and 121' for rectifying the power supplied from the charging receiver module 110 by performing AC/DC conversion, a switch mode charging control circuit 122 for charging the battery BAT made of lithium ion or lithium polymer at Constant Voltage (CV) and Constant Current (CC), and a protection circuit 124 for detecting the charged status of the battery BAT and determining whether to supply or block the power supplied to the battery BAT from the charging control circuit 122 so as to protect the battery BAT. The charging protection circuit module 120 is constructed in such a way that the output of the charging receiver module 110 is the input of the rectifying circuits 121 and 121' and the output of the rectifying circuits 121 and 121' is connected to the input of the switch mode charging control circuit 122. Furthermore, the output of the charging control circuit 122 is connected to a fuel gauge 123, and the fuel gauge 123 is connected to the protection circuit 124 that protects the battery BAT from excessive charging and excessive current. Such components are mounted in the battery pack 100 of a portable device, and can be applied to a hard pack or an inner pack according to the type of the battery pack 100.

The wireless charging pad 200 functioning as a non-contact charger has various input ports having DC inputs, so that the wireless charging pad 200 can be used in

connection with various types of external power sources (e.g., the output of an AC adapter, a USB port of a computer, cigar lighter jack of a vehicle, etc.). In the wireless charging pad 200, the primary side of the transformer is provided, switching loss is reduced through zero voltage and zero current soft switching by switching at a frequency higher than a resonant point using a half-bridge resonant converter, and linkage flux is induced to the battery pack 100 of a portable device that constitutes a secondary side. Furthermore, the wireless charging pad 200 has a function of detecting the wireless identification information of the battery BAT and indicating charged status information on the wireless charging pad 200 through radio communication when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200, and a function of entering a shutdown mode and an energy saving mode when an object other than a battery pack 100 is placed on the wireless charging pad 200. Furthermore, when a plurality of portable devices is placed on the wireless charging pad 200, the wireless charging pad 200 reads the wireless identification information (e.g., personal phone numbers, etc.) stored in the RFID tag 130, indicates the wireless identification information on the wireless charging pad 200, indicates charged status, and indicates charging completion status on the wireless charging pad 200 after receiving information

on the completion of charging from the battery pack 100.

The RFID tag 130 and the tag antenna TA function to interface with the fuel gauge 123 that controls the charged status information of the battery BAT and transmit the charged status information of the battery BAT to the wireless charging pad 200 in a radio data form using a radio frequency in HF (13.56MHz) or UHF (900MHz) bands. The RFID tag 130 includes a memory block and a logic block, and stores the wireless identification information, such as a product name, a serial number and a user identification number (e.g., personal telephone number), therein. In this case, the user identification number is stored in the memory block of the RFID tag 130 through the communication between the terminal body of the portable device and the battery pack 100.

FIGS. 3 and 4 are views illustrating the components of the wireless charging pad and the battery pack according to the present invention, respectively.

Referring to FIG. 3, the wireless charging pad 200 according to the present invention includes a controller 240 for reading the RFID tag and controlling charging, drive circuits 220 and 220', and primary coils Pcoil1 and Pcoil2.

The wireless charging pad 200 may include various input ports having DC inputs, and generates the switching patterns of the primary coils Pcoil1 and Pcoil2 through the

drive circuits 220 and 220', respectively, and performs a control function of detecting portable devices placed on the wireless charging pad 200 and indicating the energy saving mode and the charged status of each of the portable devices. The drive circuits 220 and 220' are On/Off switching devices for switching the primary coils Pcoil1 and Pcoil2, respectively, each of which is composed of an upper switch and a lower switch. The drive circuits 220 and 220' are each constructed using a half-bridge or full-bridge resonant converter (serial, parallel or serial-parallel resonant converter).

Referring to FIG. 4, in the wireless charging pad 200 according to the present invention, the primary side of the transformer is constructed in such way that the two primary coils Pcoil1 and Pcoil2 are wound on a planar core, which is formed by combining small cobalt-based amorphous metallic cores, such as Co, Fe, Ni, B and Si, or ferrite cores in various shapes, in directions perpendicular to each other as shown in FIG. 4. In this case, the switching patterns perform switching so that a phase difference of 90 degrees occurs between the two primary coils Pcoil1 and Pcoil2. Accordingly, induced energy can be received regardless of the location of the portable device that is placed on the wireless charging pad 200 and has the battery pack 100 equipped with the charging receiver module 100.

The input form of the wireless charging pad 200 is

described below.

A control power source supplies the driving power of the controller 240 and the drive circuits 220 and 220' using a flyback converter in a 110/220 V direct drive fashion. In the resonant converter, DC power obtained by rectifying AC power in a 110/220 V switching fashion is always set to a 110 V input condition. DC power (12, 24, 48 V) is generated using the flyback converter for free voltages ranging from 86 to 265 V and is used as the input power of the resonant converter, and forms the driving power of the controller 240 and the drive circuits 220 and 220' using a regulator.

The controller 240 performs both a function of reading an RFID tag and a function of controlling charging. The construction of the controller 240 is described below.

First, a controller 240 is provided to detect the battery pack 100 equipped with the charging receiver module 110 and control charging. Wireless identification information, such as the product code and serial number of the battery BAT, and charged status information are read from the RFID tag 130 of the battery pack 100 through the controller 240. Furthermore, when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200 while the controller 240 in a sleep mode is maintained in a standby mode (energy saving mode: below 1 W) and monitors the battery pack 100, the

controller 240 wakes up and switches to an active mode to generate induced electromotive force by controlling the drive circuits 220 and 220', starts to charge the battery pack 100, and indicates the charged status of the battery pack 100. When the charging of the battery pack 100 is completed, the wireless charging pad 200 switches from the active mode to the energy saving mode again to save energy.

Second, when a plurality of battery packs 100 each equipped with a charging receiver modules 110 is placed on the wireless charging pad 200, wireless identification information stored in the RFID tags 130 of the battery packs 100 is read in order in which the battery packs 100 are placed. Furthermore, a fully charged battery pack 100 is indicated by a green Light Emitting Diode (LED) and a discharged battery pack 100 is indicated by a red LED. When the battery pack 100 is fully charged, the LED switches from red to green by receiving the wireless identification information of the RFID tag 130 so that the charged status is indicated by the wireless charging pad 200.

The construction of the drive circuits 220 and 220' is described below.

Two resonant converters control perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and the primary coils Pcoil1 and Pcoil2 are switched at a frequency higher than a resonant point so that the switching patterns of the primary coils have a phase

difference of 90 degrees. Accordingly, linkage flux rotates by 360 degrees in eight steps, thus enabling the battery pack 100 to be charged regardless of the location of the battery pack 100.

The construction of the primary side of the transformer is described below.

A single square or rectangular pad core is formed by connecting a plurality of small planar cores, is surrounded by an insulation tape, is provided with a coil wound thereon in a vertical direction, and is insulated by an insulation tape. Furthermore, the pad core is provided with a coil wound thereon in a horizontal direction and is insulated by an insulation tape, thus manufacturing the primary side of a planar transformer. In this case, the coil may be formed into a bobbinless type and be inserted into the pad core in vertical and horizontal directions. The charging receiver module 110 is operated as the secondary side of the transformer.

FIG. 5 is a view showing the charging receiver module 110. The charging receiver module 110 is manufactured in such a way that a plurality of cobalt-based amorphous metallic cores is stacked to form a single planar core, and secondary coils Scoil1 and Scoil2 are wound on the single planar core in vertical and horizontal directions, respectively. In this case, the planar core is made of an amorphous metal-based material that has high magnetic

permeability (>80,000) and a non-breakable characteristic. In the charging receiver module 110, the magnitude of induced electromotive force varies according to a function of the number of stacked cores forming the planar core, the sectional area of the planar core and the number of windings of the coils. The charging receiver module 110 has a load curve in which voltage is inversely proportional to current.

FIG. 6 is a view showing a method of generating a magnetic field depending on the switching patterns of the wireless charging pad according to the present invention.

In the wireless charging pad 200, a magnetic field rotates by 360 degrees in the case where current is applied by successively switching regions in the sequence of a first region→ a second region→ a third region→ a fourth region→ a fifth region→ a sixth region→ a seventh region→ an eighth region at a predetermined frequency, thus enabling a portable device equipped with the charging receiver module 110 to be charged regardless of the location and direction of the portable device when the portable device is placed on the wireless charging pad 200 (the magnetic field is rotated by 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°). In this case, the drive circuits 220 and 220′ include two half-bridge series-parallel resonant converters to control the perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and switch

the primary coils Pcoil1 and Pcoil2 at a frequency higher than a resonant point so that the switching patterns of the primary coils Pcoil1 and Pcoil2 have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating by 360 degrees in the sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention.

In a process of forming a pad core constituting the wireless charging pad 200, a wireless charging pad 200 having a desired size and shape can be formed by combining a plurality of small cobalt-based metallic or ferrite planar cores. For example, a pad core is formed by combining m cores in a longitudinal direction and n cores in a transverse direction according to the number of portable devices desired to be charged.

FIG. 8 is a view showing the detailed construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack according to the present invention.

As shown in FIG. 8, a primary-side wireless charging pad 200 and a secondary-side battery pack 100 equipped with the charging receiver module 110 are magnetically combined with each other.

The primary-side wireless charging pad 200 includes a power input terminal, an AC/DC conversion circuit 210, a controller 240 for detecting wireless identification information transmitted from the secondary side, two half-bridge serial-parallel resonant converters, drive circuits 220 and 220′ for generating a magnetic field by generating control signals for controlling the two primary coils Pcoil1 and Pcoil2, respectively, a primary-side transformer constructed by winding the two primary coils Pcoil1 and Pcoil2 on the pad core in vertical and horizontal directions, respectively, and inductive couplers 230 and 230′ formed by providing L_r and L_r' to the corresponding primary-side transformer.

Furthermore, the primary-side wireless charging pad 200 may further include an electromagnetic wave filter 250 connected to the power input terminal for the purpose of blocking the electromagnetic waves of input AC power, and a flyback converter 210′ connected to the AC/DC conversion circuit 210 for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter 250 and rectifying the AC power into DC power and the controller 240 for the purpose of accumulating power while an equipped transistor is turned on and transmitting the accumulated power to the controller 240 when the equipped transistor is turned off so as to enable the drive circuits 220 and 220′ to be driven.

The secondary-side battery pack 100 includes a receiver module 110 composed of an amorphous metallic planar core and two secondary coils Scoil1 and Scoil2 that are wound on the planar core in vertical and horizontal directions, respectively, to be magnetically combined with the wireless charging pad 100, thus inducing induced electromotive force; a charging protection circuit module 120 for generating charged status information by periodically monitoring the charged status of a battery BAT, recording the generated charged status information in an RFID tag 130 and controlling whether to charge or discharge the battery BAT by selectively supplying or blocking the power, which is induced to the charging receiver module 110, to the battery BAT under the On/Off control of the RFID tag 130; the RFID tag 130 combined with the charging protection circuit module 120 to store the wireless identification information of the battery BAT and periodically record the charged status information therein, generate and modulate RFID data including the wireless identification information and charged status information of the battery BAT and transmit the modulated RFID data to the wireless charging pad 200 in response to an RFID carrier signal transmitted from the wireless charging pad 200 through a tag antenna TA; and the battery BAT to be charged under the control of the protection circuit 124.

The charging protection circuit module 120 may

include rectifying circuits 121 and 121' adapted to rectify the power induced to the charging receiver module 110 and supply the rectified power to a charging control circuit 122, the charging control circuit 122 combined with the rectifying circuits 121 and 121' to supply the power, rectified by the rectifying circuits 121 and 121' under the On/Off control of the RFID tag 130, to a fuel gauge 123, the fuel gauge 123 adapted to supply the power supplied from the charging control circuit 122 to the battery BAT through the protection circuit 124, and generate the charged status information by monitoring the charged status of the battery BAT and periodically record the charged status information in the RFID tag 130, and the protection circuit 124 combined with the fuel gauge 123 and the battery BAT to protect the battery BAT by controlling whether to charge or discharge in accordance with the charged status of the battery BAT.

When the RFID carrier signal is transmitted from the wireless charging pad 200 through the tag antenna TA, the RFID tag 130 generates and modulates RFID data that includes previously stored wireless identification information of the battery BAT and charged status information, which is periodically recorded through the fuel gauge 123, in response to the RFID carrier signal, and transmits the modulated RFID data to the wireless charging pad 200. In this case, the RFID tag 130 is composed of a

memory block and a logic block. The memory block can be implemented using ROM 134 in which the wireless identification information and the charged status information are recorded. It is preferable to use Electrically Erasable and Programmable Read Only Memory (EEPROM) as the ROM 134. The logic block can be implemented using a clock extraction unit 131 for extracting a clock from the RFID carrier signal that is wirelessly received from the wireless charging pad 200, a sequencer 132 for inspecting the sequence of arranged data extracted from the clock extraction unit 131 and transmitting a control signal to a data encoder 133, the data encoder 133 for receiving the wireless identification information and charged status information of the battery BAT from a tag 135 when the control signal is transmitted from the sequencer 132, encoding the received information and transmitting the encoded information to a data modulator 136, the data modulator 136 for generating the modulated RFID data by modulating the data received from the data encoder 133 and wirelessly transmitting the modulated RFID data to the wireless charging pad 200, and the tag 135 for reading the wireless identification information and charged status information of the battery BAT stored in the ROM 134 and transmitting the wireless identification information and charged status information to the data encoder 133.

FIG. 9 is a flowchart showing a method of charging a

battery through the wireless charging pad of FIG. 8. The method of charging a battery using the wireless charging pad 200 according to the present invention is described with reference to FIG. 9 below.

Step S100) First, when the secondary-side battery pack 100 is placed on the primary-side wireless charging pad 200, the primary-side wireless charging pad 200 generates an RFID carrier signal and inspects an object placed on the wireless charging pad 200.

Step S110) If, as a result of the inspection, the object does not contain information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the primary-side wireless charging pad 200 always enters an energy saving mode.

Step S120) If, as a result of the inspection, the object contains information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the wireless charging pad 200 wakes up to detect wireless identification information and starts charging control.

Step S130) Wireless identification information about the battery pack 100 of each of various portable devices is displayed, and whether the battery pack 100 is in charging status or fully charged status is indicated after receiving charged status information. The battery 100 in fully charged status that indicates charging is completed is

indicated by a green LED, and the battery 100 being charged is indicated by a red LED.

Step S140) When the fully charged status in which the charging of all the battery packs 100 are completed is established, the wireless charging pad 200 collects the wireless identification information and enters a standby mode, that is, the energy saving mode.

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters provided to the wireless charging pad according to the present invention.

FIGS. 10 and 11 are views showing the equivalent circuits of a separative transformer that has a gap between the wireless charging pad 200 and the battery pack 100. In a non-contact type charging method in which energy is transmitted using the magnetic coupling of the transformer, the primary side of the transformer is included in the wireless charging pad 200 functioning as a non-contact charger and the secondary side of the transformer is included in the battery pack 100, so that a gap exists between the primary and secondary sides, thus causing inefficiency in energy transmission because a coupling coefficient and magnetizing inductance are reduced and leakage inductance is increased. Besides, it is problematic in that it is difficult to electrically transmit output information to a primary-side controller at the time of

controlling feedback. In the present invention, in order to overcome the disadvantages of the separative transformer and effectively transmit energy, a half-bridge serial resonant converter is applied to the primary side of the transformer. The serial resonant converter applied to the primary side of the transformer reduces the influence of leakage inductance on the primary side of the separative transformer, thus enabling effective energy transmission.

The self-inductance L_1 and L_2 are measured in such a way that a secondary-side module is opened and primary-side inductance is measured, and the leakage inductance L_{11} and L_{12} are measured in such a way that a secondary-side module is shorted and primary-side inductance is measured.

Mutual inductance L_M is calculated in such a way that impedance L_P is measured by connecting the primary and secondary sides in parallel, impedance L_S is measured by connecting the primary and secondary sides in series, and the measured impedance L_P and L_S are substituted for L_P and L_s of Equation 1,

$$L_M = \frac{L_P - L_s}{4} \quad (1)$$

The magnetizing inductance L_m is measured using Equations 2 to 4,

$$L_m = L_M(\frac{N_1}{N_2}), \quad N = \frac{N_2}{N_1} \tag{2}$$

(N_1: number of primary windings, N_2: number of secondary windings)

$$k = \frac{L_M}{\sqrt{L_1 L_2}} \tag{3}$$

$$L_{l1} = L_1 - L_m, \quad L_{l2} = L_2 - NL_M \tag{4}$$

Voltage imposed in the primary side of the transformer is applied to the primary side of the transformer through the voltage distribution of L_{l1} and L_{l2}, and is transmitted to the secondary side based on a winding ratio. The secondary-side voltage is transmitted to the actual secondary side of the transformer through the voltage distribution of L_{l2} and secondary-side load, so that the voltage gain is lower than that of an ideal transformer.

Furthermore, if the coupling coefficient is low, the magnetizing inductance L_m of the transformer is low, so that current flowing to the primary side of the transformer is not transmitted to the secondary side of the transformer through L_{l2}, but is circulated and transmitted to the first side of the transformer again through the magnetizing inductance L_m that has lower impedance. That is, in order to supply current required by the load, input current must be large. If the primary-side current increases, continuity loss in a switch increases, thus causing the efficiency of

a system to decrease. Accordingly, in order to increase the efficiency of the system by reducing the primary-side current, the coupling coefficient of the transformer must be increased. In the non-contact charger, the primary- and secondary-side cores are separated by a gap, and winding areas are also separated. Furthermore, the gap is located in a path through which magnetic flux passes, so that magnetic resistance is increased, thus lowering the magnetic flux density inside the cores.

When a large gap exists between the primary- and secondary-side cores, magnetic flux density is expressed by Equation 5,

$$B_f = \frac{NI}{\frac{l_f}{\mu_f} + \frac{l_g}{\mu_o}} \approx \frac{\mu_o NI}{l_g} (\mu_f >> \mu_o) \quad (5)$$

(B: magnetic flux density, N: number of windings, I: current flowing through transformer, l_f: length of magnetic path of core, l_g: length of magnetic path in gap, μ_f: magnetic permeability of core, μ_o: magnetic permeability of gap)

The magnetic flux density, when the gap does not exist, is expressed by Equation 6,

$$B_f = \frac{\mu_f NI}{l_f} >> B_f \quad (6)$$

The magnetic permeability of the core is considerably larger than that of air, and the size of the gap is relatively larger than that of the core, so that the magnetic flux density in the case where the gap does not exist has a value considerably higher than that in the case where the gap is large. As a result, in the case of a transformer having a large gap, it is difficult for saturation status to occur inside the core, and also local saturation status is not generated easily. Accordingly, with respect to the shape of a core, a narrow section or protrusion is allowed. Furthermore, the magnetic flux density in the core is low, so that core loss due to hysteresis is also low.

Since the gap is large, the magnetic resistance is increased, so that the inductance of the core is decreased. Accordingly, in order to obtain required magnetizing inductance, the number of windings is increased and a wider winding area is required as a result.

The magnetizing inductance L_m may be expressed by Equation 7,

$$L_m = L_M(\frac{N_1}{N_2}) = \frac{N_1}{N_2}(\frac{N_1 N_2}{R_m}) = \frac{N_1^2}{R_m} \quad (7)$$

(R_m: magnetic resistance, N_1: number of primary windings, N_2: number of secondary windings, L_M: mutual inductance)

That is, since the magnetic resistance R_m is large, the number of windings is increased to obtain the required magnetizing inductance L_M. Generally, the difference between the primary- and secondary-side voltages of a non-contact charger is large, so that a difference in the winding ratio is also large. As a result, since the winding areas of the primary and secondary sides are different and the difference between the winding ratios is large, the shapes of the primary- and secondary-side cores are generally asymmetric.

Most leakage magnetic flux is generated in the gap existing between the primary- and secondary-side cores, so that a section area of the cores opposite to each other must be large to increase the coupling coefficient in the transformer. However, in the case of a transformer used in the non-contact charger, the volume and weight of the secondary-side core are limited because the secondary-side core is located inside the battery pack, so that the section area of the cores opposite to each other is also limited. However, in the present invention, a planar pad core, the section area of which is large in considerations of limited volume and weight, is used.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter provided to the wireless charging pad of the present invention, according

to modes.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter (upper converter), according to modes.

In FIG. 12, when Q_1 is turned on, current i_1 flows to a transformer through the switch Q_1. In FIG. 13, when the switch Q_1 is turned off, the current i_1 flows while discharging the parallel capacitor of a switch Q_2 and charging the parallel capacitor of the switch Q_1. In FIG. 14, when the voltage of the switch Q_2 is zero (the voltage of the switch Q_1 is input voltage), the current i_1 flows through the parallel diode of the switch Q_2, and the voltage of the switch Q_2 remains at zero. Furthermore, if the switch Q^2 is turned on before the direction of the current i_1 is reversed, Zero Voltage Switching (ZVS) is achieved in the switch Q_2. In FIG. 15, when the direction of the current i_1 is reversed, the current i_1 flows through the switch Q^2. In FIG. 16, when the switch Q^2 is turned off, the current i_1 flows while discharging the parallel capacitor of the switch Q^1 and charging the parallel capacitor of the switch Q^2. In FIG. 17, when the voltage of the switch Q^2 is zero (the voltage of the switch Q^2 is the input voltage), the current i_1 flows through the parallel diode of the switch Q^1, and the voltage of the switch Q^1 remains at zero. Furthermore, when the switch Q^1 is turned on before the direction of the current is restored, the ZVS is achieved

in the switch Q^1.

In order to achieve the ZVS of the switch Q^2, the magnitude of the current i_1 at the time of being changed from FIG. 12 to FIG. 13 must be large enough so that the energy of a magnetic circuit depending on the current i_1 can charge or discharge the parallel capacitor, and the gate signal of the switch Q^2 must be provided before the direction of the current i_1 is reversed. The switch Q^1 can achieve the ZVS using the same principle.

In this case, a resonant frequency considerably affects efficiency. The switching frequency is operated at a frequency close to the resonant frequency, so that the core loss and gap loss of the transformer are reduced if the resonant frequency is low. However, the loss may be increased because magnetic current, that is, the primary-side current of the transformer, is increased. Accordingly, the switching loss attributable to the ZVS is reduced by selecting a switching frequency higher than the resonant frequency.

FIG. 18 is a view showing the voltage and current waveforms of the transformer according to the gate signal of the half-bridge series resonant converter provided in the wireless charging pad of the present invention.

Referring to FIG. 18, square wave voltage identical to the input voltage is applied to the transformer by the gate signals of the switches Q^1 and Q^2, and sine wave current

identical to the current i_1 flows to the transformer through the resonant circuit.

FIG. 19 is a view showing the rotating directions of the magnetic field according to the operation of the half-bridge series resonant converter provided in the wireless charging pad of the present invention, according to modes.

FIG. 20 is a view showing the rotating directions of the magnetic field generated according to the operation of the half-bridge series resonant converter according to modes. Accordingly, since the magnetic field rotates by 360 degrees, induced electromotive force can be transmitted to the secondary side regardless of the location and direction of the battery pack 100 when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200.

FIGS. 20 to 23 are views showing the rectifying circuits of the charging receiver module according to the present invention.

Referring to FIGS. 20 to 23, the secondary-side charging receiver module 110 transmits power through a series-parallel resonant center tap half-bridge rectifying circuit that uses the output of a single center tap rectifying diode and an output filter capacitor, or through a series-parallel resonant full-bridge rectifying circuit that uses the output of a full-bridge rectifying diode and an output filter capacitor.

FIG. 24 is a view showing the construction of a controller provided in the wireless charging pad of the present invention.

The controller 240 provided in the wireless charging pad 200 of the present invention determines whether a battery pack 100 is placed on the wireless charging pad 200, reads wireless identification information, which is stored in the RFID tag 130, from the battery pack 100 if the battery pack 100 is placed, determines whether the battery pack 100 needs to be charged or how many battery packs 100 are placed, and generates a drive control signal and indicates the charged status of each of the battery packs at the same time.

Referring to FIG. 24, the controller 240 provided in the wireless charging pad 200 of the present invention may include an oscillator 241 for generating an oscillation signal of a certain frequency, an antenna driver 242, a demodulator 243 for demodulating RF data received by the antenna driver 242, a filter and amplification unit 244 for filtering wireless identification information and charged status information from the demodulated data and amplifying the filtered information, a data decoder 245 for decoding the wireless identification information and charged status information received by the filter and amplification unit 244, a driver control unit 246 for performing mode conversion according to the charged status based on the

decoded data, a display unit 247 for displaying the data decoded by the data decoder 245, a timer 248, and a reset unit 249.

The antenna driver 242 uses the oscillation signal of the oscillator 241 as a clock, monitors the access of the battery pack 100, and wirelessly receives RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack 100, in response to an RF carrier signal through the reader antenna RA when the battery pack 100 makes access. In this case, a polling method of periodically transmitting the RF carrier signal to the outside through the reader antenna RA and monitoring whether a return signal exists can be applied as a method of the antenna driver 242 monitoring the access of the battery pack 100.

Furthermore, in the case where a plurality of battery packs 100 is placed, the controller 240 reads the wireless identification information and charged status information of each of the battery packs 100 in order in which the battery packs 100 are placed, indicates the charged status of each of the battery packs 100, and switches from an active mode to an energy saving mode when all the battery packs 100 are completely charged, and thereby, the fully charged status is established.

FIG. 25 is a view showing the flow of the RF signal between the wireless charging pad and the battery pack

according to the present invention.

Referring to FIG. 25, when the controller 240 accesses the RFID tag 130 in the battery pack 100 equipped with the charging receiver module 110 to access information on the battery BAT using a carrier frequency in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands, the battery information stored in the memory block of the RFID tag 130 is transmitted to the wireless charging pad 200 in a modulated RF signal form.

The present invention may be modified in various forms without departing from the basic concept of the invention according to the demands of those skilled in the art.

CLAIMS

1. A wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a controller (240) for switching to an active mode and controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed;

the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and

a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based

amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

2. The wireless charging pad according to claim 1, wherein the controller (240) reads wireless identification information and charged status information of each of battery packs (100) in order in which battery packs (100) are placed, indicates charged status of each battery pack (100), and switches to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status is established.

3. The wireless charging pad according to claim 1 or 2, wherein the controller (240) comprises an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the

battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

4. The wireless charging pad according to claim 1, wherein the drive circuits (220 and 220') include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

5. The wireless charging pad according to claim 1, further comprising:

an electromagnetic wave filter (250) combined with a

power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

6. The wireless charging pad according to claim 1, wherein the wireless charging pad (200) includes input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a cigar lighter jack for a vehicle.

7. The wireless charging pad according to claim 1, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in an Radio Frequency Identification (RFID) tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

8. The wireless charging pad according to claim 1, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz) bands.

9. A battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200);

a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an RFID tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT);

the RFID tag (130) combined with the charging protection circuit module (120) to store wireless

identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted from the wireless charging pad (200) through a tag antenna (TA); and

the battery (BAT) to be charged under control of the protection circuit (124).

10. The wireless charging pad according to claim 9, further comprising an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

11. The wireless charging pad according to claim 9 or 10, further comprising a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

12. The wireless charging pad according to claim 9, wherein the charging protection circuit module (120) comprises:

rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

13. The wireless charging pad according to claim 12, wherein the rectifying circuits (121 and 121') are series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying

diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

14. The wireless charging pad according to claim 9, wherein the RFID tag (130) comprises:

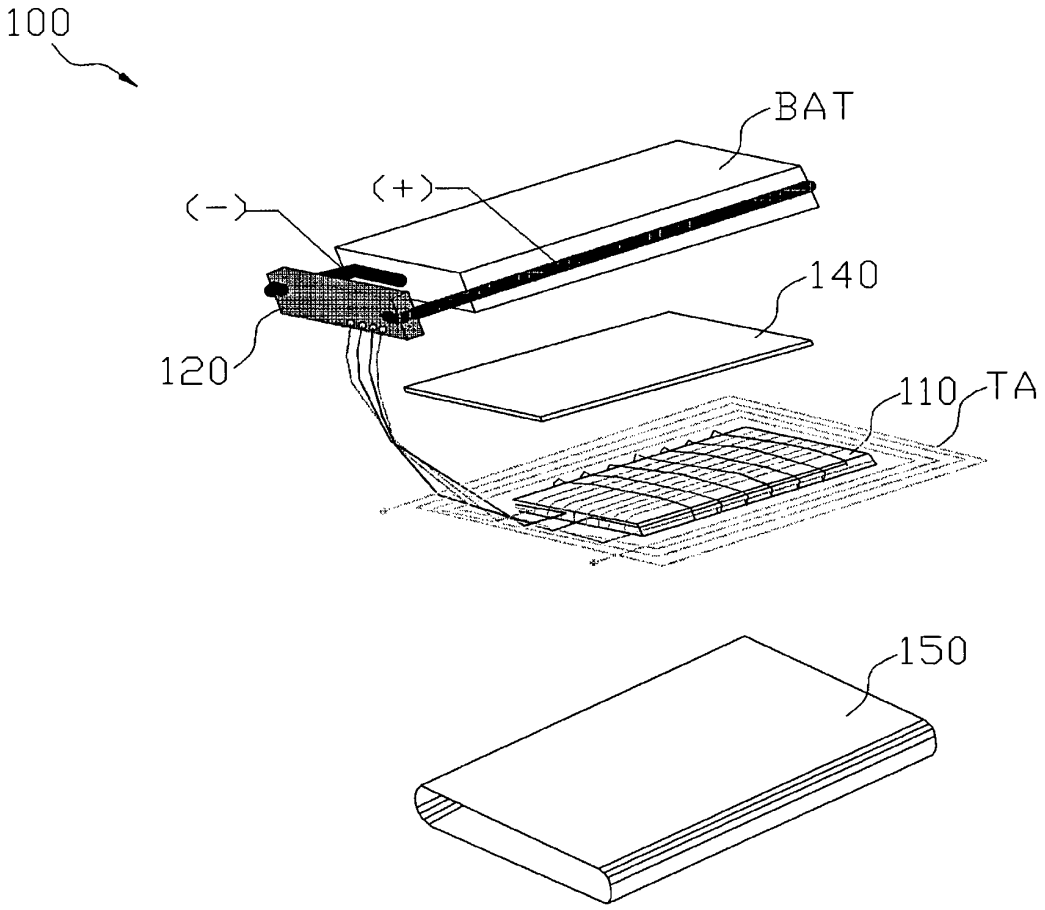
a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for

reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

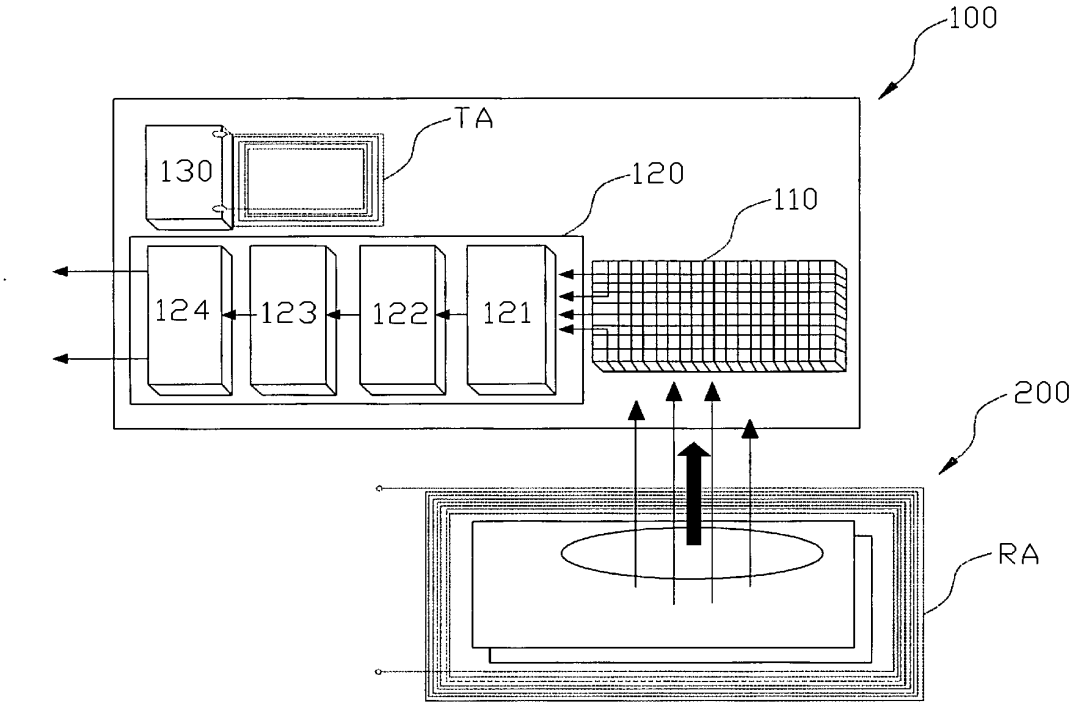
15. The wireless charging pad according to claim 9, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

16. The wireless charging pad according to claim 9, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands.

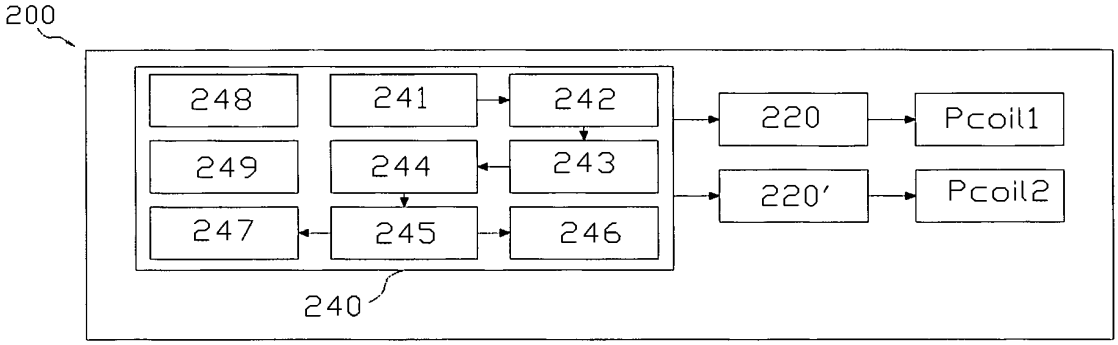
【FIG. 1】



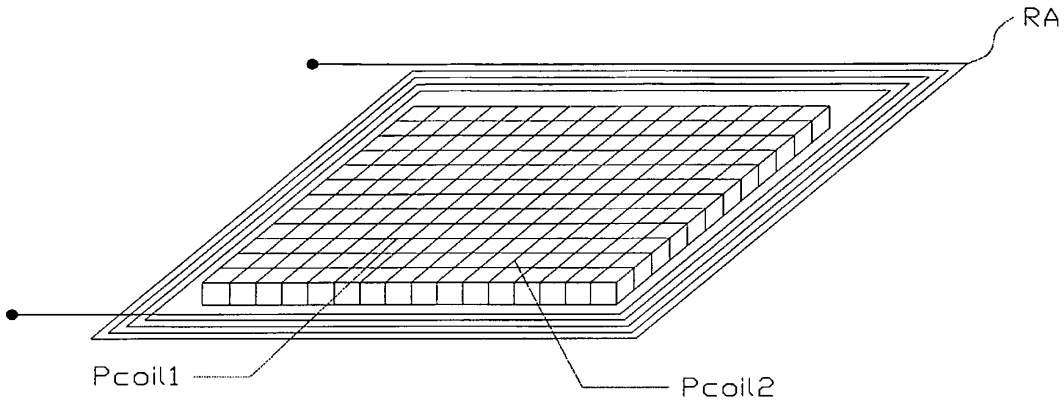
【FIG. 2】


100
TA
130
120
110
124
123
122
121
200
RA

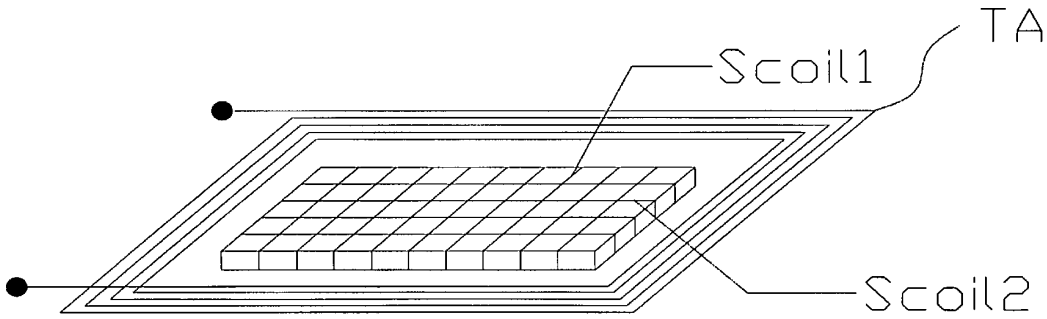
【FIG. 3】


200
248
241
242
220
Pcoil1
249
244
243
220'
Pcoil2
247
245
246
240

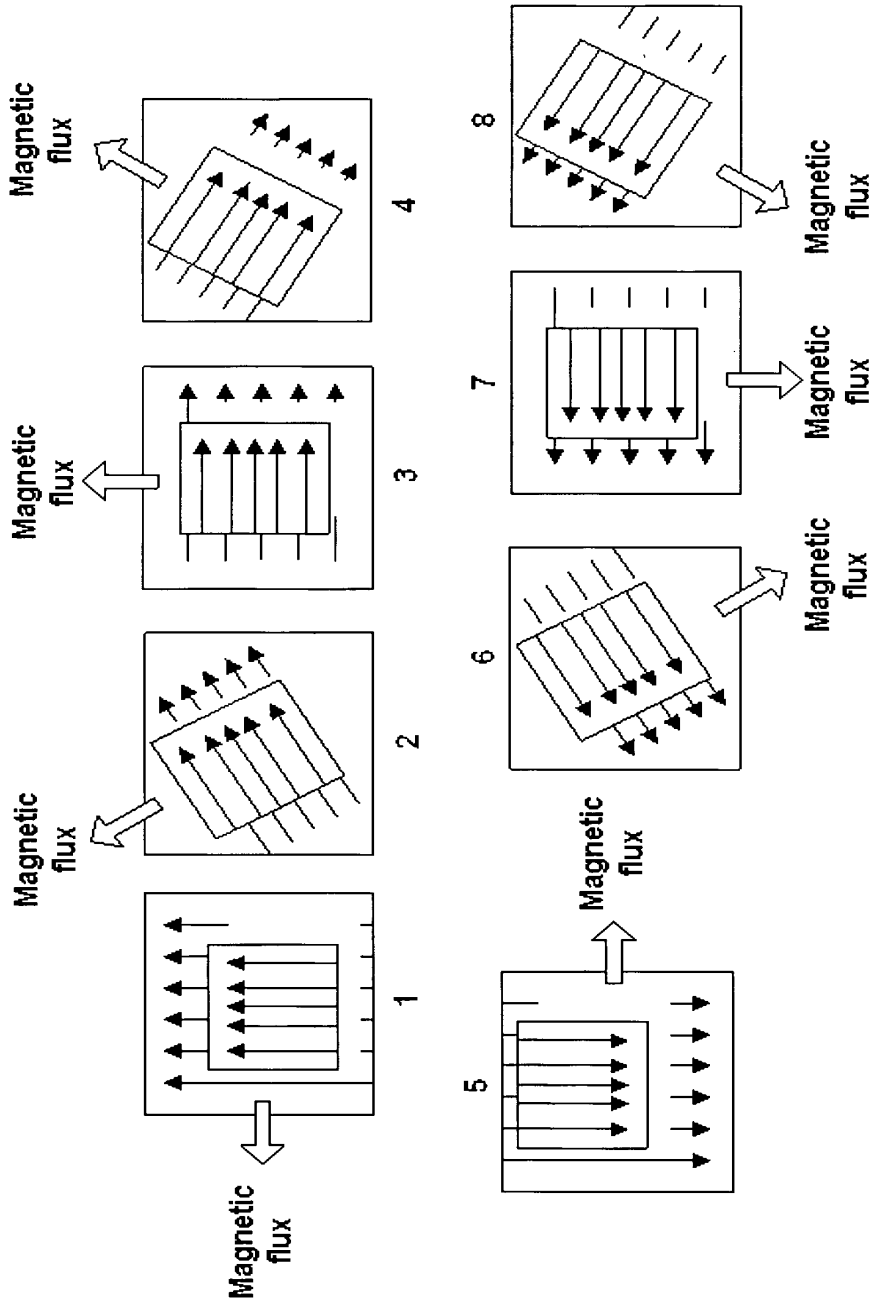
【FIG. 4】



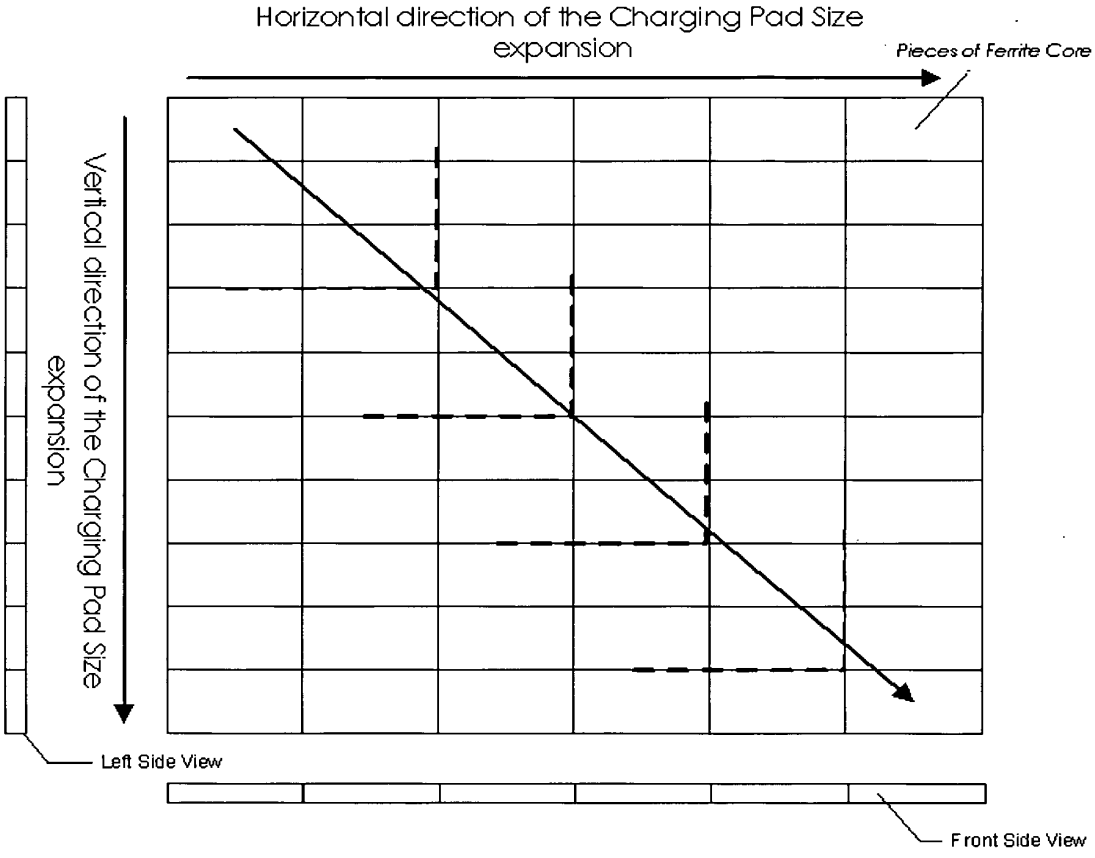
【FIG. 5】



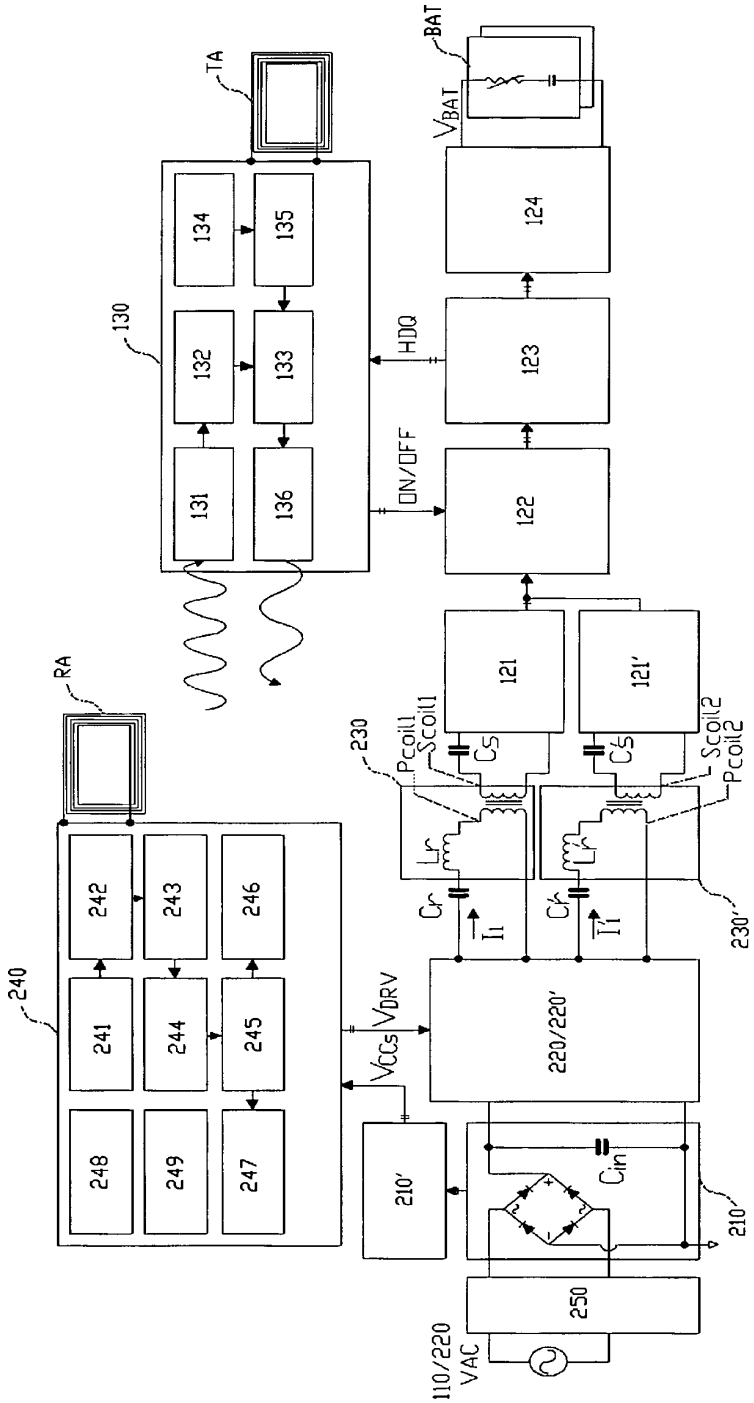
【FIG. 6】


Magnetic flux
1
Magnetic flux
2
Magnetic flux
3
Magnetic flux
4
Magnetic flux
5
Magnetic flux
6
Magnetic flux
7
Magnetic flux
8

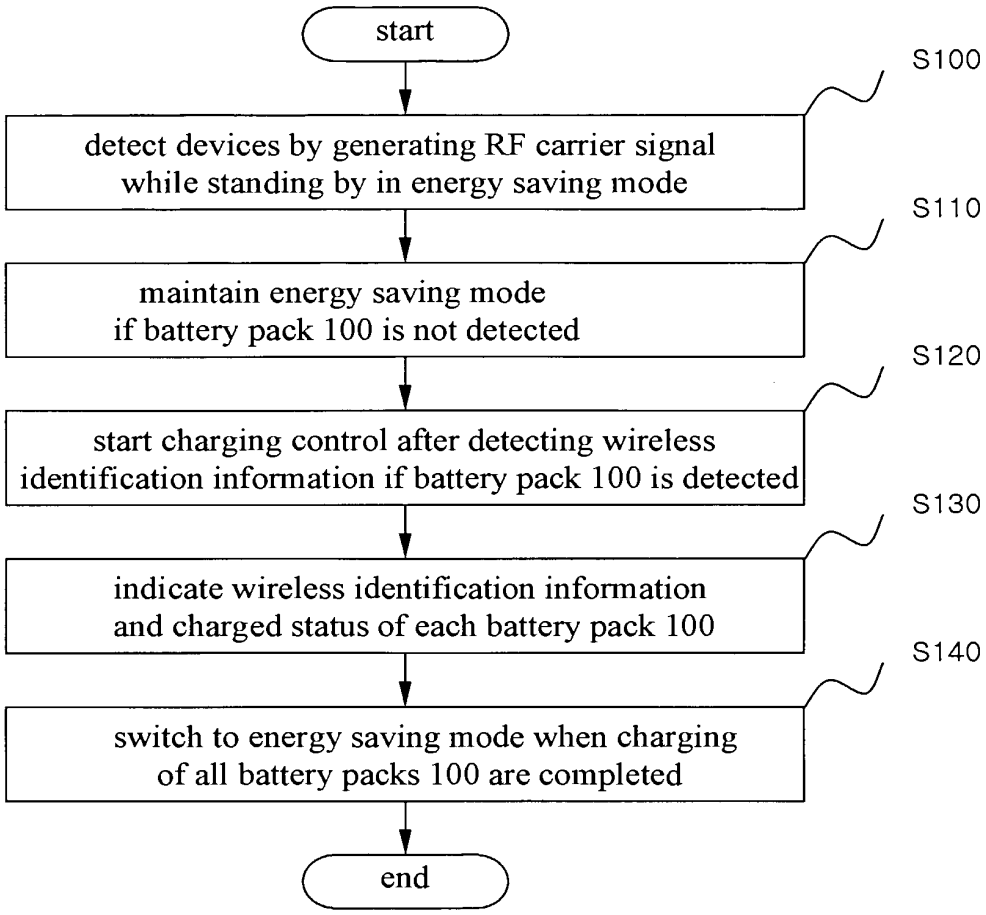
【FIG. 7】


Horizontal direction of the Charging Pad Size expansion
Pieces of Ferrite Core
Vertical direction of the Charging Pad Size expansion
Left Side View
Front Side View

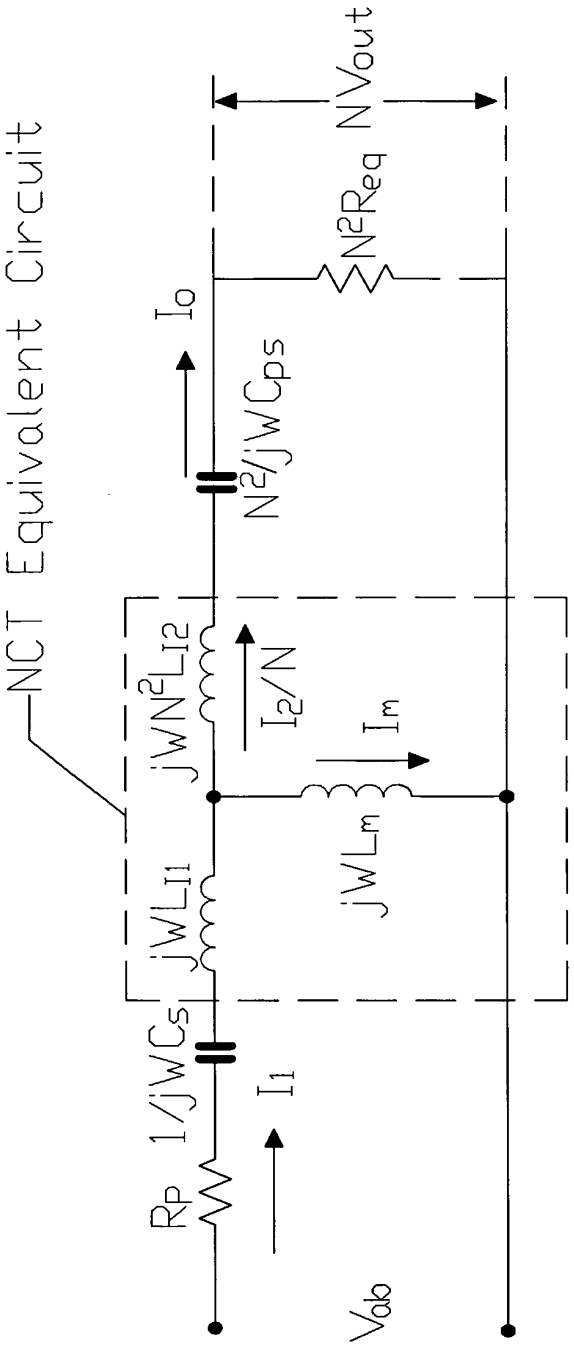
【FIG. 8】


TA
BAT
VBAT
124
123
122
130
134
135
132
133
131
136
HDQ
ON/OFF
121
121'
RA
230
Pcoil1
Scoil1
Cs
Scoil2
Pcoil2
Lp
Lp'
Cp
Cp'
I1
I1'
230'
240
242
243
246
241
244
245
248
249
247
VDRV
VCCs
220/220'
210'
Cin
250
110/220
VAC

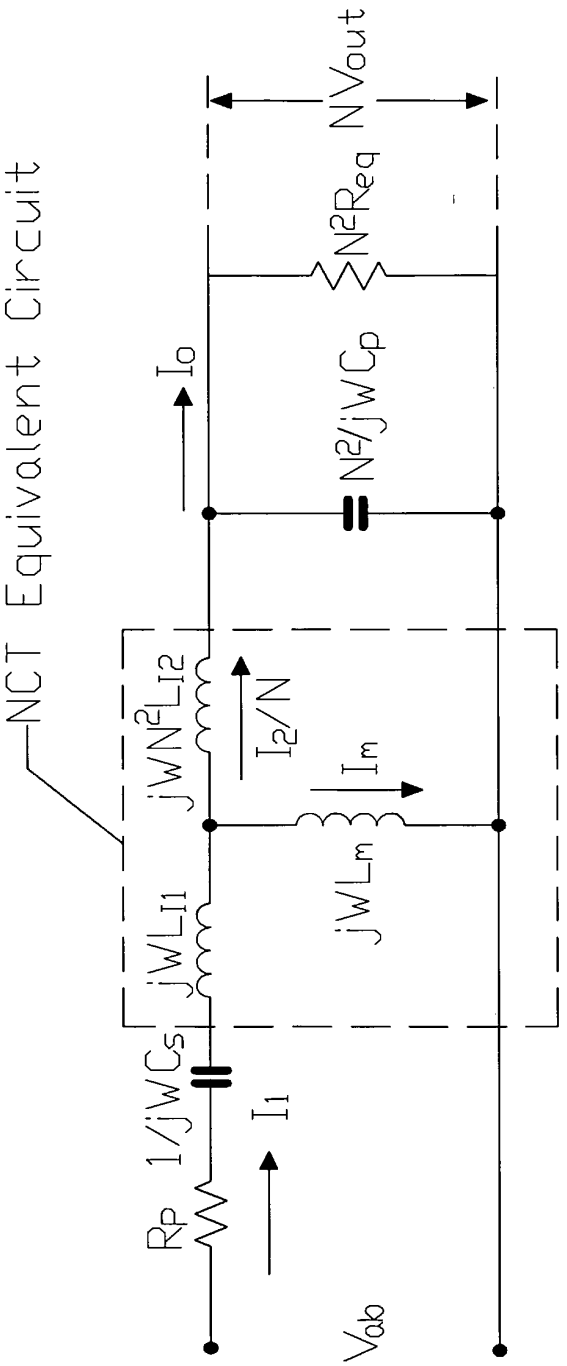
【FIG. 9】


start
S100
detect devices by generating RF carrier signal while standing by in energy saving mode
S110
maintain energy saving mode if battery pack 100 is not detected
S120
start charging control after detecting wireless identification information if battery pack 100 is detected
S130
indicate wireless identification information and charged status of each battery pack 100
S140
switch to energy saving mode when charging of all battery packs 100 are completed
end

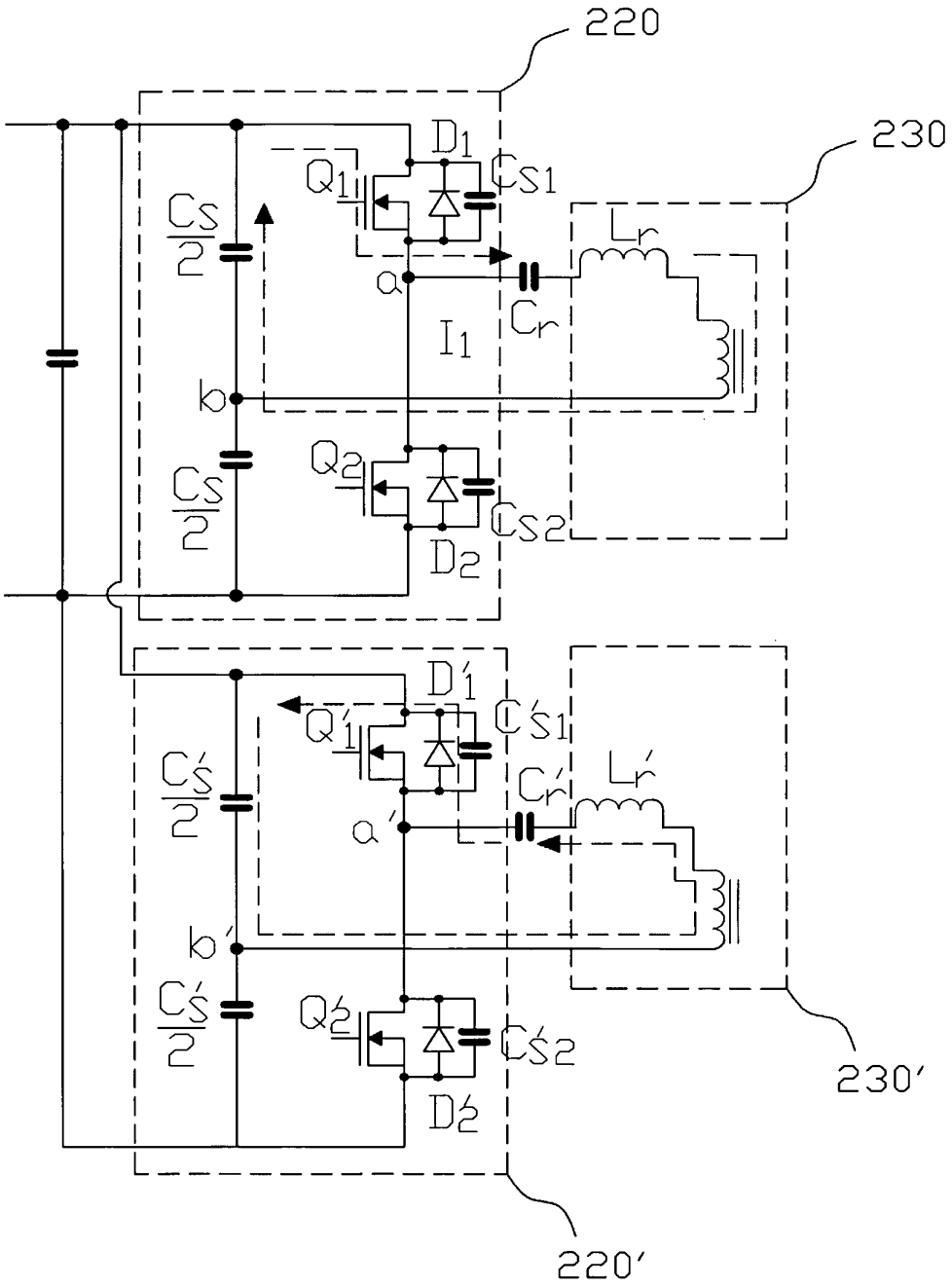
【FIG. 10】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jWCps
I2/N
Im
jWN²LI2
jWLm
jWLI1
1/jWCs
RP
I1
Vab

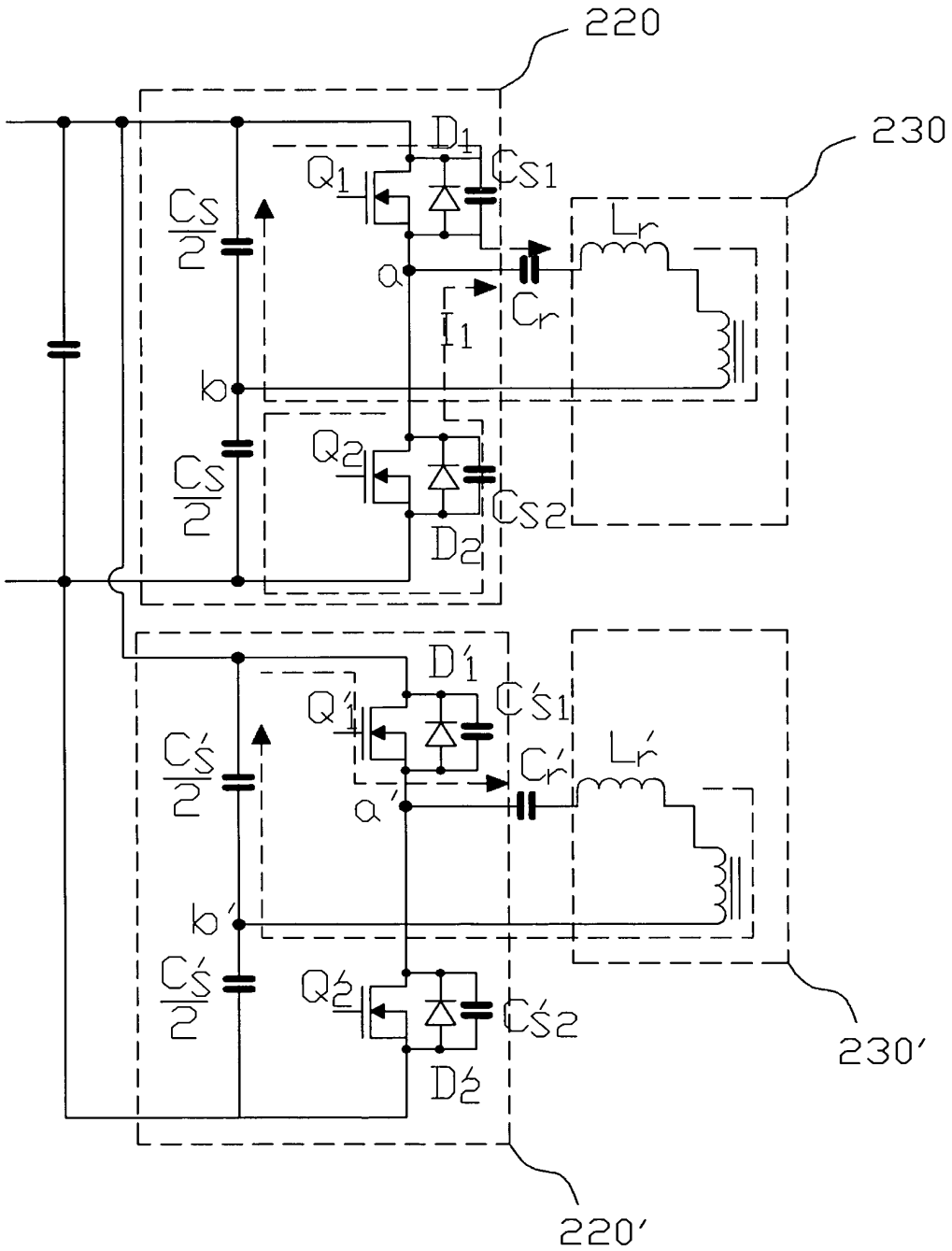
【FIG. 11】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jwCp
I2/N
Im
jwN²LI2
jwLm
jwLI1
1/jwCs
RP
I1
Vab

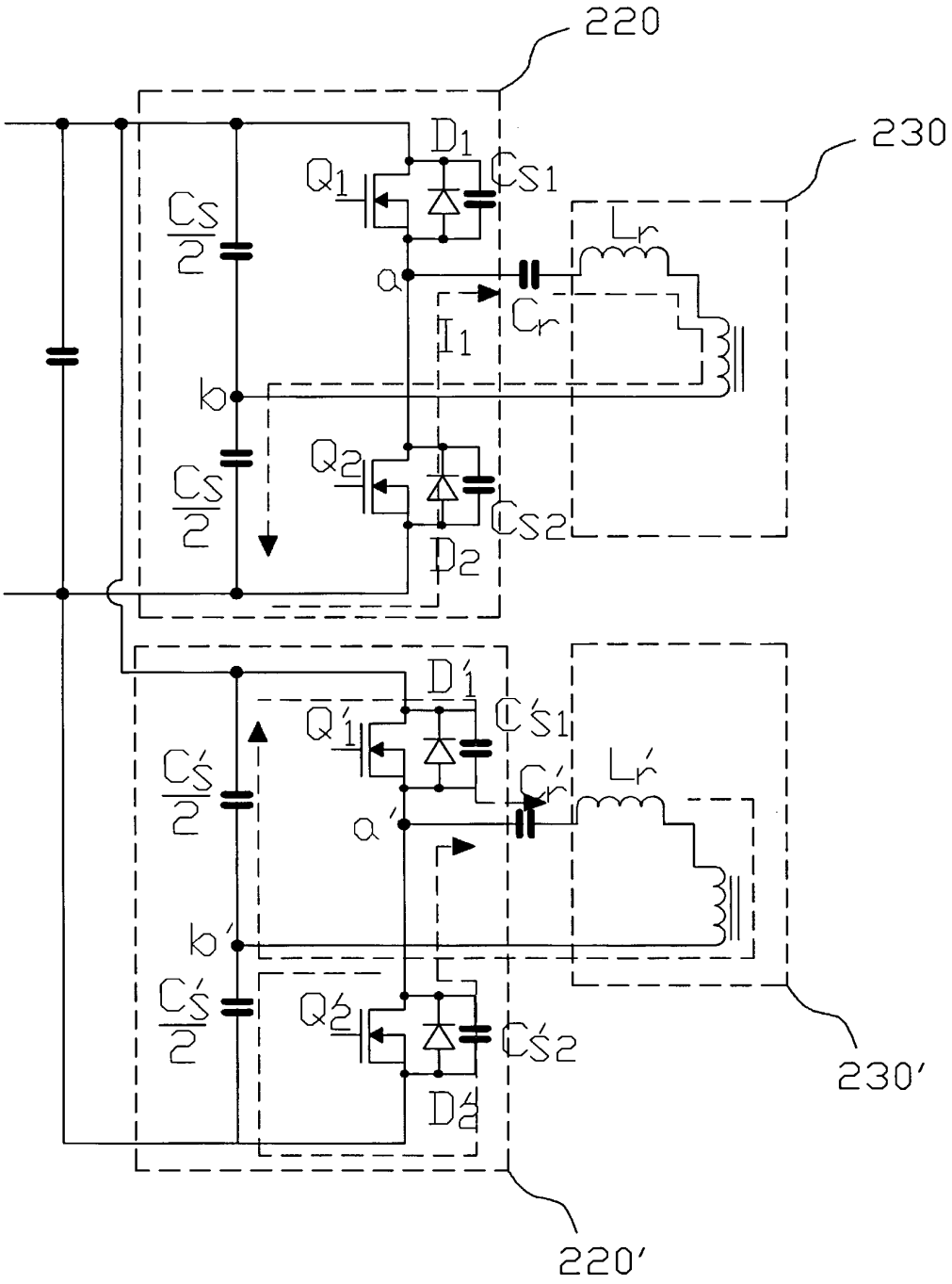
【FIG. 12】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

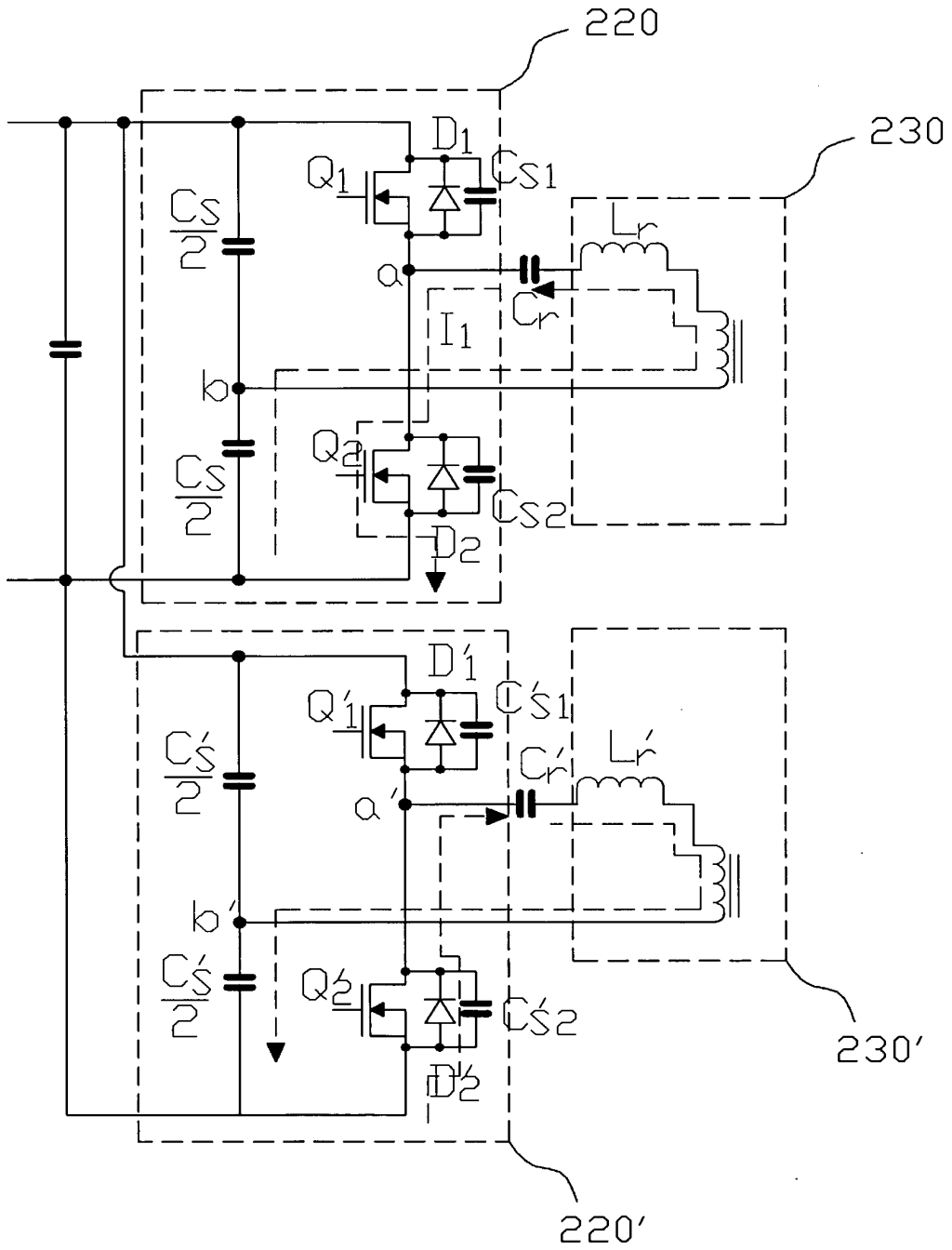
【FIG. 13】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
Cr'
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

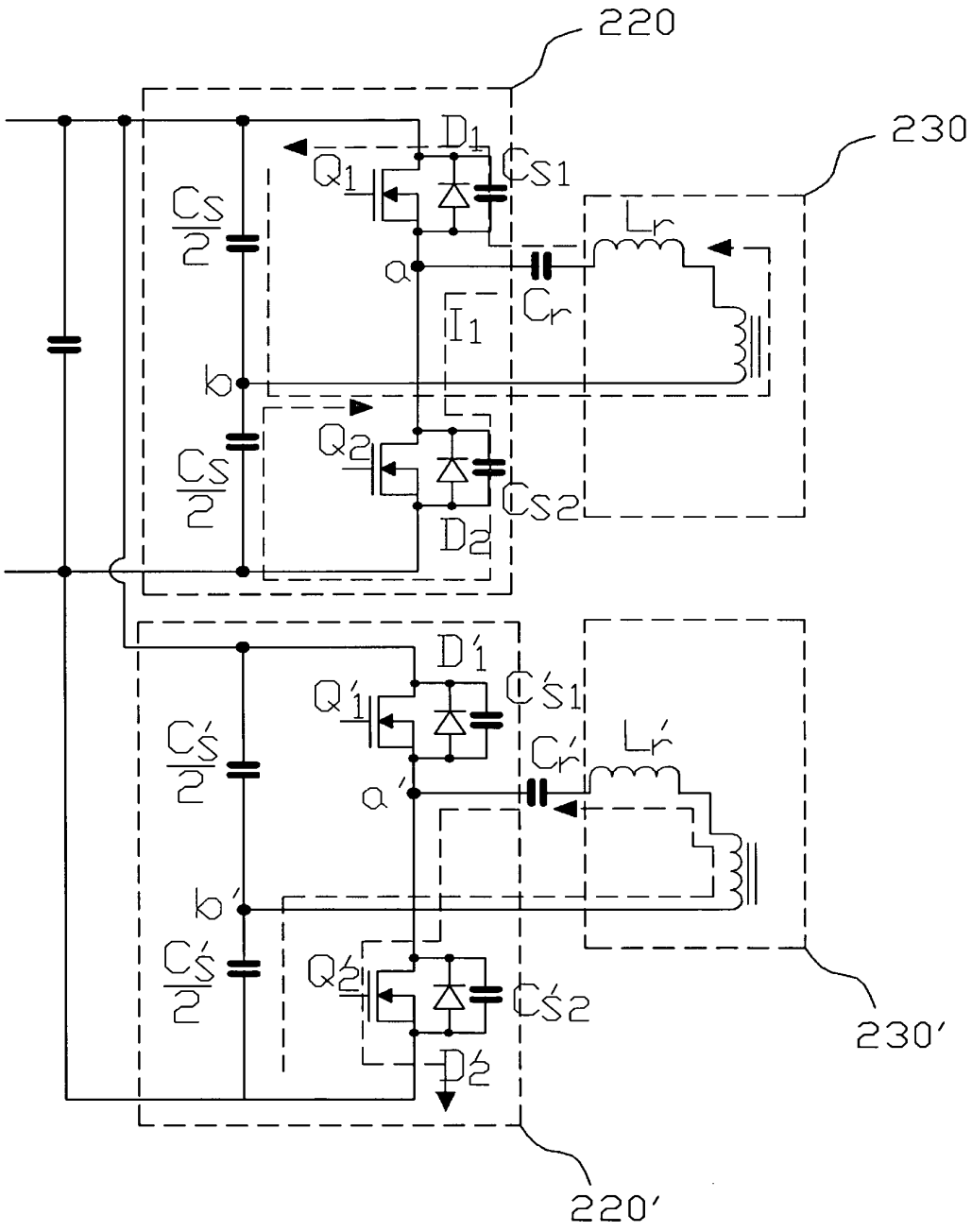
【FIG. 14】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

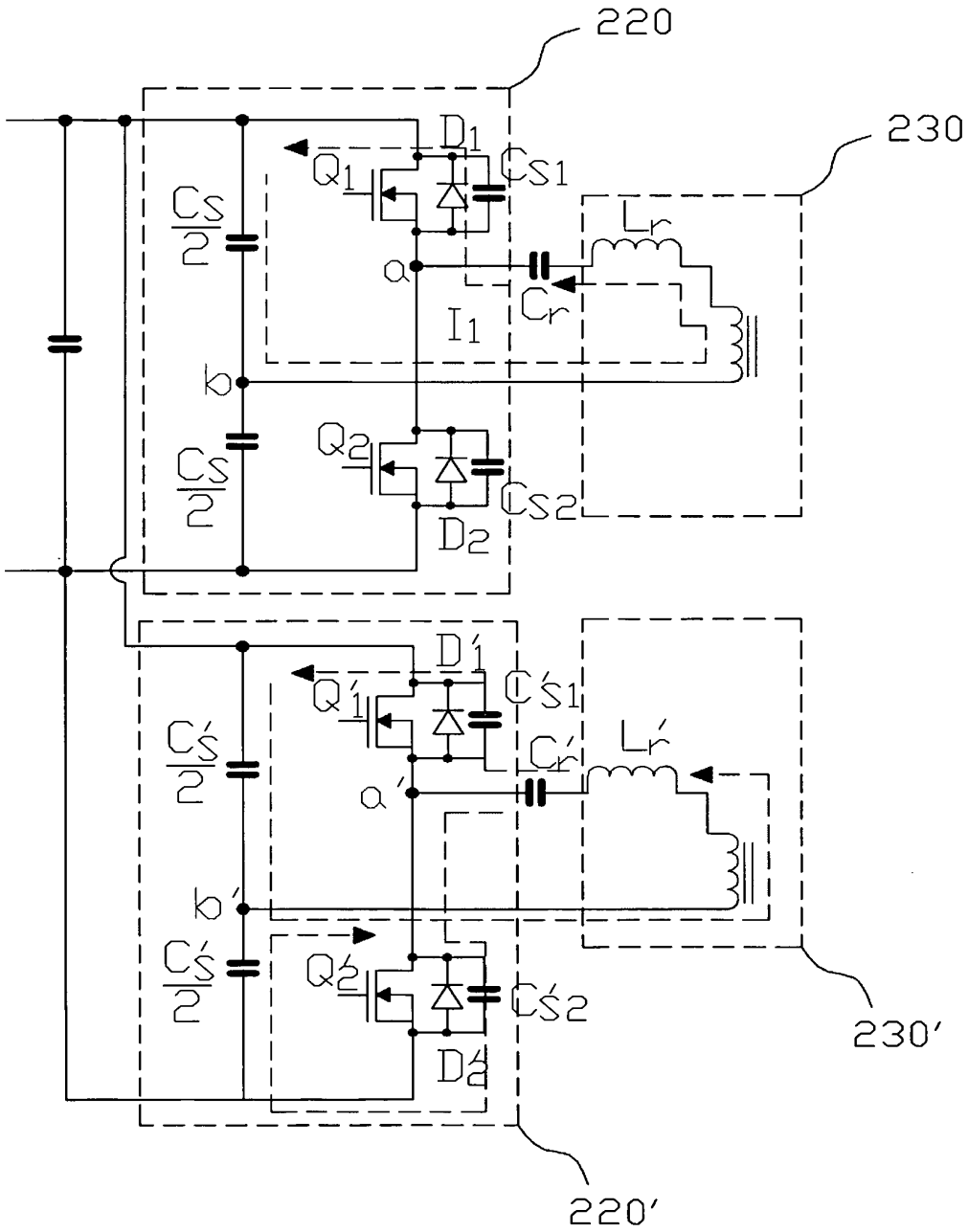
【FIG. 15】


220
230
D1
Q1
CS1
Cs/2
a
Lr
Cr
I1
b
Q2
Cs/2
CS2
D2
D'1
Q'1
C'S1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C'S2
D'2
230'
220'

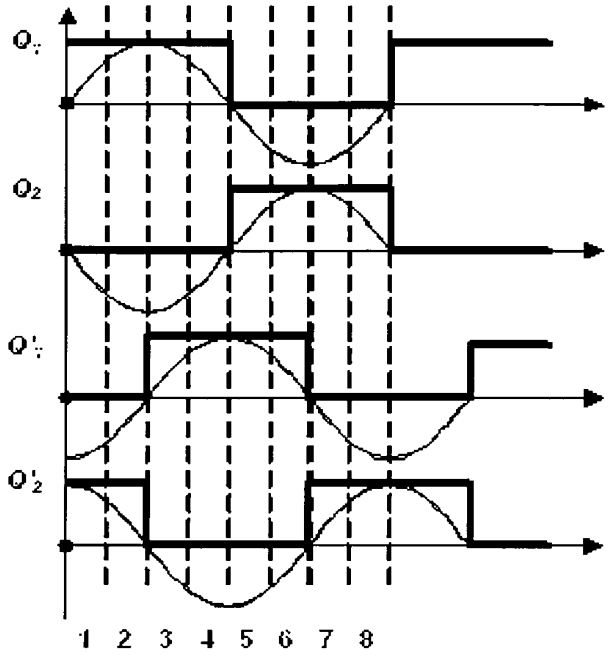
【FIG. 16】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

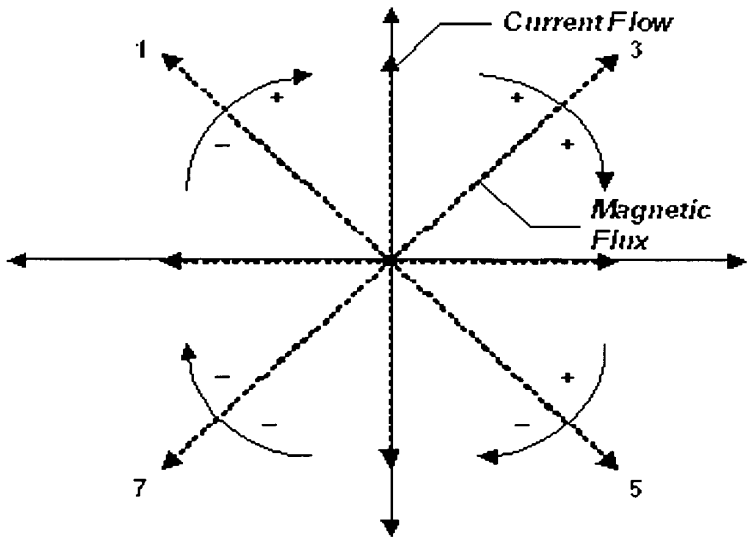
【FIG. 17】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

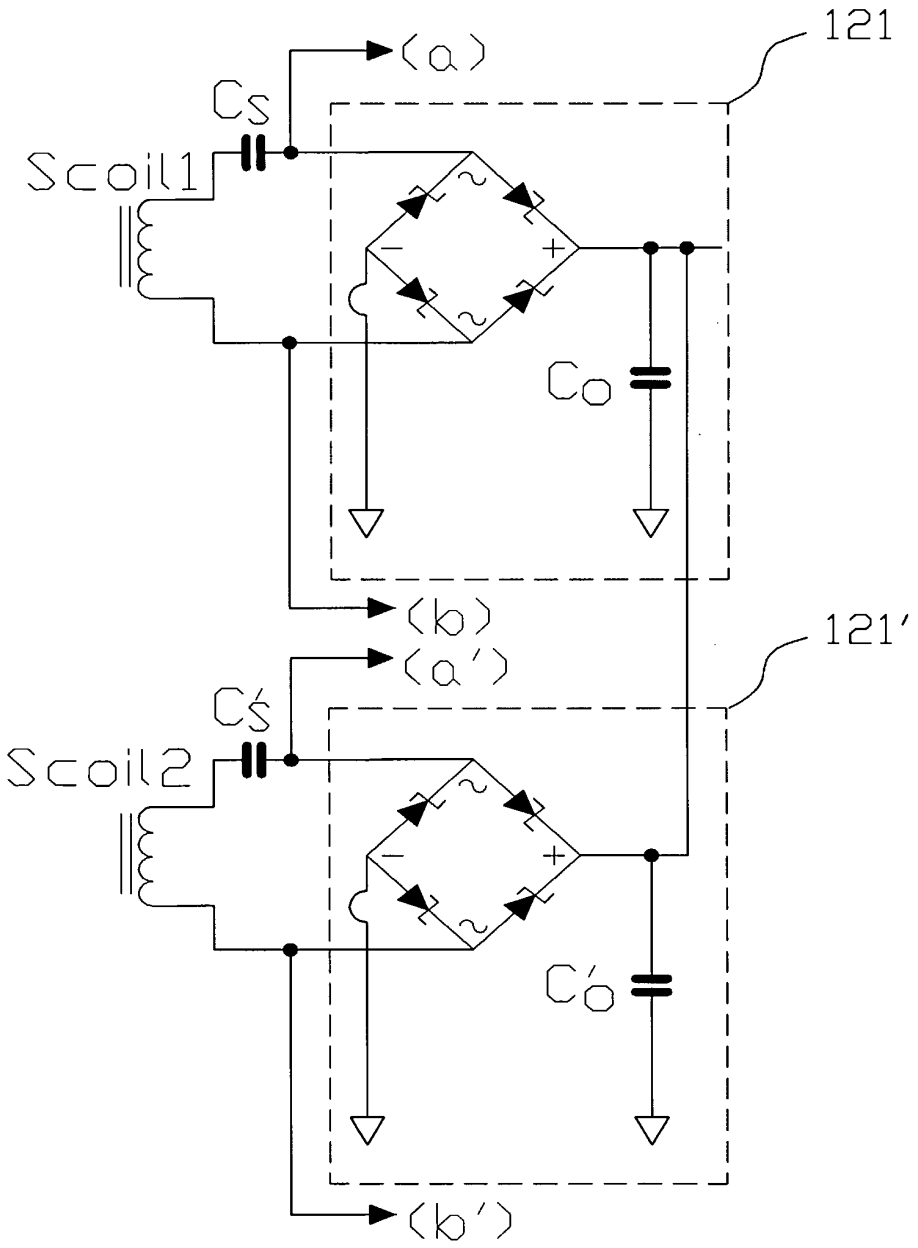
【FIG. 18】



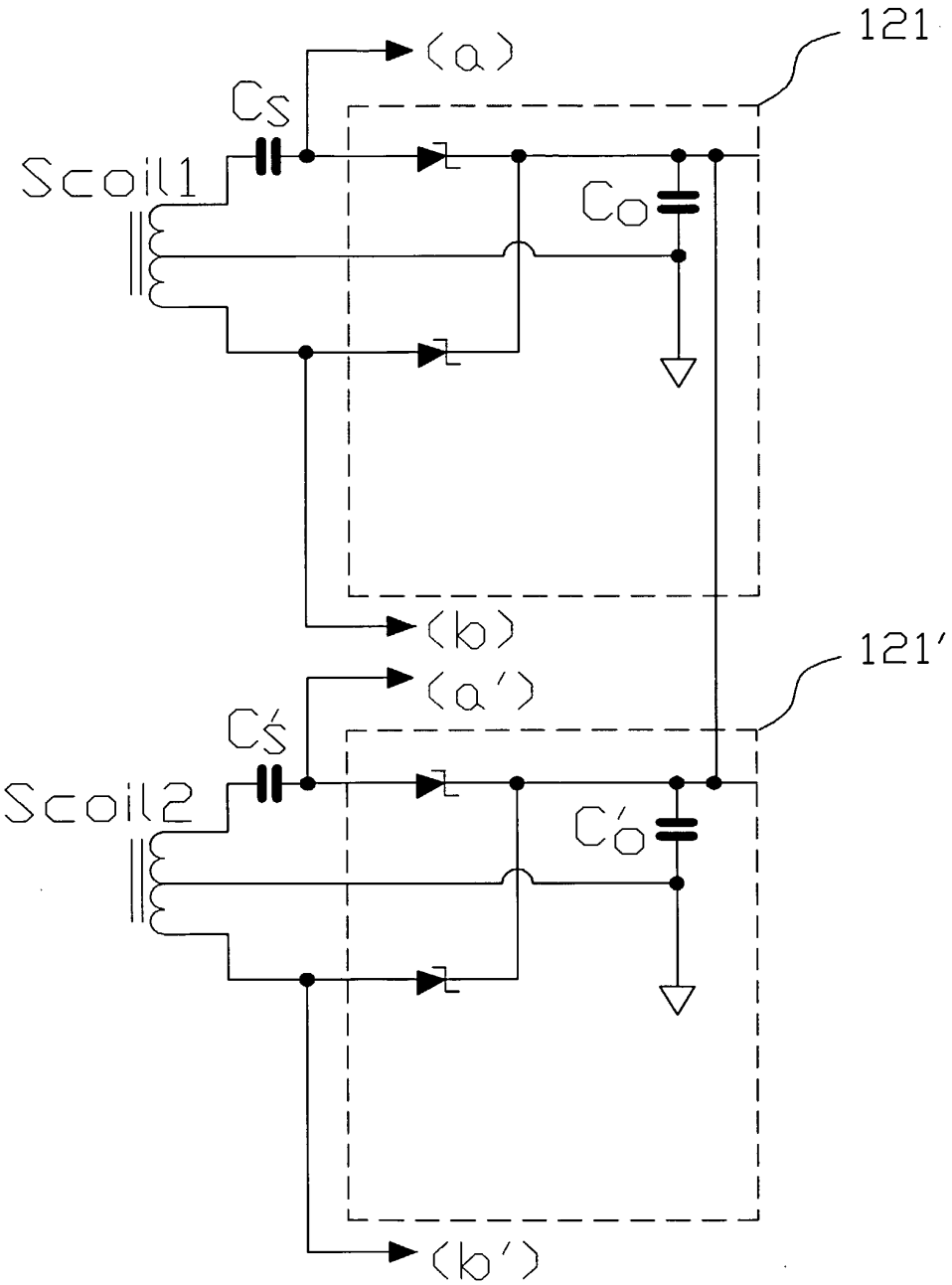
【FIG. 19】



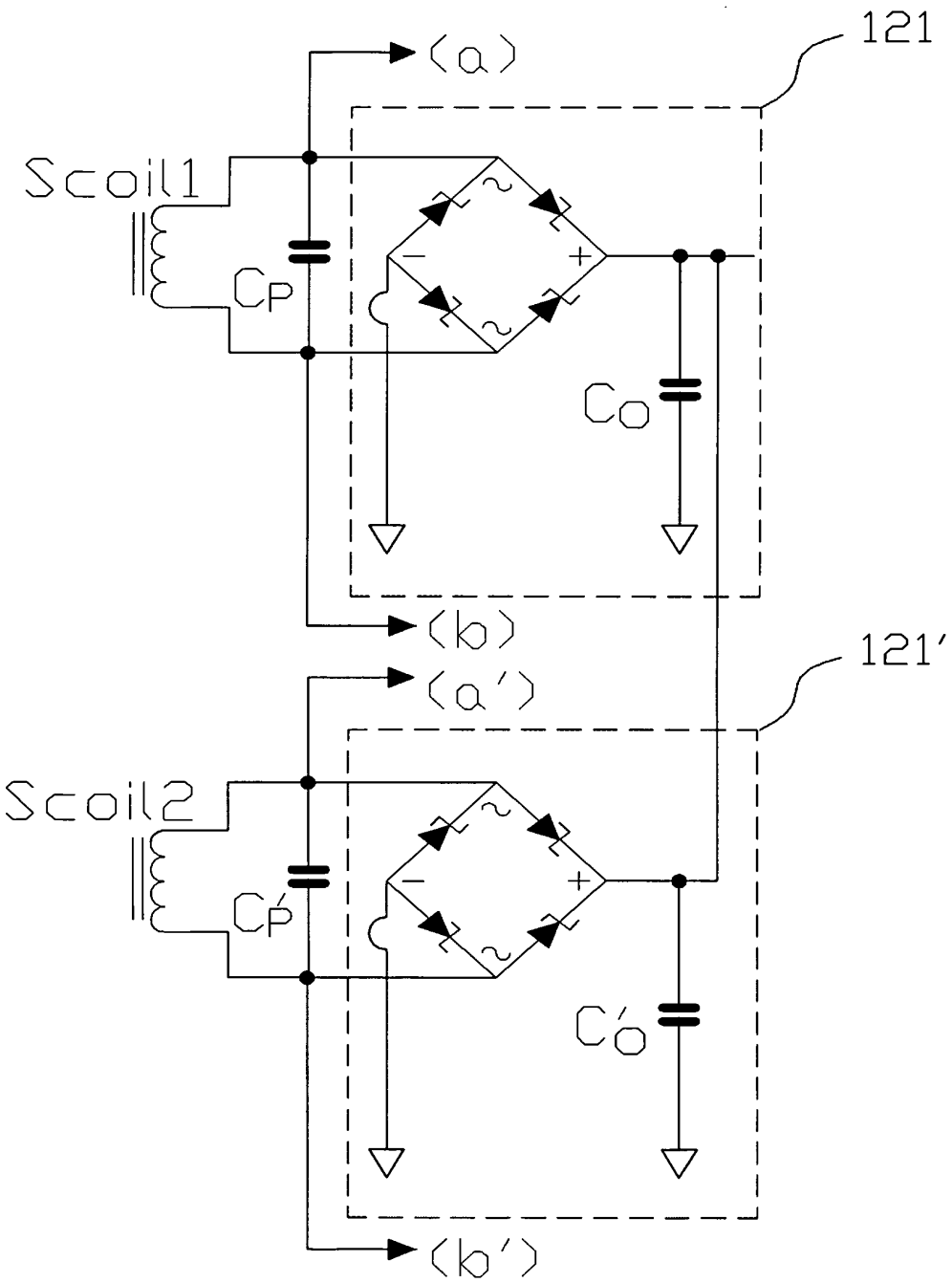
【FIG. 20】



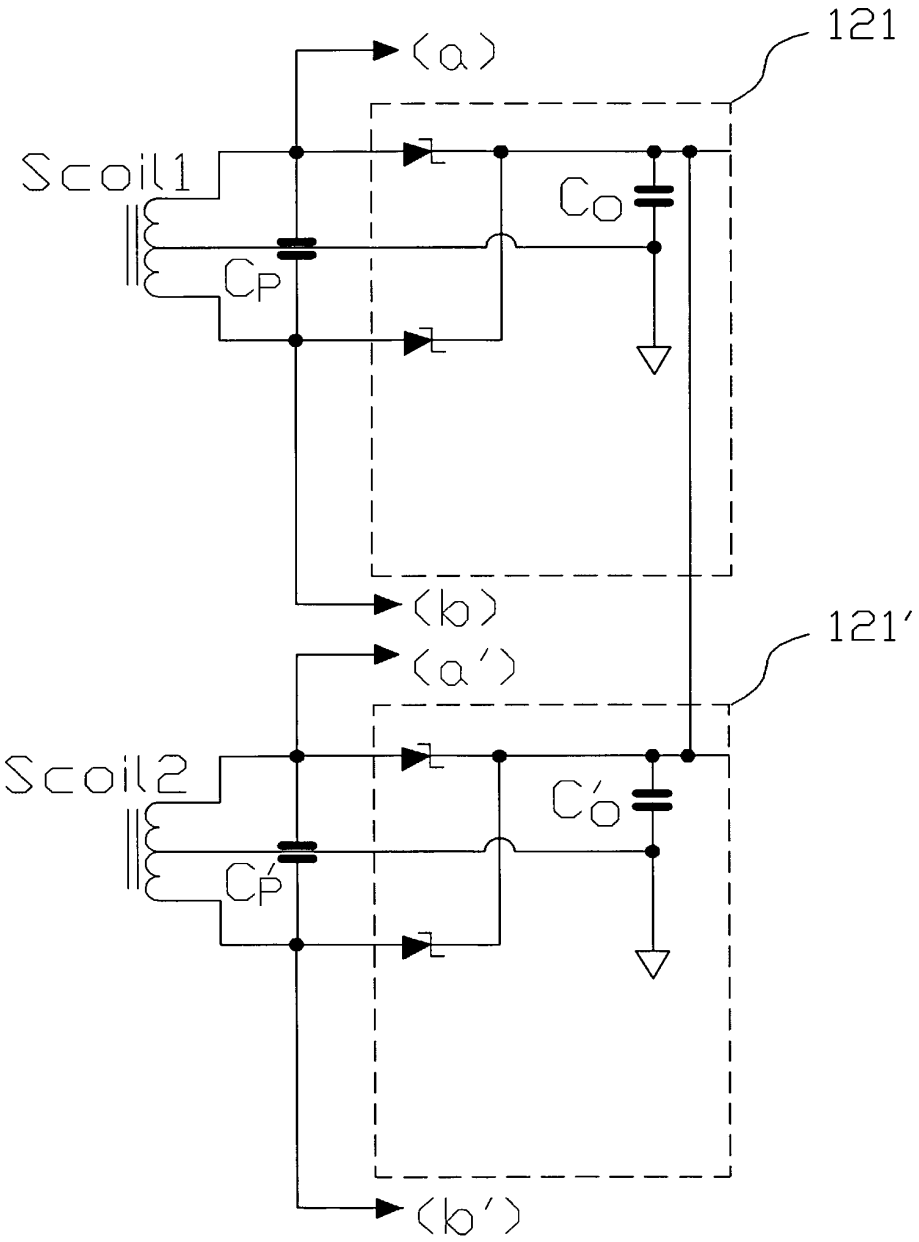
【FIG. 21】



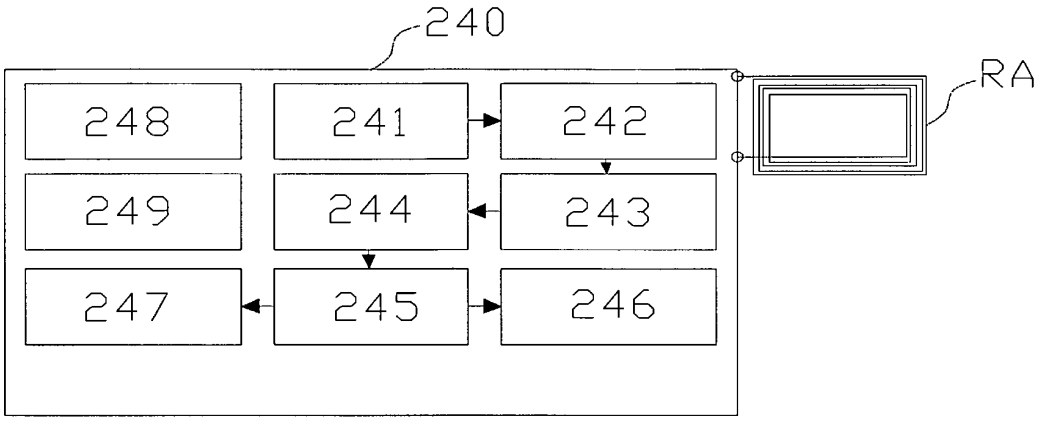
【FIG. 22】



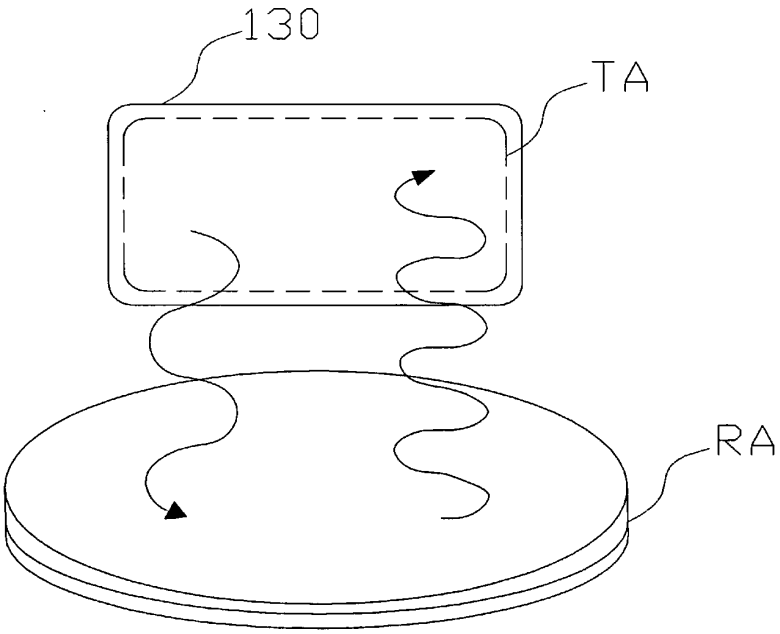
【FIG. 23】



【FIG. 24】



【FIG. 25】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/002263

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H02J 7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7: H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and application for inventions since 1975
Korean Utility Modles and application for Utility for Utility Models since 1975
Japanese Utility modles and application for Utility for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5600225 A (NEC CO., LTD.) 4 FEB. 1997 Abstract, fig. 2, Claims 1-3	1, 9
A	JP 2003-047178 A (SONY CO., LTD.) 14 FEB. 2003 Abstract, fig. 1, Claims 1-3	1, 9
A	JP 11-178232 A (CANON INC.) 2 JUL. 1999 Fig. 1, Claims 1-3	1, 9
A	JP 2002-272020 A (SONY CO., LTD.) 20 SEP 2002 Abstract, fig. 1, Claims 1-4	1, 9
A	JP 09-233706 A (HITACHI CO., LTD) 5 SEP. 1997 Abstract, fig. 1, Claim 1	1, 9
A	JP 11-68837 A (CASIO COMPUTER CO., LTD) 22 JUN. 1999 See the whole document	1, 9
A	JP 10-201113 A (OKI ELECTRIC INDUSTRIAL CO., LTD.) 31 JUL. 1998 See the whole document	1, 9

☐ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 MARCH 2005 (25.03.2005)	**26 MARCH 2005 (26.03.2005)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea	JEON, Yong Hai
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5657

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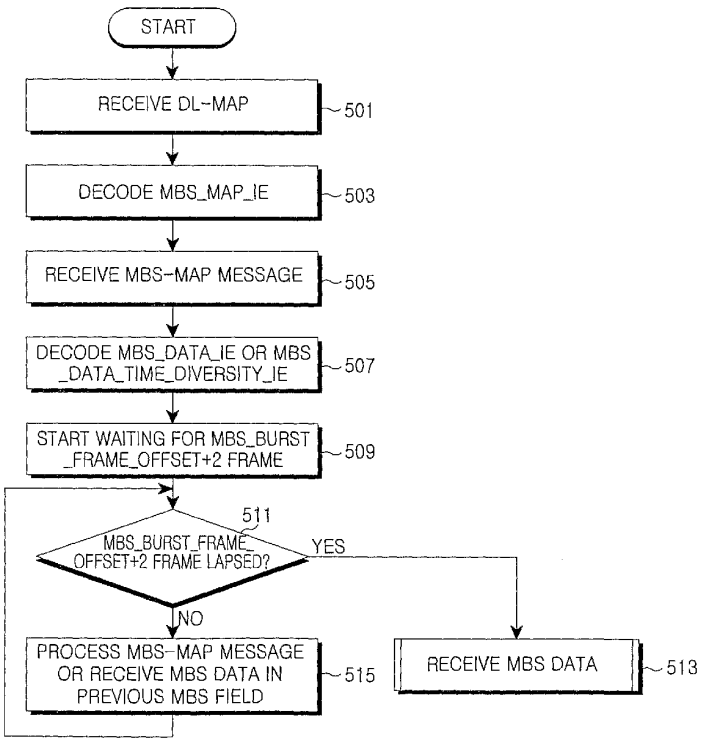
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(74) Agent: **LEE, Keon-Joo**; Mihwa Bldg. 110-2, Myongryun-dong 4-ga, Chongro-gu, Seoul 110-524 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO,

[Continued on next page]

(54) Title: METHOD FOR TRANSMITTING/RECEIVING DATA IN A COMMUNICATION SYSTEM



(57) Abstract: Provided is a method for transmitting/receiving data in a communication system providing Multicast/Broadcast Service (MBS). The method includes, generating transmission data to be transmitted to a receiver; allocating the transmission data to a frame; setting a MAP message that includes information on a frame offset related to the frame; and transmitting to the receiver the MAP message.

WO 2006/115368 A1

NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD FOR TRANSMITTING/RECEIVING DATA IN A COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a communication system, and in particular, to a method for transmitting/receiving data in a communication system providing Multicast and Broadcast Service (MBS).

2. Description of the Related Art

In the next generation communication system, active research is being conducted to provide users with services varying in Quality-of-Service (QoS) and at a high data rate. Particularly, in the current next generation communication system, studies are being carried out to support high-speed services capable of guaranteeing mobility and QoS in a Broadband Wireless Access (BWA) communication system such as a wireless Local Area Network (LAN) communication system and a wireless Metropolitan Area Network (MAN) communication system. The Institute of Electrical and Electronics Engineers (IEEE) 802.16 communication system is a typical BWA, LAN and MAN communication system.

The IEEE 802.16 communication system employs an Orthogonal Frequency Division Multiplexing (OFDM)/Orthogonal Frequency Division Multiple Access (OFDMA) scheme to support a broadband transmission network for physical channels of the wireless MAN system. The IEEE 802.16 communication system currently takes into account not only fixed elements of a system but also mobile a subscriber stations (SS). An SS having both fixed elements and mobile elements will be referred to as a mobile station (MS).

The BWA communication system provides user with high-speed multimedia communication service, for example, MBS, beyond the voice and packet data communication services provided in the existing communication system. That is, in a communication system providing MBS, a transmitter, for example, a base station (BS), provides broadcast contents to a plurality of

receivers, for example, MSs, using a multicast scheme. The multicast scheme refers to a transmission scheme in which one transmitter transmits transmission data to a plurality of receivers. The communication system providing MBS divides its full broadcast service area into a plurality of service areas, and in each of the divided service areas, one or more transmitters transmit MBS data to all receivers located in their service area using the multicast scheme. The receivers located in each service area simultaneously receive the MBS data from their transmitter(s). In the communication system providing a MBS, one transmitter may manage more than one service areas and simultaneously provide the MBS to receivers located in the multiply service areas.

In the communication system providing the MBS, particularly in the IEEE 802.16 communication system, a transmitter transmits MBS data to receivers at the same frame number and the same MBS symbol position at the same time using the same coding scheme. In order to allow a receiver located in a boundary area of each service area to obtain a macro diversity effect through radio frequency combining, the transmitter should define an MBS field (or MBS zone) in a downlink frame and transmit the MBS data through the MBS field. The receiver receives an MBS-MAP message including information on an MBS field that it should receive in the downlink frame, to detect the MBS field, thereby receiving the MBS data transmitted through the MBS field. Herein, the MAP message transmitting downlink resource allocation information is referred to as a downlink-MAP (DL-MAP) message, and the MAP message transmitting uplink resource allocation information is referred to as an uplink-MAP (UL-MAP) message.

If the transmitter transmits downlink resource allocation information and uplink resource allocation information through the DL-MAP message and the UL-MAP message in this way, the receivers decode the DL-MAP message and UL-MAP message transmitted by the transmitter to detect the allocation position of resources allocated thereto and the control information of the data they should receive. The MSs can transmit/receive data through the downlink and the uplink by detecting the resource allocation position and control information.

FIG. 1 is a diagram illustrating a structure of a downlink frame in a

general communication system providing MBS. In FIG. 1, a downlink frame is represented by subchannels and symbols in a time domain and a frequency domain.

Referring to FIG. 1, a downlink frame includes a preamble field 101, DL-MAP fields 103 and 105, an MBS-MAP message field 109, and a plurality of MBS data burst fields, i.e., an MBS data burst 1 field 113, an MBS data burst 2 field 115, and an MBS data burst 3 field 117. Further, the DL-MAP field 103 includes an MBS_MAP_Information Element (MBS_MAP_IE) field 107, and the MBS-MAP message field 109 includes an MBS_Data_Information Element (MBS_Data_IE) field 111.

The preamble field 101 transmits a synchronization signal, i.e., a preamble sequence, for synchronization acquisition between a transmitter and a receiver. The DL-MAP fields 103 and 105, fields for transmitting DL-MAP information, include the MBS_MAP_IE field 107 to provide MBS, and an MBS_MAP_IE included in the MBS_MAP_IE field 107 provides information for decoding the MBS-MAP message field 109. A format of the MBS_MAP_IE included in the MBS_MAP_IE field 107 is shown in Table 1 below.

Table 1

Syntax	Size (bits)	Notes
MBS_MAP_IE() {		
Extended DIUC	4	MBS_MAP=0x0A
Length	4	
MBS Zone Identifier	7	MBS Zone identifier corresponds to the identifier provided by the BS at connection initiation
Macro diversity enhanced	1	0=Non Macro diversity enhanced zone 1=Macro diversity enhanced zone
If(Macro diversity enhanced=1) {		
Permutation	2	0b00=PUSC permutation 0b01=FUSC permutation 0b10=Optional FUSC permutation 0b11=Adjacent subcarrier permutation

IDcell	6	
}		
OFDMA symbol offset	7	OFDMA symbol offset with respect to start of the MBS region
DIUC change indication	1	Used to indicate DIUC change is included
If(DIUC change indication=1) {		
Reserved	1	
Boosting	3	
DIUC	4	
No. subchannels	6	
No. OFDMA symbols	2	
Repetition coding indication	2	0b00=No repetition coding 0b01=repetition coding of 2 used 0b10=repetition coding of 4 used 0b11=repetition coding of 6 used
} else {		
DIUC	4	
CID	12	12 LSB of CID
OFDMA symbol offset	8	The offset of the OFDMA symbol in which the burst starts, measured in OFDMA symbols from beginning of the downlink frame in which the DL-MAP is transmitted.
Subchannel offset	6	The lowest index OFDMA subchannel used for carrying the burst, starting from subchannel 0.
Boosting	3	
SLC_3_Indication	1	Used to notify sleep mode class 3 is used for single BS MBS service
No. OFDMA symbols	6	
No. subchannels	6	
Repetition coding indication	2	0b00=No repetition coding 0b01=Repetition coding of 2 used 0b10=Repetition coding of 4 used 0b11=Repetition coding of 6 used
If(SLC_3_Indication=0) {		

Next MBS frame offset	8	The Next MBS frame offset value is lower 8bits of the frame number in which the BS shall transmit the next MBS frame.
Next MBS OFDMA symbol offset	8	The offset of the OFDMA symbol in which the next MBS zone starts, measured in OFDMA symbols from the beginning of the downlink frame in which the MBS-MAP is transmitted.
}		
}		
If!(byte boundary) {		
Padding nibble	Variable	Padding to reach byte boundary
}		
}		

Table 1 shows Information Elements (IEs) of the MBS_MAP_IE included in the MBS_MAP_IE field 107. In Table 1, 'Extended Downlink Interval Usage Code (Extended DIUC)' indicates that the MBS_MAP_IE includes MBS-MAP information, and is set to have a value of '0x0A'. 'MBS Zone Identifier' indicates an identifier of the MBS field, 'Macro Diversity Enhanced' indicates whether macro diversity is applied to the MBS field, and 'Permutation' and 'IDcell' indicate information necessary when the macro diversity is applied to the MBS zone. Herein, the MBS field includes the MBS-MAP message field 109 having the MBS_Data_IE field 111, and a plurality of MBS data burst fields 113, 115 and 117.

In addition, 'OFDMA symbol offset' indicates a start offset of an MBS-MAP message in the MBS field, 'DIUC change indication' indicates a change in DIUC to be used for receiving the MBS-MAP message, and 'No. Subchannels' indicates the number of allocated subchannels. Further, 'No. OFDMA Symbols' indicates the number of allocated OFDMA symbols, and 'Repetition coding indication' indicates coding information to be used for decoding the MBS-MAP message. The IEs not mentioned in Table 1 are not directly related to the present invention, so a detailed description thereof will be omitted herein.

As shown in Table 1, the MBS_MAP_IE field 107 includes information on the MBS-MAP message field 109, and receivers receive the MBS-MAP message transmitted with the MBS-MAP message field 109 through the MBS_MAP_IE. With reference to Table 2, a detailed description will now be made of the MBS-MAP message. Table 2 below shows a format of the MBS-MAP message.

Table 2

Syntax	Size(bits)	Notes
MBS-MAP Message format () {		
MAC Generic Header	48	6bytes
Management message type=62	4	
Frame number	4	The frame number is identical to the frame number in the DL-MAP
MBS_DIUC_Change_Count	8	
# MBS_DATA_IE	4	Number of included MBS_DATA_IE
For(i=0;i<n; i++) {		N= #MBS_DATA_IE
MBS_DATA_IE	Variable	
}		
#MBS_DATA_Time_Diversity_IE	4	Number of included MBS_DATA_Time_Diversity_IE
For(i=0;i<m; i++) {		m= #MBS_DATA_ Time_Diversity_IE
MBS_DATA_Time_Diversity_IE	Variable	
}		
If(!byte boundary) {		
Padding nibble	8	
}		
TLV encoding element		
}		

Table 2 shows a format of the MBS-MAP message transmitted through the MBS-MAP message field 109. The MBS-MAP message includes a 6-byte or 48-bit Medium Access Control (MAC) Generic Header, and a plurality of IEs. Of the IEs, 'Management Message Type' indicates a type of a management message,

'Frame number' indicates the same frame number as a frame number of the DL-MAP, and 'MBS DIUC Change Count' indicates whether the MBS data burst profile is identical to a previous MBS data burst profile.

If a value of the 'MBS DIUC Change Count' is changed, the receiver that received the MBS-MAP message should receive downlink burst profile information included as Time/Length/Value (TLV) information of the MBS-MAP message. However, if the downlink burst profile information is not included in the MBS-MAP message, the receiver receives the downlink burst profile information through a next Downlink Channel Descriptor (DCD) message. In addition, 'MBS_Data_IE' and 'MBS_Data_Time_Diversity_Information Element' (MBS_Data_Time_Diversity_IE) indicate field information of MBS data bursts that the receiver will receive. The 'MBS_Data_Time_Diversity_IE' includes information on MBS data bursts allocated when there is only the MBS burst data for a receiver supporting a Hybrid Automatic Repeat reQuest (HARQ) scheme. The IEs not mentioned in Table 2 are not directly related to the present invention, so a detailed description thereof will be omitted herein.

With reference to Table 3, a description will now be made of the MBS_Data_IE including information on the MBS data burst fields 113, 115 and 117 over which MBS data is transmitted.

Table 3

Syntax	Size (bits)	Notes
MBS_DATA_IE {		
MBS_MAP_Type=0	4	MBS_DATA_IE
Next MBS MAP change indication	1	This indicates whether the size of MBS MAP message of next MBS frame for these multicast CIDs included this IE will be different from the size of this MBS MAP message.
No. of Multicast CID	3	
For(i=0;i<No. of Multicast CIDs; i++) {		
Multicast CID	12	12 LSBs of CID for multicast

}		
MBS DIUC	4	
OFDMA symbol offset	8	OFDMA symbol offset with respect to start of the MBS portion
Subchannel offset	6	OFDMA subchannel offset with respect to start of the MBS portion
Boosting	3	
No. OFDMA symbols	7	The size of MBS data
No. subchannels	6	
Repetition coding indication	2	0b00=No repetition coding 0b01=Repetition coding of 2 used 0b10=Repetition coding of 4 used 0b11=Repetition coding of 6 used
Next MBS frame offset	8	The Next MBS frame offset value is lower 8 bits of the frame number in which the BS shall transmit the next MBS frame.
Next MBS OFDMA symbol offset	8	The offset of the OFDMA symbol in which the next MBS portion starts, measured in OFDMA symbols from beginning of the downlink frame in which the MBS-MAP is transmitted.
If(Next MBS MAP change indication=1) {		
Next MBS No. OFDMA symbols	2	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
Next MBS No. OFDMA symbols	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
}		
}		

Table 3 shows IEs of the MBS_Data_IE transmitted through the MBS_Data_IE field 111. In Table 3, 'MBS_MAP_Type' indicates that the IEs of Table 3 are MBS_Data_IE, and 'Next MBS MAP change indication' indicates a

change in size of an MBS-MAP message that will come in the next MBS frame, wherein the MBS frame means the frame that includes information of the MBS data or the data burst of the MBS. In addition, 'Multicast Connection Identifier (CID)' indicates multicast identifier information mapped to the MBS_Data_IE, 'OFDMA Symbol Offset' and 'Subchannel Offset' indicate start offsets of the MBS data burst fields 113, 115 and 117, and 'No. Subchannels' indicates the number of subchannels of the MBS data burst fields 113, 115 and 117 allocated to the MBS frame. Further, 'No. OFDMA Symbols' indicates the number of OFDMA symbols of the allocated MBS data burst fields 113, 115 and 117, and 'Repetition coding indication' indicates the number of repetitions (or iterations) needed for decoding the MBS data transmitted through the MBS data burst fields 113, 115 and 117.

In addition, 'Next MBS frame offset' indicates an offset of the next MBS frame, and 'Next MBS OFDMA symbol offset' indicates an offset of a downlink frame OFDMA symbol for receiving the next MBS-MAP message. Herein, if the 'Next MBS MAP change indication' is set to '1', it means that the 'Next MBS OFDMA symbol offset' includes 'Next MBS No. OFDMA symbols' indicating a size of an MBS-MAP message that will come in the next MBS frame, and 'Next MBS No. OFDMA subchannels'. After receiving the 'Next MBS frame offset' and the 'Next MBS OFDMA symbol offset', the receiver can obtain the MBS service information without receiving the MBS_MAP_IE of the DL-MAP. The IEs not mentioned in Table 3 are not directly related to the present invention, so a detailed description thereof will be omitted herein.

The foregoing MBS-MAP message serves as a MAC control message including information so that the receiver can decode the MBS data burst fields and the corresponding MBS data in MBS data transmitted through the fields. As a result, the MBS-MAP message shown in Table 2 provides information on the MBS data burst fields to the receivers, along with 48-bit MAC Generic Header, as described above. If the amount of information on the MBS data burst fields in which the MBS-MAP message is to be included is large, the MBS-MAP message may not include information on many MBS data burst fields that should be included in one MBS frame, because of the 48-bit MAC Generic Header. Accordingly, the MBS-MAP message is not fully transmitted in one MBS frame,

and is transmitted in the next MBS frame, along with the MAC Generic Header.

As the MBS-MAP message is transmitted over two MBS frames together with the MAC Generic Header, the MAC Generic Header becomes an overhead. In addition, the transmitter transmits the MBS-MAP message over two MBS frames due to the 48-bit MAC Generic Header even for the information on the MBS data burst fields that can be transmitted in one MBS frame, thereby causing a waste of frequency bands. In order to prevent the waste of the frequency bands, it is also possible to allocate information on some of the MBS data burst fields to the current MBS frame before transmission, and transmit information on the other MBS data burst fields in the next MBS frame. In this case, there is a need for a scheme for additionally transmitting information indicating to which MBS frame the information on the MBS data burst fields included in the MBS-MAP message transmitted in the current MBS frame is allocated before being transmitted.

FIG. 2 is a diagram schematically illustrating a structure of an MBS frame in a general communication system providing MBS. In FIG. 2, an MBS-MAP message and information on MBS data burst fields included in the MBS-MAP message are transmitted over two frames of a particular frame n and the next frame (n+1). For convenience, FIG. 2 illustrates only the MBS field in the downlink MBS frame of FIG. 1.

Referring to FIG. 2, an MBS frame n 200 includes an MBS-MAP message field 201, and a plurality of MBS data burst fields that include an MBS data burst 1 field 211, an MBS data burst 2 field 213 and an MBS data burst 3 field 215. The MBS-MAP message field 201 includes a plurality of an MBS_Data_IE fields 203, 205, 207 and 209 each including MBS data burst field information. In addition, an MBS frame (n+1) 250, the next frame of the MBS frame n 200, includes an MBS-MAP message field 251, and a plurality of MBS data burst fields that include an MBS data burst 4 field 255 and an MBS data burst 5 field 257. The MBS-MAP message field 251 includes an MBS_Data_IE 253 including the MBS data burst field information. The MBS_Data_IEs transmitted through the MBS_Data_IE fields 203, 205, 207 and 209 included in the MBS-MAP message field 201 of the MBS frame n 200 include information on the MBS data burst fields 211, 213, 215 and 255. In addition, the

MBS_Data_IE transmitted through the MBS_Data_IE field 253 included in the MBS-MAP message field 251 of the MBS frame (n+1) 250 includes information on the MBS data burst fields 257.

Because the MBS data burst fields 211, 213, 215 and 255 mapped to the MBS_Data_IE transmitted through the MBS_Data_IE fields 203, 205, 207 and 209 included in the MBS-MAP message field 201 of the MBS frame n 200 cannot be wholly allocated to one MBS frame, i.e., the MBS frame n 200, the receiver cannot fully receive the MBS data transmitted through the MBS data burst fields 211, 213, 215 and 255. Accordingly, the MBS data burst 1 field 211, the MBS data burst 2 field 213 and the MBS data burst 3 field 215 among the MBS data burst fields 211, 213, 215 and 255 are allocated to the MBS frame n 200, so that the receiver receives MBS data transmitted through the MBS data burst 1 field 211, the MBS data burst 2 field 213 and the MBS data burst 3 field 215 in the MBS frame n 200. In addition, the MBS data burst 4 field 255 among the MBS data burst fields 211, 213, 215 and 255 is allocated to the MBS frame (n+1) 250, so that the receiver receives MBS data transmitted through the MBS data burst 4 field 255 in the MBS frame (n+1) 250.

At this moment, the receiver cannot determine whether the transmitter has allocated the MBS data bursts 211, 213, 215 and 255 mapped to the MBS-MAP message field 201 of the MBS frame n 200 in the current MBS frame, i.e., the MBS frame n 200, or in the next MBS frame, i.e., the MBS frame (n+1) 250. Therefore, upon receiving the MBS frame n 200, the receiver decodes the MBS data of the MBS data burst 1 field 211, MBS data of the MBS data burst 2 field 213, and MBS data of the MBS data burst 3 field 215 received in the MBS frame n 200, using the MBS_Data_IE included in the MBS_Data_IE fields 203, 205 and 207 of the MBS-MAP message field 201. In addition, upon receiving the next MBS frame, i.e., the MBS frame (n+1) 250, the receiver decodes the MBS data of the MBS data burst 5 field 257 received in the MBS frame (n+1) 250 using the MBS_Data_IE included in the MBS_Data_IE field 253 of the MBS-MAP message field 251.

FIG. 2 illustrates operations 221, 223, 255 and 271 of decoding the MBS data transmitted through the MBS data burst fields 211, 213, 215 and 257, using the

MBS_Data_IE in each frame. As described with reference to FIG. 2, in the MBS frame n 200, information on the MBS data burst fields included in the MBS-MAP message field 201 is information on the MBS data burst 1 field 211, the MBS data burst 2 field 213, the MBS data burst 3 field 215 and the MBS data burst 4 field 255. Although the information on the MBS data burst fields 211, 213, 215 and 255 is allocated to the MBS frame n 200 in this manner, the MBS data burst 4 field 255 is actually allocated to the MBS frame (n+1) 250.

However, the receiver receiving the MBS frame n 200 cannot determine that the transmitter has allocated the MBS data burst fields 211, 213, 215 and 255 as described above, using the MBS-MAP message and the MBS_Data_IE having the structures of Table 2 and Table 3, transmitted through the MBS-MAP message field 201 and the MBS_Data_IE fields 203, 205, 207 and 209 of the MBS frame n 200. Therefore, upon receiving the MBS frame n 200, i.e., the current MBS frame, the receiver performs an operation 227 of decoding the MBS data transmitted through the MBS data burst 4 field 255, considering that the MBS data burst 4 field 255 is allocated to the current MBS frame. However, because the MBS data burst 4 field 255 is not allocated to the MBS frame n 200, an error may occur in the receiver.

In addition, the receiver, receiving the MBS-MAP message with the MBS_Data_IE in a particular MBS frame, may not decode the MBS data transmitted through the MBS data burst fields mapped to the MBS_Data_IE in the particular MBS frame in a real time. That is, even though the transmitter has transmitted the MBS data through the MBS_Data_IE and the MBS data burst fields including allocation and decoding information of the MBS data burst fields in the particular MBS frame, the receiver may fail to decode the MBS data transmitted through the MBS data burst fields due to its processing delay.

Therefore, because the MBS data burst fields individually mapped to the MBS data burst fields included in the MBS_Data_IE of the MBS-MAP message should be allocated to the same MBS frame as the MBS-MAP message field through which the MBS-MAP message is transmitted, there is a need for a scheme for reducing a size of the MBS-MAP message. In addition, there is a demand for a scheme for reducing a processing error which may occur when the

receiver recognizes an MBS frame to which the MBS data burst fields are allocated, and decodes the MBS data transmitted through the MBS data burst fields. Further, there is a need for a scheme in which the transmitter provides the receiver with information used for previously decoding the MBS data before a transmission time of the MBS data through the MBS data burst fields, and an allocation time of the MBS data burst fields through which the MBS data is transmitted, i.e., a transmission time of the MBS data, thereby preventing the processing delay of the receiver.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a method for transmitting/receiving data in a communication system.

It is another object of the present invention to provide a data transmission/reception method for preventing processing delay and misoperation of the system by previously transmitting/receiving data transmission information before a data transmission time in a communication system.

It is further another object of the present invention to provide a data transmission/reception method in a communication system providing MBS.

According to one aspect of the present invention, there is provided a method for transmitting data in a communication system. The method includes, generating transmission data to be transmitted to a receiver; allocating the transmission data to a frame; setting a MAP message that includes information on a frame offset related to the frame; and transmitting to the receiver the MAP message.

According to another aspect of the present invention, there is provided a method for transmitting data in a communication system. The method includes, upon generation of data to be transmitted to a receiver, determining a transmission field of the generated data, and allocating the determined transmission field to a frame; setting in transmission field information location information of the transmission field allocated to the frame and frame offset information defining an

offset between the frame to which the transmission field is allocated and a reference frame; and transmitting to the receiver a MAP message including the set transmission field information.

According to another aspect of the present invention, there is provided a method for transmitting data in a communication system. The method includes, upon generation of data to be transmitted to a receiver, determining a transmission field of the generated data; determining offset of frame including the transmission field; setting in data information offset information defining the offset of frame and location information of the transmission field according to the offset information; and transmitting to the receiver a MAP message including the set data information.

According to another aspect of the present invention, there is provided a method for transmitting multicast broadcast service (MBS) data of a base station (BS) in a broadband wireless access (BWA) communication system. The method includes, determining a frame offset of MBS data burst, a frame comprising the MBS data burst is the n-th frame following the current frame comprising the frame offset; determining a position of the MBS data burst within the n-th frame; setting information of the frame offset and the position in a message; and transmitting the message to a mobile station.

According to further another aspect of the present invention, there is provided a method for receiving data in a communication system. The method includesreceiving a MAP message that includes information on a frame offset related to a data burst before receiving the data burst from a transmitter; analyzing the information on the frame offset; and receiving from the transmitter the data burst within the n-th frame flowing a frame comprising the MAP message according to the analysis of the information.

According to yet another aspect of the present invention, there is provided a method for receiving data in a communication system. The method includesupon receiving a MAP message before receiving data from a transmitter, analyzing location information of a data burst included in the MAP message and frame offset information defining an offset between a frame to which the data

burst is allocated and a current frame; and receiving the data burst within the frame according to the analyzed location information and the frame offset information.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram illustrating a structure of a downlink frame in a general communication system providing MBS;

FIG. 2 is a diagram illustrating a structure of an MBS frame in a general communication system providing MBS;

FIG. 3 is a diagram illustrating a structure of an MBS frame in a communication system providing MBS according to the present invention;

FIG. 4 is a flowchart schematically illustrating an operation of a receiver in a communication system providing MBS according to the present invention;

FIG. 5 is a flowchart illustrating an operation of a receiver in a communication system providing MBS according to another embodiment of the present invention; and

FIG. 6 is a flowchart illustrating an operation of a transmitter in a communication system providing MBS according to the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the annexed drawings. In the following description, a detailed description of known functions and configurations incorporated herein has been omitted for clarity and conciseness.

The present invention proposes a method for transmitting/receiving data in an communication system, for example, Institute of Electrical and Electronics Engineers (IEEE) 802.16 communication system which is a typical Broadband Wireless Access (BWA) communication system. Although the present invention will be described below with reference to an IEEE 802.16 communication system

employing an Orthogonal Frequency Division Multiplexing (OFDM)/Orthogonal Frequency Division Multiple Access (OFDMA) scheme, the data transmission method proposed in the present invention can also be applied to other communication systems.

In addition, the present invention proposes a data transmission/reception method between a transmitter, for example, a base station (BS), for managing a service area and a receiver, for example, a mobile station (MS), for receiving communication service from the transmitter in a communication system, wherein the MS is both fixed and mobile. The present invention proposes a method in which a transmitter transmits Multicast and Broadcast Service (MBS) data to a plurality of receivers located in its coverage area and the receivers receive the transmitted MBS data in a communication system providing MBS.

Further, the present invention proposes a method in which a transmitter previously transmits information related to transmission data to a receiver before a data transmission time before transmitting data in a communication system. Herein, the "information related to transmission data" can include information about a frame in which the data is transmitted, information about a data transmission field allocated for data transmission in the frame, and decoding information for the data. The present invention will be described herein based on the communication system providing the MBS. In the communication system providing the MBS, a downlink MBS frame can be represented with subchannels and symbols in a time domain and a frequency domain as described with reference to FIG. 1, wherein the MBS frame means the frame that includes information of the MBS data or the data burst of the MBS. In addition, the downlink MBS frame includes a preamble field, a DL-MAP field, an MBS-MAP message field, and a plurality of MBS data burst fields. Further, the DL-MAP field includes an MBS_MAP_Information Element (MBS_MAP_IE) field, and the MBS-MAP message field includes an MBS_Data_Information Element (MBS_Data_IE) field.

The preamble field transmits a synchronization signal, i.e., a preamble sequence, for synchronization acquisition between a transmitter and a receiver. The DL-MAP field, a field for transmitting DL-MAP information, includes the

MBS_MAP_IE field to provide MBS, and an MBS_MAP_IE included in the MBS_MAP_IE field provides information for decoding the MBS-MAP message field. A format of the MBS_MAP_IE included in the MBS_MAP_IE field is shown in Table 1. As shown in Table 1, 'Extended Downlink Interval Usage Code (Extended DIUC)' of the MBS_MAP_IE indicates that the MBS_MAP_IE includes MBS-MAP information, and is set to have a value of '0x0A'. 'MBS Zone Identifier' indicates an identifier of the MBS field, 'Macro Diversity Enhanced' indicates whether macro diversity is applied to the MBS field (or MBS zone), and 'Permutation' and 'IDcell' indicate information necessary when the macro diversity is applied to the MBS zone. Herein, the MBS field includes the MBS-MAP message field having the MBS_Data_IE field, and a plurality of MBS data burst fields in FIG. 1.

In addition, 'OFDMA symbol offset' indicates a start offset of an MBS-MAP message in the MBS field, 'DIUC change indication' indicates a change in DIUC to be used for receiving the MBS-MAP message, and 'No. Subchannels' indicates the number of allocated subchannels. Further, 'No. OFDMA Symbols' indicates the number of allocated OFDMA symbols, and 'Repetition coding indication' indicates coding information to be used for decoding the MBS-MAP message.

The present invention reduces an overhead due to the MBS-MAP message that a receiver desiring to receive MBS data from a transmitter receives in a communication system providing MBS, allowing the receiver to transmit the MBS-MAP message within one MBS frame. The present invention proposes a method in which when decoding MBS data using information on MBS data burst fields in which MBS data included in the MBS-MAP message is transmitted, a receiver receives MBS data using either information on the MBS-MAP message transmitted over the current MBS frame, or information on the MBS-MAP message transmitted over a previous MBS frame. In this method, the receiver receives MBS data actually transmitted through the MBS data burst fields, and recognizes a processing time of the MBS data, i.e., a decoding time of the MBS data, using the 'MBS_Burst_Frame_Offset' included in the MBS_Data_IE and the MBS_Data_Time_Diversity_Information Element (MBS_Data_Time_Diversity_IE) of the MBS-MAP message. Herein, the

MBS_Data_IE and the MBS_Data_Time_Diversity_IE indicate field information of the MBS data bursts the receiver will receive. The receiver receives the MBS data transmitted through the MBS data burst fields allocated to the MBS frame at the recognized time according to the recognized information, and processes the received MBS data.

A detailed description will now be made of an MBS-MAP message transmitted through the MBS-MAP message field of the MBS frame and a MBS_Data_IE transmitted through a MBS_Data_IE field included in the MBS-MAP message field in the communication system providing MBS according to the present invention.

Table 4 below shows the format of the MBS-MAP message transmitted through the MBS-MAP message field of the MBS frame in the communication system providing MBS according to the present invention.

Table 4

Syntax	Size(bits)	Notes
MBS-MAP Message format () {		
MBS MAP indicator	5	Shall be set to 11101
Reserved	3	Shall be set to 0
Frame number	4	The frame number is identical to the frame number in the DL-MAP
MBS_DIUC_Change_Count	8	
#MBS_DATA_IE	4	Number of included MBS_DATA_IE
For(i=0;i<n; i++) {		n= #MBS_DATA_IE
MBS_DATA_IE	variable	
}		
#MBS_DATA_Time_Diversity_IE	4	Number of included MBS_DATA_Time_Diversity_IE
For(i=0;i<m; i++) {		m= #MBS_DATA_Time_Diversity_IE
MBS_DATA_Time_Diversity_IE	variable	
}		
If(!byte boundary) {		

Padding nibble	8	
}		
TLV encoding element		
}		

Although Table 4, showing the format of the MBS-MAP message transmitted through the MBS-MAP message field of the MBS frame, provides the information similar to that of the MBS-MAP message of Table 2, the MBS-MAP message of Table 4 does not include the 48-bit Medium Access Control (MAC) Generic Header of Table 2. That is, in the communication system providing MBS according to the present invention, the MBS-MAP message uses a format of an independently provided MAC header without transmitting the 48-bit MAC Generic Header to the receiver.

With reference to Table 4, a detailed description will now be made of the MBS-MAP message in the communication system providing MBS according to the present invention. The MBS-MAP message includes an MBS MAP indicator. The MBS MAP indicator has a value '11101', and two Most Significant Bit (MSB) bits, i.e., first and second MSB bits, of the MBS MAP indicator, indicate information mapped to a Header Type (HT) field and an Encryption (EC) field of the MAC header. A value of the HT field, the first MSB bit of the MBS MAP indicator, indicates whether the MBS-MAP message transmits a general MAC PDU or a bandwidth request message, and the EC field, the second MSB bit of the MBS MAP indicator, indicates whether encryption is applied to the currently transmitted frame. A third MSB bit of the MBS MAP indicator indicates whether the corresponding MAP is a compressed MAP, and the third MSB bit of the MBS MAP indicator being set to '0' indicates a compressed MAP. The last two bits, i.e., fourth and fifth MSB bits, of the MBS MAP indicator indicate that the corresponding MAP is a Sub DownLink UpLink MAP (Sub-DL-UL-MAP). Herein, the fourth and fifth MSB bits of the MBS MAP indicator being set to '00' indicates that the next information is a Sub-DL-UL-MAP, and if the fourth and fifth MSB bits of the MBS MAP indicator are set to '01', it indicates that the next information is a MBS-MAP message. The compressed MAP and the Sub-DL-UL-MAP are not related to the present invention, so a detailed description thereof will

be omitted herein.

That is, a transmitter desiring to transmit the MBS-MAP message to the receiver sets the first and second MSB bits of the MBS MAP indicator to '11', and sets the third MSB bit to '1' to indicate a non-compressed MAP. Further, the transmitter sets the fourth and fifth MSB bits of the MBS MAP indicator to '01' to indicate an MBS-MAP message. As a result, the transmitter sets the MBS MAP indicator of the MBS-MAP message to '11101'. Thereafter, the transmitter transmits the MBS MAP indicator to the receiver through the MBS-MAP message field of the MBS frame, and the receiver, receiving the set MBS MAP indicator of the MBS-MAP message through the MBS-MAP message field of the MBS frame, recognizes that the received information is an MBS-MAP message if the five bits of the MBS MAP indicator are set to '11101'.

Thereafter, the receiver performs decoding on the recognized MBS-MAP message, and decodes MBS data transmitted through MBS data burst fields of the MBS frame using information on the MBS data burst fields included in the MBS-MAP message. In addition, 'Frame number' of the MBS-MAP message indicates the same frame number as a frame number of the DL-MAP, and 'MBS DIUC Change Count' indicates whether the MBS data burst profile is identical to a previous MBS data burst profile.

If a value of the 'MBS DIUC Change Count' is changed, the receiver receiving the MBS-MAP message should receive downlink burst profile information included as Time/Length/Value (TLV) information of the MBS-MAP message. However, if the downlink burst profile information is not included in the MBS-MAP message, the receiver receives the downlink burst profile information through a next Downlink Channel Descriptor (DCD) message. In addition, 'MBS_Data_IE' and 'MBS_Data_Time_Diversity_Information Element' (MBS_Data_Time_Diversity_IE) indicate field information of MBS data bursts the receiver will receive. The MBS_Data_Time_Diversity_IE includes information on MBS data bursts allocated when there is only the MBS burst data for a receiver supporting a Hybrid Automatic Repeat reQuest (HARQ) scheme. The IEs not mentioned in Table 4 are not directly related to the present invention, so a detailed description thereof will be omitted herein.

With reference to Table 5, a description will now be made of the MBS_Data_IE including information on the MBS data burst fields in which MBS data is transmitted.

Table 5

Syntax	Size (bits)	Notes
MBS_DATA_IE {		
MBS_MAP_Type=0	3	MBS_DATA_IE
Next MBS frame indicator	1	0=MBS data burst of the current MBS frame 1=MBS data burst of the next MBS frame
Next MBS MAP change indication	1	This indicates whether the size of MBS MAP message of next MBS frame for these multicast CIDs included this IE will be different from the size of this MBS MAP message.
No. of Multicast CID	3	
For(i=o; i<No. of Multicast CIDs; i++) {		
Multicast CID	12	12 LSBs of CID for multicast
}		
MBS DIUC	4	
OFDMA symbol offset	8	OFDMA symbol offset with respect to start of the MBS portion
Subchannel offset	6	OFDMA subchannel offset with respect to start of the MBS portion
Boosting	3	
No. OFDMA symbols	7	The size of MBS data
No. subchannels	6	
Repetition coding indication	2	0b00=No repetition coding 0b01=Repetition coding of 2 used 0b10=Repetition coding of 4 used 0b11=Repetition coding of 6 used
Next MBS frame offset	8	The Next MBS frame offset value is lower 8 bits of the frame number in which the BS shall transmit the next MBS frame.
Next MBS OFDMA symbol offset	8	The offset of the OFDMA symbol in which the

		next MBS portion starts, measured in OFDMA symbols from the beginning of the downlink frame in which the MBS-MAP is transmitted.
If(Next MBS MAP change indication=1) {		
Next MBS No. OFDMA symbols	2	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
Next MBS No. OFDMA subchannels	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
}		
}		

Table 5 shows IEs of the MBS_Data_IE transmitted through the MBS_Data_IE field. The MBS_Data_IE is included in the MBS-MAP message, and includes information on the MBS data transmitted from the transmitter to the receiver through the MBS data burst fields of the MBS frame. 'MBS_MAP_Type' of the MBS_Data_IE indicates that the IEs of Table 5 are MBS_Data_IE, and 'Next MBS MAP change indication' indicates a change in size of an MBS-MAP message that will come in the next MBS frame. In addition, the MBS_Data_IE transmits information indicating whether the MBS data corresponds to the same MBS frame as the MBS frame in which an MBS-MAP message is currently received, or corresponds to an MBS frame in which the next MBS-MAP will be received, using a Next MBS frame indicator.

In other words, if the Next MBS frame indicator of the MBS_Data_IE is set to '0', the receiver processes, or decodes the MBS data transmitted through the MBS data burst fields in the current MBS frame, recognizing that the information included in the MBS_Data_IE transmitted through the current MBS frame is MBS data will be processed in the current MBS frame. However, if the Next MBS frame indicator is set to '1', the receiver processes, or decodes the

MBS data transmitted through the MBS data burst fields in the next MBS frame, recognizing that the information included in the MBS_Data_IE transmitted through the current MBS frame will be processed in the next MBS frame. In this manner, the receiver receives the MBS data. If the Next MBS frame indicator is set to '1', i.e., if the receiver recognizes that the information included in the MBS_Data_IE transmitted through the current MBS frame is MBS data will be processed in the next MBS frame, the receiver buffers the information on the MBS data burst fields included in the MBS_Data_IE using a specific buffer, and then processes the MBS data transmitted through the MBS data burst files in the next MBS frame.

In addition, 'Next MBS MAP change indication' of the MBS_Data_IE indicates a change in size of an MBS-MAP message that will come in the next MBS frame. 'Multicast Connection Identifier (CID)' indicates multicast identifier information mapped to the MBS_Data_IE, 'OFDMA Symbol Offset' and 'Subchannel Offset' indicate start offsets of the MBS data burst fields, and 'No. Subchannels' indicates the number of subchannels of the MBS data burst fields allocated to the MBS frame. 'No. OFDMA Symbols' indicates the number of OFDMA symbols of the allocated MBS data burst fields, and 'Repetition coding indication' indicates the number of repetitions needed for decoding the MBS data transmitted through the MBS data burst fields.

'Next MBS frame offset' indicates an offset of the next MBS frame, and 'Next MBS OFDMA symbol offset' indicates an offset of a downlink frame OFDMA symbol for receiving the next MBS-MAP message. Herein, the 'Next MBS MAP change indication' being set to '1' means that the 'Next MBS OFDMA symbol offset' includes 'Next MBS No. OFDMA symbols' indicating a size of an MBS-MAP message that will come in the next MBS frame, and 'Next MBS No. OFDMA subchannels'. After receiving the 'Next MBS frame offset' and the 'Next MBS OFDMA symbol offset', the receiver can obtain MBS service information without receiving the MBS_MAP_IE of the DL-MAP. The IEs not mentioned in Table 5 are not directly related to the present invention, so a detailed description thereof will be omitted herein.

A description will now be made of a method for transmitting/receiving

data using the MBS-MAP message and information on the MBS_Data_IE included in the MBS-MAP message in the communication system providing MBS according to the present invention.

FIG. 3 is a diagram illustrating a structure of an MBS frame in a communication system providing MBS according to the present invention. For convenience, in FIG. 3, an MBS-MAP message and information on MBS data burst fields included in the MBS-MAP message are transmitted over two frames of a particular frame n and the next frame (n+1). In other words, FIG. 3 illustrates a structure of an MBS frame for the case where the Next MBS frame indicator of the MBS_Data_IE shown in Table 5 is set to '1', wherein the receiver receives MBS data by processing, or decoding the MBS data transmitted through the MBS data burst fields in the next MBS frame, recognizing that the information included in the MBS_Data_IE transmitted through the current MBS frame, i.e., the MBS frame n, is MBS data will be processed in the next MBS frame, i.e., the MBS frame (n+1). The process for the Next MBS frame indicator='1' has been described, so a description thereof will be omitted herein. Similarly, FIG. 3 illustrates only the MBS field in the downlink MBS frame of FIG. 1, for convenience.

Referring to FIG. 3, an MBS frame n 300 includes an MBS-MAP message field 301, and a plurality of MBS data burst fields of an MBS data burst 1 field 311, an MBS data burst 2 field 313 and an MBS data burst 3 field 315. The MBS-MAP message field 301 includes MBS_Data_IE fields 303, 305, 307 and 309 for processing the MBS data burst fields. In addition, an MBS frame (n+1) 350, the next frame of the MBS frame n 300, includes an MBS-MAP message field 351, and a plurality of MBS data burst fields of an MBS data burst 4 field 355 and an MBS data burst 5 field 357. The MBS-MAP message field 351 includes an MBS_Data_IE 353. The MBS_Data_IE transmitted through the MBS_Data_IE fields 303, 305, 307 and 309 included in the MBS-MAP message field 301 of the MBS frame n 300 includes information on the MBS data burst fields 311, 313, 315 and 355. In addition, the MBS_Data_IE transmitted through the MBS_Data_IE field 353 included in the MBS-MAP message field 351 of the MBS frame (n+1) 350 includes information on the MBS data burst fields 357.

Because the MBS data burst fields 311, 313, 315 and 355 mapped to the MBS_Data_IE transmitted through the MBS_Data_IE fields 303, 305, 307 and 309 included in the MBS-MAP message field 301 of the MBS frame n 300 cannot be wholly allocated to one MBS frame, i.e., the MBS frame n 300, the MBS data burst fields 311, 313, 315 and 355 are allocated to the current MBS frame, i.e., MBS frame n 300, and the next frame, i.e., MBS frame (n+1) 350. At this time, the receiver determines whether the MBS data burst fields 311, 313, 315 and 355 are allocated to the MBS frame n 300 and the MBS frame (n+1) 350, using the Next MBS frame indicator of the MBS_Data_IE transmitted through the MBS_Data_IE fields 303, 305, 307 and 309 included in the MBS-MAP message field 301.

That is, upon receiving the MBS frame n 300, the receiver checks the allocation information of the MBS data burst 1 field 311, the MBS data burst 2 field 313, the MBS data burst 3 field 315 received in the current MBS frame, i.e., MBS frame n 300, using the MBS_Data_IE transmitted through the MBS_Data_IE fields 303, 305 and 307 included in the MBS-MAP message field 301 of the MBS frame #n 300, and decodes the MBS data transmitted through each of the allocated MBS data burst fields 311, 313 and 315. In addition, the receiver checks the allocation information of the MBS data burst #4 field 355 in the MBS frame (n+1) 350 using the MBS_Data_IE transmitted through the MBS_Data_IE field 309 included in the MBS-MAP message field 301 of the MBS frame n 300, and decodes MBS data transmitted through the allocated MBS data burst 4 field 355 in the MBS frame (n+1) frame 350.

More specifically, the MBS data burst 4 field 355 is allocated to the MBS frame (n+1) 350, and a value of the Next MBS frame indicator in the MBS_Data_IE 309 of the MBS frame n 300 having information on the MBS data burst 4 field 355 is set to '1'. The receiver receiving the MBS frame n 300 processes, or decodes, the MBS data transmitted through the MBS data burst 4 field 355 allocated to the MBS frame (n+1) 350 upon receipt of the MBS frame (n+1) 350, recognizing that the MBS data burst 4 field 355 is allocated to the next MBS frame, i.e., the MBS frame (n+1) 350.

In addition, the receiver receiving the MBS frame (n+1) 350 checks the

allocation information of the MBS data burst 5 field 357 received in the current MBS frame, i.e., the MBS frame (n+1) 350, using the MBS_Data_IE transmitted through the MBS_Data_IE field 353 included in the MBS-MAP message field 351 of the MBS frame (n+1) 350, and decodes the MBS data transmitted through the allocated MBS data burst 5 field 357. FIG. 3 illustrates operations 321, 323, 325, 327 and 371 of decoding the MBS data transmitted through the MBS data burst fields 311, 313, 315, 355 and 357, using the MBS_Data_IE in each frame.

FIG. 4 is a flowchart illustrating an operation of a receiver in a communication system providing MBS according to the present invention.

Referring to FIG. 4, in step 401, a receiver receives a DL-MAP message transmitted from a transmitter through a DL-MAP message field allocated to an MBS frame. In step 403, if a DIUC value of the received DL-MAP message shown in Table 4 is set to '0x0A', the receiver decodes an MBS_MAP_IE transmitted through an MBS_MAP_IE field included in the DL-MAP message. Thereafter, in step 405, the receiver acquires location information and decoding information of an MBS-MAP message from the received MBS_MAP_IE, and receives an MBS-MAP message transmitted from the transmitter through an MBS-MAP message field allocated to the MBS frame. A format of the received MBS-MAP message is shown in Table 4.

Next, in step 407, the receiver decodes an MBS_Data_IE including the information on the MBS data burst fields in the MBS frame. That is, the receiver receives an MBS_Data_IE transmitted through the MBS_Data_IE field included in the MBS-MAP message field. In step 409, the receiver determines whether a Next MBS frame indicator of the received MBS_Data_IE shown in Table 5 is set to '1'. If it is determined in step 409 that the Next MBS frame indicator is set to '1', the receiver proceeds to step 411. However, if the Next MBS frame indicator is set to '0', the receiver proceeds to step 413.

In step 411, after waiting from an MBS frame, i.e., the current MBS frame, received at the present time until the time that the next MBS frame is received, the receiver processes, or decodes the MBS data transmitted through the MBS data burst fields allocated to the current MBS frame and the next MBS

frame using information included in the MBS_Data_IE transmitted through an MBS_Data_IE field included in each MBS-MAP message of the current MBS frame and the next MBS frame. The method of processing, or decoding, data transmitted through the MBS data burst fields allocated to the two frames has been described above, so a detailed description will be omitted herein.

Meanwhile, in step 413, the receiver processes, or decodes, MBS data transmitted through MBS data burst fields allocated to the current MBS frame using information included in an MBS_Data_IE in the current MBS frame. The method of processing, or decoding data transmitted through the MBS data burst fields allocated to the one frame has also been described above, so a detailed description will be omitted herein. After processing the MBS data transmitted through the MBS data burst fields allocated to each MBS frame in steps 411 and 413, if the receiver continues to receive the MBS provided from the transmitter, the process returns to step 405 and repeats the operation of step 405 and its succeeding steps.

In FIG. 4, the receiver determines whether the information on the MBS data burst fields included in the MBS_Data_IE of the MBS-MAP message corresponds to the current MBS frame or both of the current MBS frame and the next MBS frame, i.e., whether MBS data burst fields are allocated to two consecutive MBS frames, and then processes, or decodes, the MBS data transmitted through the allocated MBS data burst fields according to the determination results. After receiving the MBS-MAP message in the current MBS frame, the receiver receiving MBS provided from the transmitter may receive MBS data transmitted through MBS data burst fields allocated to an MBS frame following more than two MBS frames including the current MBS frame.

That is, the information on the MBS data burst fields included in the MBS_Data_IE of the MBS-MAP message in the current MBS frame may not only be the current MBS frame or both of the current frame and the next frame but also be the information on the MBS data burst fields allocated to the frame transmitted after the next frame. In this case, the receiver should process, or decode, the data transmitted through the MBS data burst fields in real time.

A description will now be made of a method for decoding received MBS data by a receiver in the case where the information on the MBS data burst fields included in the MBS_Data_IE of the MBS-MAP message in the current MBS frame is not only the current MBS frame or both of the current MBS frame and the next frame but also the information on the MBS data burst fields allocated to the frame transmitted after the next frame in the communication system providing MBS according to the present invention.

In the above case, in the communication system according to the present invention, the receiver previously receives information on the MBS data burst fields to be allocated to the frame following at least two frames through the MBS-MAP message transmitted in the current MBS frame. Thereafter, the receiver decodes the MBS data transmitted through the MBS data burst fields allocated to the frame following the at least two frames using the previously received information. Therefore, the MBS-MAP message transmitted through the MBS-MAP message field allocated to the MBS frame includes information indicating how many frames later from the current MBS frame the frame in which MBS data transmitted through the MBS data burst fields is decoded is located. A format of the MBS_Data_IE including such information is shown in Table 6 below.

Table 6

Syntax	Size (bits)	Notes
MBS_DATA_IE {		
MBS-MAP-Type=0	2	MBS_DATA_IE
MBS_Burst_Frame_Offset	2	This indicates the burst indicated by this IE will be shown after MBS_Burst_Frame_offset + 2 frames.
Next MBS MAP change indication	1	This indicates whether the size of MBS MAP message of next MBS frame for these multicast CIDs included this IE will be different from the size of this MBS MAP message.
No. of Multicast CID	3	
For(i=o; i<No. of Multicast CIDs; i++) {		

Multicast CID	12	12 LSBs of CID for multicast
}		
MBS DIUC	4	
OFDMA symbol offset	8	OFDMA symbol offset with respect to start of the next (MBS_Burst_Frame_offset +2)th frame
Subchannel offset	6	OFDMA subchannel offset with respect to start of the next (MBS_Burst_Frame_offset +2)th frame
Boosting	3	
No. OFDMA symbols	7	The size of MBS data
No. subchannels	6	
Repetition coding indication	2	0b00=No repetition coding 0b01=Repetition coding of 2 used 0b10=Repetition coding of 4 used 0b11=Repetition coding of 6 used
Next MBS frame offset	8	The Next MBS frame offset value is lower 8 bits of the frame number in which the BS shall transmit the next MBS frame.
Next MBS OFDMA symbol offset	8	The offset of the OFDMA symbol in which the next MBS portion starts, measured in OFDMA symbols from the beginning of the downlink frame in which the MBS-MAP is transmitted.
If(Next MBS MAP change indication=1) {		
Next MBS No. OFDMA symbols	2	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
Next MBS No. OFDMA subchannels	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.

}		
}		

Table 6 shows IEs of the MBS_Data_IE transmitted through the MBS_Data_IE field. The MBS_Data_IE is included in the MBS-MAP message, and includes information on the MBS data transmitted from the transmitter to the receiver through the MBS data burst fields of the MBS frame. Herein, MBS_MAP Type='0' means that the MBS_Data_IE is transmitted through the MBS_Data_IE field, MBS_MAP Type='1' means that MBS_Data_Time_Diversity_IE is transmitted through the MBS_Data_IE field, and MBS_MAP Type='2' means that an Extended MBS_MAP_Information Element (Extended MBS_MAP_IE) is transmitted through the MBS_Data_IE field. For both MBS_MAP Type='0' and '2', because the MBS_Data_IE is transmitted through the MBS_Data_IE field and IEs for both cases are identical to each other, the following description will be given for the MBS_MAP Type='0', for convenience.

A detailed description of the MBS_MAP Type='1' in which the MBS_Data_Time_Diversity_IE is transmitted through the MBS_Data_IE field will be made later with reference to Table 7 below.

The MBS_Data_IE includes MBS_Burst_Frame_Offset indicating how many frames later from the frame where the current MBS-MAP message is received the MBS data burst field is allocated, i.e., indicating how many frames later from the current MBS frame the MBS data the MBS data will be received at the receiver. After decoding the MBS_Data_IE, the receiver recognizes the possibility of processing, or decoding the MBS data transmitted through MBS data burst fields allocated to an frame received more than two frames later from the MBS frame where the MBS_Data_IE is received.

In other words, for MBS_Burst_Frame_Offset='0', the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame received the two frames later, recognizing the possibility of receiving MBS data through MBS data burst fields allocated to an frame following two frames later

from the MBS frame where the MBS_Data_IE is received. For MBS_Burst_Frame_Offset='1', the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame received the three frames later, recognizing the possibility of receiving MBS data through MBS data burst fields allocated to an frame following three frames later from the MBS frame where the MBS_Data_IE is received.

Similarly, for MBS_Burst_Frame_Offset='2' or '3', the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame received four or five frames later.

Table 6 shows an exemplary case where the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame corresponding to each MBS_Burst_Frame_Offset value, wherein the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame following two frames. However, it is also possible to extend the two frames to four frames, six frames, eight frames, and so on. The frame corresponding to the MBS_Burst_Frame_Offset value is a factor that varies according to the system situations or characteristics. The IEs not mentioned in Table 6 have been described in detail with reference to Table 5.

In the case where receivers supporting an HARQ scheme receive MBS service from a transmitter, the transmitter transmits an MBS_Data_Time_Diversity_IE instead of the MBS_Data_IE to the receivers along with the MBS-MAP message. A format of the MBS_Data_Time_Diversity_IE included in the MBS-MAP message is shown in Table 7 below.

Table 7

Syntax	Size (bits)	Notes
MBS_DATA_Time_Diversity_IE() {		
MBS_MAP_Type=1	2	MBS_DATA_Time_Diversity_IE
MBS_Burst_Frame_Offset	2	This indicates the burst indicated by this IE will be shown after MBS_Burst_Frame_Offset +2

		frames.
Multicast CID	12	
OFDMA symbol offset	8	This indicates starting position of the region of MBS Bursts with respect to start of the next (MBS_Burst_Frame_Offset +2)th frame
N_EP code	4	
N_SCH code	4	
AI_SN	1	
SPID	2	
ACID	4	
Next MBS MAP change indication	1	This indicates whether the size of MBS MAP message of next MBS frame for these multicast CIDs included this IE will be different from the size of this MBS MAP message.
Next MBS frame offset	8	
Next MBS OFDMA symbol offset	8	
If(Next MBS MAP change indication=1) {		
Next MBS No. OFDMA symbols	2	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
Nest MBS No. OFDMA subchannels	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for multicast CIDs in this IE.
}		
}		

Table 7 shows IEs of the MBS_Data_Time_Diversity_IE transmitted instead of the MBS_Data_IE transmitted through the MBS_Data_IE field included in the MBS-MAP message field of the MBS frame, and the MBS_Data_Time_Diversity_IE is transmitted through the MBS_Data_IE field included in the MBS-MAP message field in which MBS_Data_IE is transmitted.

In the MBS_Data_Time_Diversity_IE, MBS_MAP_Type indicates that IEs of Table 7 are MBS_Data_Time_Diversity_IE. Further, MBS_Burst_Frame_Offset indicates an MBS_Burst_Frame_Offset indicating how many frames later from the frame where the current MBS-MAP message is received, i.e., from the current MBS frame, the MBS data burst fields will be allocated. 'Multicast CID' indicates information on a multicast identifier mapped to the MBS_Data_Time_Diversity_IE, and 'OFDMA symbol offset' indicates a start offset of MBS data burst fields allocated to the frame.

'N_EP code', 'N_SCH code', 'ARQ Identifier_Sequence Number (AI_SN)', 'Sub_Packet IDentifier (SPID)' and 'Hybrid ARQ Channel IDentifier (ACID)' indicate information used for decoding the HARQ data. 'Next MBS MAP change indication' indicates any change in MBS-MAP message to be transmitted through an MBS-MAP message field in the next MBS frame, and 'Next MBS frame offset' indicates an offset of the next MBS frame. 'Next MBS OFDMA symbol offset' indicates an offset of a downlink frame OFDMA symbol for receiving an MBS-MAP message transmitted through the next MBS frame. Next MBS MAP change indication='1' indicates that it includes 'Next MBS No. OFDMA symbols' indicating a size of an MBS-MAP message that will be transmitted through the next MBS frame, and 'Next MBS No. OFDMA subchannels'.

Moreover, after receiving the Next MBS frame offset and the Next MBS OFDMA symbol offset, the receiver can obtain MBS information without receiving the MBS_MAP_IE of the DL-MAP message. Further, after decoding the MBS_Data_Time_Diversity_IE, the receiver recognizes the possibility of receiving MBS data transmitted through MBS data burst fields allocated to an frame received more than two frames later from the MBS frame where the MBS_Data_Time_Diversity_IE is received.

In other words, for MBS_Burst_Frame_Offset='0', the receiver processes, or decodes MBS data transmitted through MBS data burst fields allocated to an frame received the two frames later, recognizing the possibility of receiving the MBS data transmitted through MBS data burst frames allocated to an frame following two frames. For MBS_Burst_Frame_Offset='1', the receiver processes,

or decodes, MBS data transmitted through MBS data burst fields allocated to an frame received the three frames later, recognizing the possibility of receiving the MBS data transmitted through MBS data burst frames allocated to an frame following three frames.

Similarly, for MBS_Burst_Frame_Offset='2' or '3', the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame received four or five frames later. As mentioned above, Table 6 shows an exemplary case where the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame corresponding to each MBS_Burst_Frame_Offset value, wherein the receiver receives the MBS data transmitted through MBS data burst fields allocated to an frame following two frames. However, it is also possible to extend the two frames to four frames, six frames, eight frames, and so on. The frame corresponding to the MBS_Burst_Frame_Offset value is a factor that varies according to the system situations or characteristics. The IEs not mentioned in Table 6 have been described in detail with reference to Table 5.

FIG. 5 is a flowchart illustrating an operation of a receiver in a communication system providing MBS according to the present invention.

Referring to FIG. 5, in step 501, a receiver receives a DL-MAP message transmitted from a transmitter through a DL-MAP message field allocated to an MBS frame. In step 503, if a DIUC value of the received DL-MAP message shown in Table 4, Table 5 and Table 6 is set to '0x0A', the receiver decodes an MBS_MAP_IE transmitted through an MBS_MAP_IE field included in the DL-MAP message. Thereafter, in step 505, the receiver acquires location information and decoding information of an MBS-MAP message from the received MBS_MAP_IE, and receives an MBS-MAP message transmitted from the transmitter through an MBS-MAP message field allocated to the MBS frame. A format of the received MBS-MAP message is shown in Table 2, Table 4.

Next, in step 507, the receiver decodes an MBS_Data_IE or an MBS_Data_Time_Diversity_IE that include information on MBS data burst fields in the MBS frame. That is, the receiver receives the MBS_Data_IE or the MBS_Data_Time_Diversity_IE transmitted through an MBS_Data_IE field

included in an MBS-MAP message field. A format of the MBS_Data_IE is shown in Table 6, and a format of the MBS_Data_Time_Diversity_IE is shown in Table 7.

Thereafter, in step 509, the receiver recognizes an expected reception time of MBS data transmitted through the MBS data burst fields allocated to the frame using MBS_Burst_Frame_Offset information included in the MBS_Data_IE or the MBS_Data_Time_Diversity_IE received in step 507. That is, the receiver recognizes the possibility of receiving the MBS data transmitted through MBS data burst fields allocated to an frame following MBS_Burst_Frame_Offset+2 frames, for example, an frame following two or three frames, and waits for the frame where the MBS data is transmitted through MBS data burst fields actually allocated to the corresponding frame.

In step 511, the receiver determines whether the MBS_Burst_Frame_Offset+2 frames have elapsed. If it is determined in step 511 that MBS_Burst_Frame_Offset+2 frames have elapsed, the receiver proceeds to step 513. In step 513, the receiver processes, or decodes, MBS data transmitted through MBS data burst fields actually allocated to an frame following the MBS_Burst_Frame_Offset+2 frames. However, if it is determined in step 511 that the MBS_Burst_Frame_Offset+2 frames have not elapsed, the receiver proceeds to step 515.

In step 515, the receiver processes an MBS-MAP message transmitted through the next MBS frame, or processes MBS data transmitted through MBS data burst fields of the previous frame, i.e., MBS data transmitted through MBS data burst fields allocated in the current frame corresponding to the information on the MBS data burst fields previously received before the current frame is transmitted. As a result, the receiver can perform an operation in the next MBS frame according to a Next MBS Frame offset included in the MBS_Data_IE or the MBS_Data_Time_Diversity_IE decoded in step 507. This corresponds to the case where a value of the MBS Burst Frame Offset+2 frames is greater than the Next MBS Frame offset.

Alternatively, in step 515, if MBS data burst fields where MBS data is

transmitted are allocated within MBS Burst Frame Offset+2 frames from the current MBS frame based on the MBS Burst Frame Offset provided from the MBS_Data_IE or the MBS_Data_Time_Diversity_IE included in the MBS-MAP message of the previous MBS frame, the receiver receives MBS data transmitted through the MBS data burst fields. As a result, the receiver receives MBS data transmitted through MBS data burst fields allocated to an frame following a predetermined frame using the MBS_Burst_Frame_Offset in the MBS_Data_IE and the MBS_Data_Time_Diversity_IE shown in Table 6 and Table 7.

FIG. 6 is a flowchart illustrating an operation of a transmitter in a communication system providing MBS according to the present invention.

Referring to FIG. 6, in step 601, a transmitter determines an MBS Burst Frame Offset value according to the MBS data to be transmitted to a receiver, in order to allocate the MBS data burst fields, in which the MBS data is transmitted, to an frame. Thereafter, in step 603, the transmitter generates an MBS_Data_IE or an MBS_Data_Time_Diversity_IE of an MBS-MAP message including the determined MBS Burst Frame Offset value as shown in Table 6 or Table 7.

In step 605, the transmitter transmits a DL-MAP message including location information of an MBS-MAP message with the generated MBS_Data_IE or MBS_Data_Time_Diversity_IE. Herein, the location information of the MBS-MAP message includes location information of an MBS-MAP message field and an MBS_Data_IE field included the MBS-MAP message field in the downlink MBS frame, and a plurality of MBS data burst fields. That is, in step 605, the transmitter transmits all information for the MBS data transmission/reception to the receiver so that the receiver may process, or decode, the MBS data that the transmitter itself provides to the receiver. Thereafter, in step 607, the transmitter transmits MBS data to the receiver through the corresponding MBS data burst fields in MBS Burst Frame Offset+2 frames according to the MBS_Data_IE or the MBS_Data_Time_Diversity_IE included in the MBS-MAP message.

As can be understood from the foregoing description, the present invention newly defines a service MAP message and a service data information element according to the service data to be transmitted to a receiver receiving

communication service in a communication system. This contributes to an increase in resource efficiency during the transmission of the service MAP message and a reduction in overhead due to the service MAP message. The receiver recognizes the frame where the service data is transmitted by receiving the newly defined service MAP message and service data information elements. As a result, the receiver can decode the service data without error. In addition, a transmitter transmits the newly defined service MAP message and service data information elements to the receiver, to inform the receiver of a decoding time of the service data, thereby enabling real-time service data processing between the transmitter and the receiver and thus reducing the required transmission/reception load.

While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A method for transmitting data in a communication system, comprising the steps of:

generating transmission data to be transmitted to a receiver;

allocating the transmission data to a frame;

setting a MAP message that includes information on a frame offset related to the frame; and

transmitting to the receiver the MAP message.

2. The method of claim 1, wherein the frame offset indicates that the frame will be shown after a plurality of frames from the current frame comprising the frame offset.

3. The method of claim 2, wherein a number of the plurality of frames is equal to the sum of the frame offset and a predetermined number of frames.

4. The method of claim 1, wherein the MAP message includes information on a position of the transmission data within the frame.

5. The method of claim 4, wherein the information on the position includes information relating to a symbol offset within the frame.

6. The method of claim 4, wherein the information on the position includes information relating to a subchannel offset within the frame.

7. The method of claim 1, wherein the MAP message includes data time diversity information when the receiver supports a hybrid automatic repeat request scheme.

8. The method of claim 1, wherein the MAP message includes a MAP indicator of a number of bits indicating a MAP message, and the MAP indicator includes type information of a medium access control header, encryption field information, compressed MAP information, and sub downlink-uplink MAP information.

9. The method of claim 1, further comprising the step of:

buffering the allocated transmission data for a plurality of frames and transmitting the buffered transmission data within the frame to the receiver.

10. A method for receiving data in a communication system, comprising the steps of:

receiving a MAP message that includes information on a frame offset related to a data burst before receiving the data burst from a transmitter;

analyzing the information on the frame offset; and

receiving from the transmitter the data burst within the n-th frame flowing a frame comprising the MAP message according to the analysis of the information.

11. The method of claim 10, wherein the n is equal to the sum of the frame offset and a predetermined minimum frame offset.

12. The method of claim 10, wherein the MAP message includes information on a position of the data burst within the n-th frame.

13. The method of claim 12, wherein the information on the position includes information relating to a symbol offset of the data burst within the n-th frame.

14. The method of claim 12, wherein the information on the position includes information relating to a subchannel offset of the data burst within the n-th frame.

15. The method of claim 10, wherein the MAP message includes data time diversity information when the receiver supports a hybrid automatic repeat request scheme.

16. The method of claim 10, wherein the MAP message includes a MAP indicator of a number of bits indicating a MAP message, and the MAP indicator includes type information of a medium access control header, encryption

field information, compressed MAP information, and sub downlink-uplink MAP information.

17. A method for transmitting data in a communication system, comprising the steps of:

upon generation of data to be transmitted to a receiver, determining a transmission field of the generated data, and allocating the determined transmission field to a frame;

setting in transmission field information location information of the transmission field allocated to the frame and frame offset information defining an offset between the frame to which the transmission field is allocated and a reference frame; and

transmitting to the receiver a MAP message including the set transmission field information.

18. The method of claim 17, wherein the reference frame includes the MAP message.

19. The method of claim 17, wherein the offset between the frame to which the transmission field is allocated and the reference frame is equal to the sum of the frame offset information and a predetermined number of frames.

20. The method of claim 17, wherein the location information includes information on a position of the transmission data within the frame to which the transmission field is allocated.

21. The method of claim 20, wherein the information on the position includes information relating to a symbol offset and a subchannel offset within the frame.

22. The method of claim 17, wherein the MAP message includes data time diversity information when the receiver supports a hybrid automatic repeat request scheme.

23. The method of claim 17, further comprising the step of:

buffering the generated data for the offset and transmitting the buffered data within the frame to the receiver.

24. The method of claim 17, wherein the MAP message includes a MAP indicator of a number of bits indicating a MAP message, and the MAP indicator includes type information of a medium access control header, encryption field information, compressed MAP information, and sub downlink-uplink MAP information.

25. A method for receiving data in a communication system, comprising the steps of:

upon receiving a MAP message before receiving data from a transmitter, analyzing location information of a data burst included in the MAP message and frame offset information defining an offset between a frame to which the data burst is allocated and a current frame; and

receiving the data burst within the frame according to the analyzed location information and the frame offset information.

26. The method of claim 25, wherein the current frame includes the MAP message.

27. The method of claim 25, wherein the offset between the frame to which the data burst is allocated and the current frame is equal to the sum of the frame offset information and a predetermined number of frames.

28. The method of claim 25, wherein the location information includes symbol offset information and subchannel offset information of the data burst within the frame to which the data burst is allocated.

29. The method of claim 25, wherein the MAP message includes data time diversity information when the receiver supports a hybrid automatic repeat request scheme, and the data time diversity information includes the location information and the offset information.

30. The method of claim 25, wherein the MAP message includes a MAP indicator of a number of bits indicating a MAP message, and the MAP

indicator includes type information of a medium access control header, encryption field information, compressed MAP information, and sub downlink-uplink MAP information.

31. A method for transmitting data in a communication system, comprising the steps of:

upon generation of data to be transmitted to a receiver, determining a transmission field of the generated data;

determining offset of frame including the transmission field;

setting in data information offset information defining the offset of frame and location information of the transmission field according to the offset information; and

transmitting to the receiver a MAP message including the set data information.

32. The method of claim 31, wherein the offset information is used to inform the receiver that the data will be transmitted through a transmission field included to a frame following a number of frames from the frame including the MAP message.

33. The method of claim 31, wherein the location information includes symbol offset information and subchannel offset information which indicate start offset of the transmission field included to the frame.

34. The method of claim 31, wherein the MAP message includes data time diversity information when the receiver supports a hybrid automatic repeat request scheme, and the data time diversity information includes the information on the transmission field.

35. The method of claim 34, wherein the generated data is transmitted to the receiver through a transmission field for the frame according to the transmission field information.

36. The method of claim 31, wherein the MAP message includes a MAP indicator of a number of bits indicating a MAP message, and the MAP

indicator includes type information of a medium access control header, encryption field information, compressed MAP information, and sub downlink-uplink MAP information.

37. A method for transmitting multicast broadcast service (MBS) data of a base station (BS) in a broadband wireless access (BWA) communication system, the method comprising the steps of:

determining a frame offset of MBS data burst, a frame comprising the MBS data burst is the n-th frame following the current frame comprising the frame offset;

determining a position of the MBS data burst within the n-th frame;

setting information of the frame offset and the position in a message; and

transmitting the message to a mobile station.

38. The method of claim 37, wherein the 'n' is equal to the sum of the frame offset and a predetermined minimum frame offset value.

39. The method of claim 37, wherein the information of the frame offset and the position comprises information relating to a symbol offset within the n-th frame.

40. The method of claim 37, wherein the information of the frame offset and the position comprises information relating to a subchannel offset within the n-th frame.

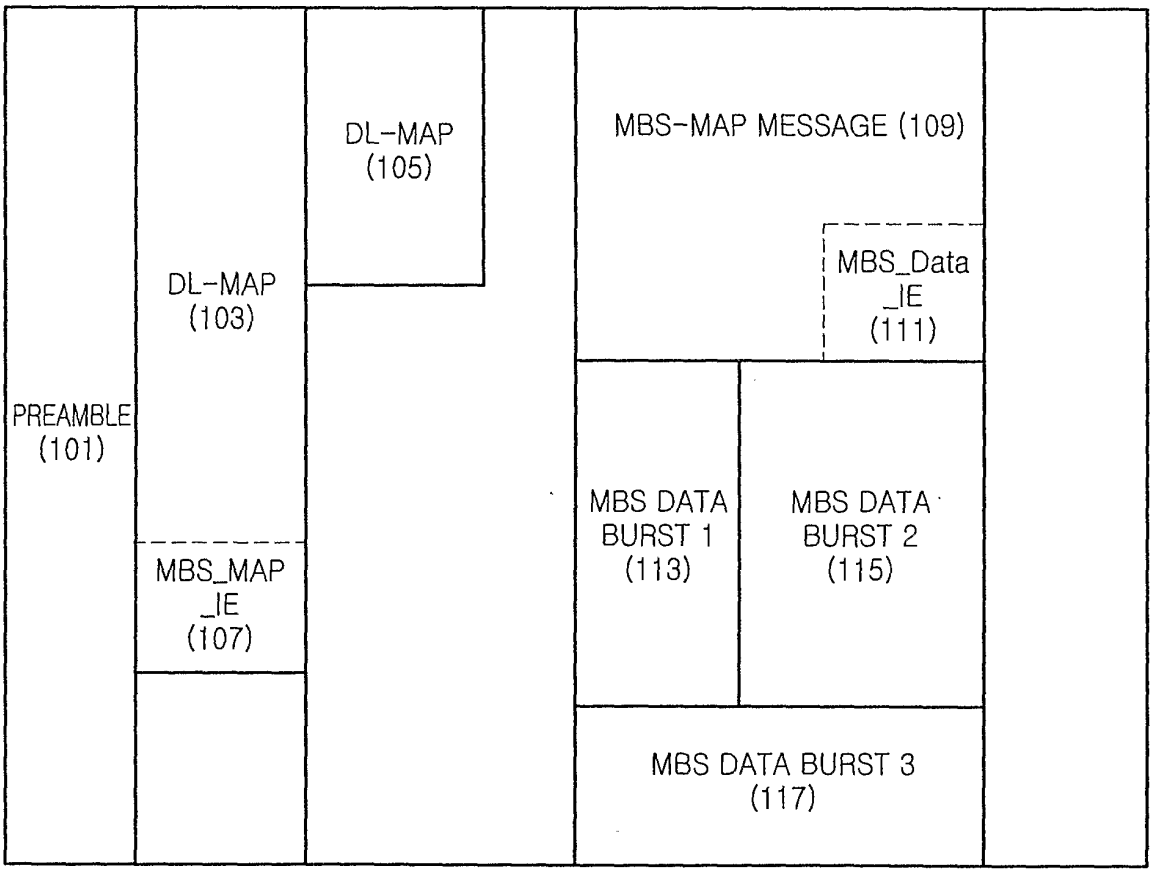

PREAMBLE
(101)
DL-MAP
(103)
MBS_MAP
_IE
(107)
DL-MAP
(105)
MBS-MAP MESSAGE (109)
MBS_Data
_IE
(111)
MBS DATA
BURST 1
(113)
MBS DATA
BURST 2
(115)
MBS DATA BURST 3
(117)

FIG.1

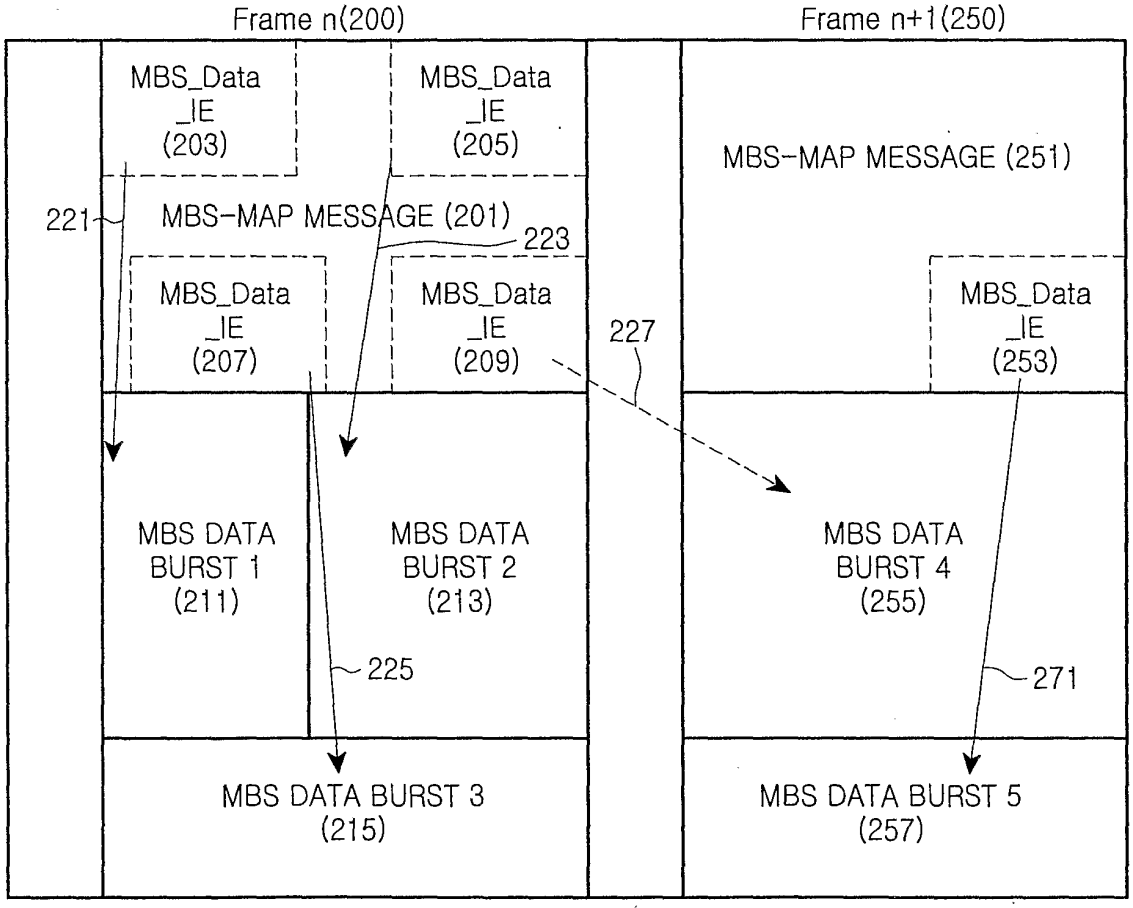

Frame n(200)
Frame n+1(250)
MBS_Data _IE (203)
MBS_Data _IE (205)
MBS-MAP MESSAGE (251)
221
MBS-MAP MESSAGE (201)
223
MBS_Data _IE (207)
MBS_Data _IE (209)
227
MBS_Data _IE (253)
MBS DATA BURST 1 (211)
MBS DATA BURST 2 (213)
MBS DATA BURST 4 (255)
225
271
MBS DATA BURST 3 (215)
MBS DATA BURST 5 (257)

FIG.2

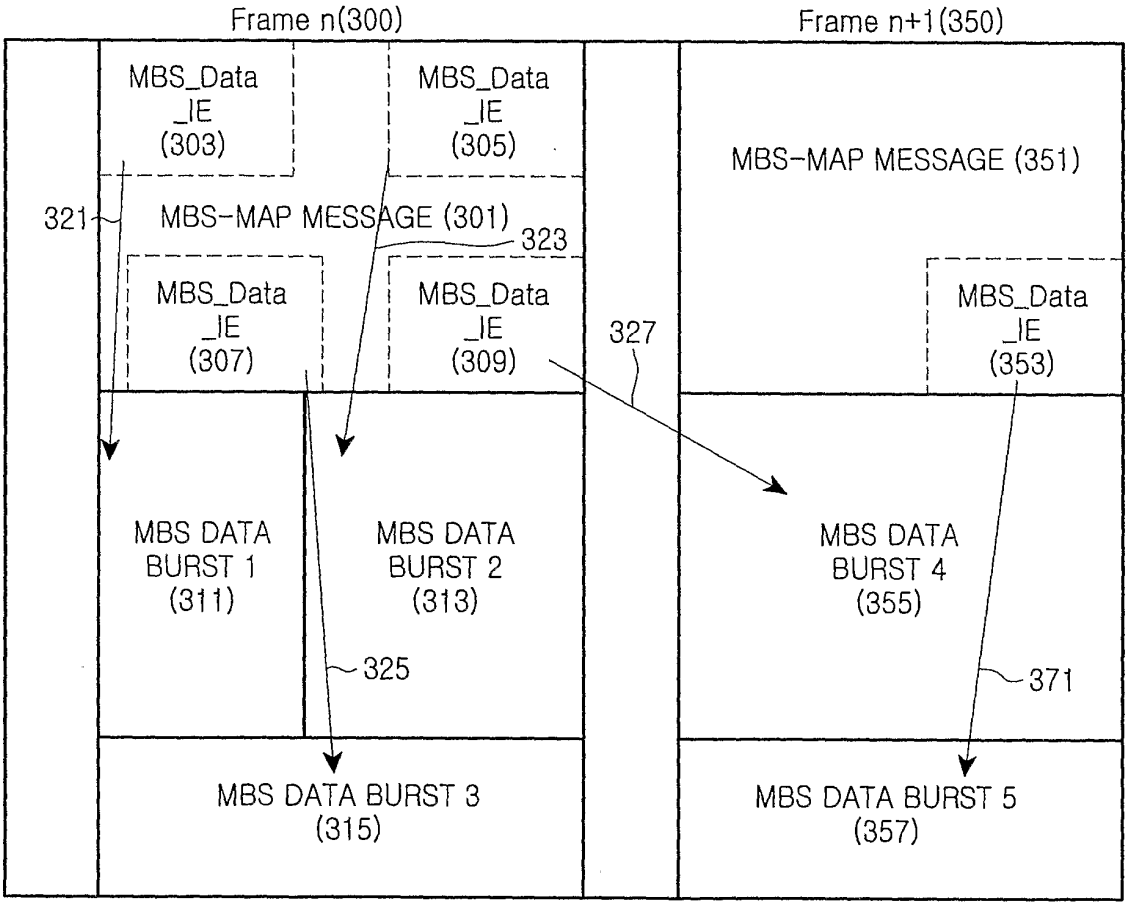

Frame n(300)
Frame n+1(350)
MBS_Data _IE (303)
MBS_Data _IE (305)
MBS-MAP MESSAGE (351)
321
MBS-MAP MESSAGE (301)
323
MBS_Data _IE (307)
MBS_Data _IE (309)
327
MBS_Data _IE (353)
MBS DATA BURST 1 (311)
MBS DATA BURST 2 (313)
MBS DATA BURST 4 (355)
325
371
MBS DATA BURST 3 (315)
MBS DATA BURST 5 (357)

FIG.3

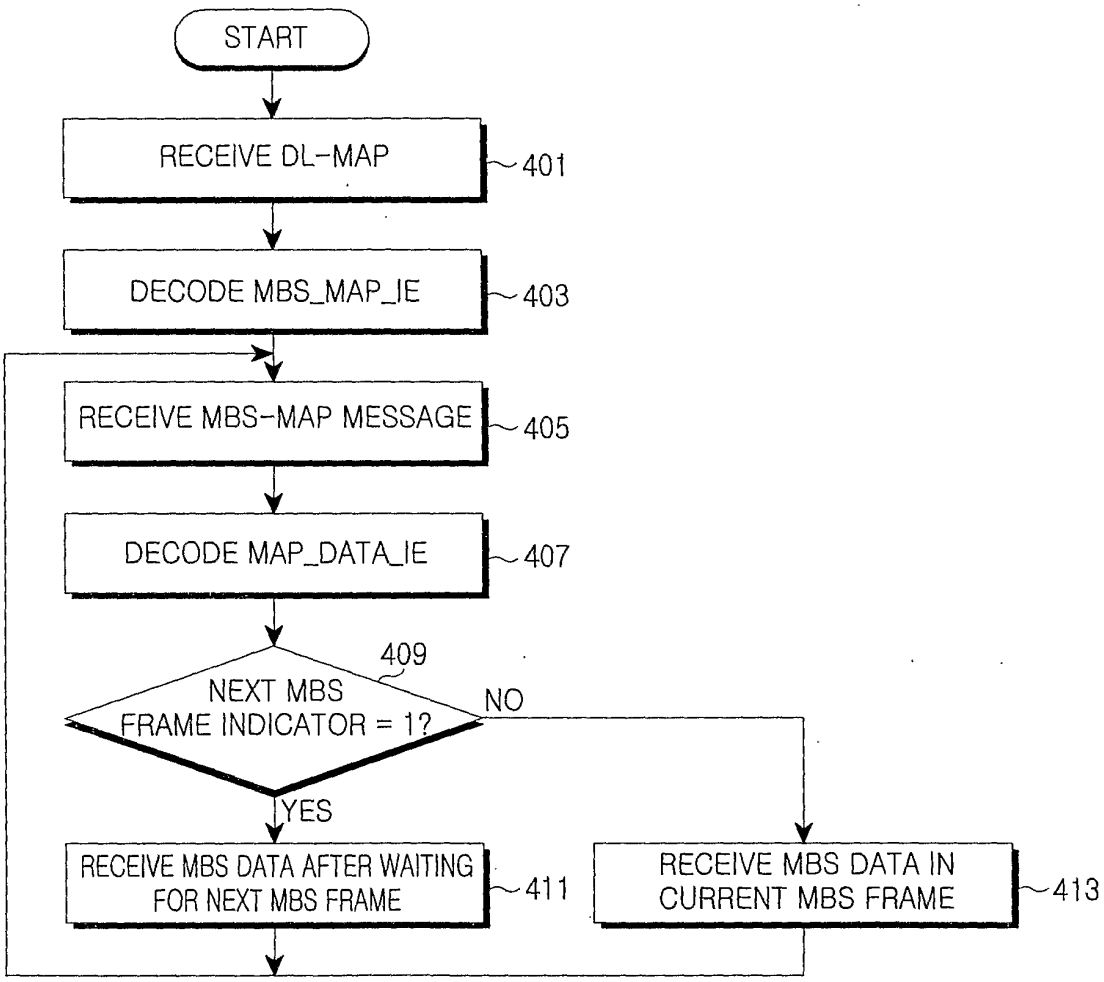

START
RECEIVE DL-MAP
401
DECODE MBS_MAP_IE
403
RECEIVE MBS-MAP MESSAGE
405
DECODE MAP_DATA_IE
407
409
NEXT MBS FRAME INDICATOR = 1?
NO
YES
RECEIVE MBS DATA AFTER WAITING FOR NEXT MBS FRAME
411
RECEIVE MBS DATA IN CURRENT MBS FRAME
413

FIG.4

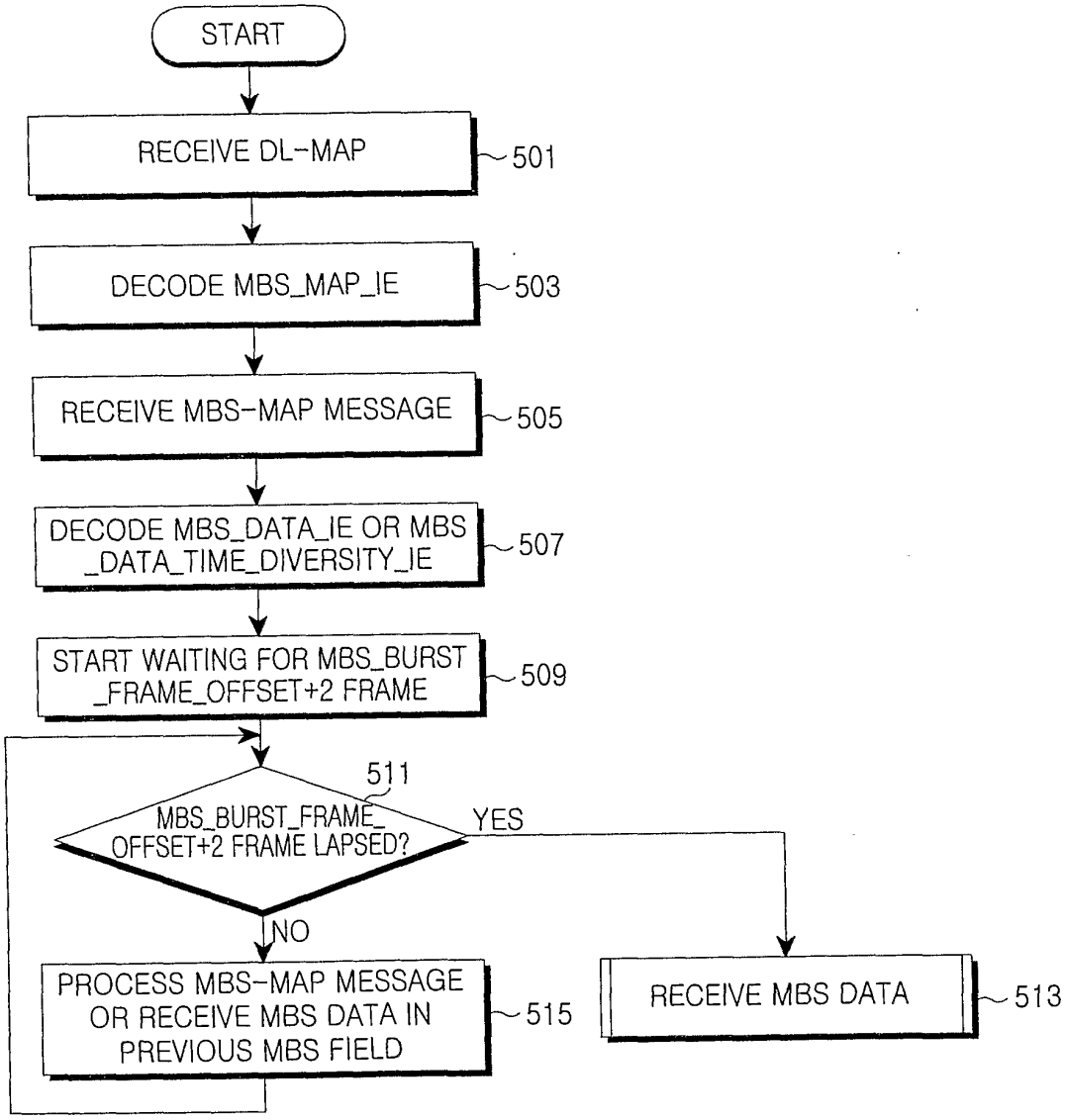

START
RECEIVE DL-MAP
501
DECODE MBS_MAP_IE
503
RECEIVE MBS-MAP MESSAGE
505
DECODE MBS_DATA_IE OR MBS _DATA_TIME_DIVERSITY_IE
507
START WAITING FOR MBS_BURST _FRAME_OFFSET+2 FRAME
509
511
MBS_BURST_FRAME_ OFFSET+2 FRAME LAPSED?
YES
NO
PROCESS MBS-MAP MESSAGE OR RECEIVE MBS DATA IN PREVIOUS MBS FIELD
515
RECEIVE MBS DATA
513

FIG.5

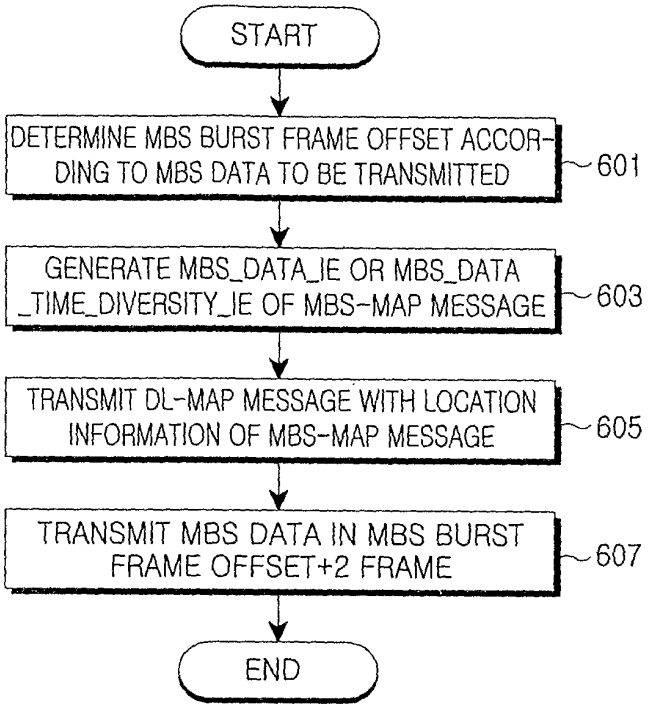

START
DETERMINE MBS BURST FRAME OFFSET ACCORDING TO MBS DATA TO BE TRANSMITTED
601
GENERATE MBS_DATA_IE OR MBS_DATA _TIME_DIVERSITY_IE OF MBS-MAP MESSAGE
603
TRANSMIT DL-MAP MESSAGE WITH LOCATION INFORMATION OF MBS-MAP MESSAGE
605
TRANSMIT MBS DATA IN MBS BURST FRAME OFFSET+2 FRAME
607
END

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/001557

A. CLASSIFICATION OF SUBJECT MATTER

H04H 1/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 8: H04J H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
KOREAN PATENTS AND APPLICATIONS FOR INVENTIONS SINCE 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
PAJ, FPD, USPAT, eKIPASS, IEEE "MULTICAST""MBS""MAP""NEXT""OFDM"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	IEEE C802/16e-05/111 (SAMSUNG ELECTRONICS) 09 MARCH 2005 see the whole document	1-40
Y	IEEE C802.16e-04/444r2 (SAMSUNG ELECTRONICS) 15 NOVEMBER 2004 see the whole document	1-40

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Republic of Korea
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Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: WIRELESS AUTOMATED VEHICLE ENERGIZING SYSTEM

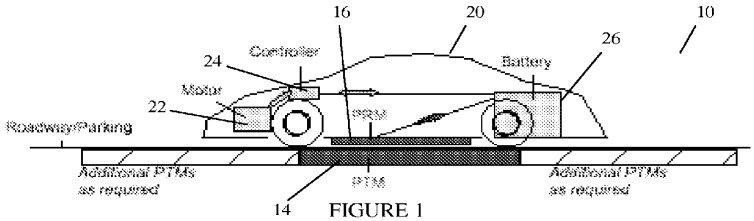


FIGURE 1

(57) **Abstract**: A wireless recharging system for battery or hybrid vehicles having an in-road magnetic power transmission assembly that interconnects to a magnetic power reception assembly onboard the vehicle. As the vehicle stops or passes over the in-road magnetic power transmission assembly, magnetic coupling transfers power to the magnetic power reception assembly which, in turn, is used to recharge the vehicle battery. The in-road magnetic power transmission assembly may be powered from the electrical grid or designated electrical generators and is preferably designed to build the powering magnetic field in response to the detection of an authorized vehicle in proximity to the transmission assembly.

WO 2012/116054 A2

TITLE

Wireless Automated Vehicle Energizing System

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a non-provisional of U.S. Provisional Application No. 61/463,717, filed on February 22, 2011 and U.S. Provisional No. 61/573,750, filed on September 12, 2011, both of which are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0002] The present invention relates to electric and hybrid electric vehicles and, more particularly, a system and method for wirelessly charging vehicle batteries while stationary or in motion.

2. DESCRIPTION OF THE RELATED ART

[0003] The rapid development of a new electric vehicle fleet is being fueled by a "perfect storm" of pressures – to cut foreign oil consumption, reduce greenhouse gas pollution and revive USA based manufacturing. However a major impediment to the rapid growth of an electric vehicle fleet is the high cost, low reliability and performance limitations associated with vehicular energy storage - the battery. Other major components required to produce a low cost, high performance electric vehicle are currently ready for mass production - strong lightweight body, electric motor and associated electronic controller. Accordingly, there is a need in the art for utility-based power generation capacity that is capable of adapting to the electrical consumption posed by any reasonable growth in electrically powered transportation.

[0004] The U.S. Department of Energy is faced with the very difficult task of driving development that will transition the energy infrastructure of our nation from one primarily based upon early 20th century technologies to an infrastructure based upon early 21st century technologies. The key being that the required 21st century technology is only partially developed, with many missing pieces and not integrated. Transitioning the transportation sector to 21st century technology is one very important component that U.S. Department of Energy must address if it is to successfully drive this difficult transition.

[0005] Vehicle fleet electrification is a fundamental way for the U.S. Department of Energy to drive fuel efficient and low pollution electrical energy generation to ubiquitously change the present inefficient nature of fossil fuel consumption. The primary impediment to widespread adoption of electric bus, truck and automobile electrification is the disconnect between electric power generation and vehicle motors, currently bridged by battery

technology that is costly, easily damaged and performance limiting. The U.S. Department of Energy is of course one of the important drivers of battery technology improvement, however this appears to be a long term developmental process. The U.S. Department of Energy thus needs an adjunct that can enable both current and longer term battery technologies to seamlessly transition into all modes of land transport. The focus upon higher and higher battery energy storage density at proportionately lower cost, volume and weight still ignores the difficulties associated with peak charging energy demands that grow larger with each improvement.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention provides.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0007] The present invention will be more fully understood and appreciated by reading the following Detailed Description in conjunction with the accompanying drawings, in which:

[0008] Figure 1 is a schematic of the wireless energizing system according to the present invention;

[0009] Figure 2 is a schematic of an in-road embodiment of a wireless power transmission system according to the present invention;

[0010] Figure 3 is a schematic of an intersection provided with a wireless power transmission system according to the present invention;

[0011] Figure 4 is a schematic of a parking lot provided with a wireless power transmission system according to the present invention;

[0012] Figure 5 is a schematic of an in-home embodiment of a wireless power transmission system according to the present invention;

[0013] Figure 6 is a schematic of a grid power multiphase interface according to the present invention;

[0014] Figure 7 is a schematic of a grid power multiphase interface according to the present invention;

[0015] Figure 8 is a schematic of a grid power multiphase interface according to the present invention;

[0016] Figure 9 is a schematic of the coil electronics subassembly of a power transmission module according to the present invention;

[0017] Figure 10 is a graph of the power transmission module primary waveform according to the present invention;

[0018] Figure 11 is a schematic of the coil electronics subassembly of a power transmission module according to the present invention;

[0019] Figure 12 is a schematic of a roadway installation of a wireless power transmission system according to the present invention;

[0020] Figure 13 is a schematic of a power transmission cable according to the present invention;

[0021] Figure 14 is a schematic of a power transmission cable interface according to the present invention;

[0022] Figure 15 is a detailed schematic of a parking lot provided with a wireless power transmission system according to the present invention;

[0023] Figure 16 is a schematic of a roadway power transmission cable and magnetic interface according to the present invention;

[0024] Figure 17 is a schematic of a power transmission module truss support assembly according to the present invention;

[0025] Figure 18 is a schematic of a power transmission module assembly according to the present invention;

[0026] Figure 19 is a schematic of a power transmission module end cap according to the present invention;

[0027] Figure 20 is a schematic of the integrated tank and link coils of the coil electronics subassembly of a power transmission module according to the present invention;

[0028] Figure 21 is a schematic of tank coil of the coil electronics subassembly of a power transmission module according to the present invention;

[0029] Figure 22 is a schematic of the integrated tank capacitor of the coil electronics subassembly of a power transmission module according to the present invention;

[0030] Figure 23 is a schematic of the design of the tank capacitor of the coil electronics subassembly of a power transmission module according to the present invention;

[0031] Figure 24A is an electrical diagram of the circuitry of the power transmission module power amplifier according to the present invention;

[0032] Figure 24B is a schematic of the power amplifier output current sampling of a power transmission module according to the present invention;

[0033] Figure 25 is a schematic of the laminate construction of the coil electronics subassembly of a power transmission module according to the present invention;

[0034] Figure 26 is a schematic of the heat sink via designs of the coil electronics subassembly of a power transmission module according to the present invention;

[0035] Figure 27 is a schematic of the magnetic fields produced by a power transmission module according to the present invention'

[0036] Figure 28 is a schematic of the selective energization of power transmission modules in a roadway according to the present invention;

[0037] Figure 29 is an electrical schematic of an embodiment of the H-bridge power amplifier according to the present invention;

[0038] Figure 30 is a schematic of a power receive module according to the present invention;

[0039] Figure 31 is flowchart of the logic of a power transmit module according to the present invention;

[0040] Figure 32 is a schematic of the vehicle interfaces of a power transmit module according to the present invention;

[0041] Figure 33 is a schematic of an integrated power receive module coil assembly according to the present invention;

[0042] Figure 34 is a schematic of a dual mode embodiment of the wireless power transmission system according to the present invention;

[0043] Figure 35 is a schematic of an intersection provided with a wireless power transmission system according to the present invention;

[0044] Figure 36 is a schematic of a steering correct display according to the present invention;

[0045] Figure 37 is a schematic of a power receive module configuration for use with a steering correct display according to the present invention;

[0046] Figure 38 is an electrical schematic of an example of a power transmit module according to the present invention;

[0047] Figure 39 is an electrical schematic of an example of the electronic subassemblies of a power transmit module according to the present invention;

[0048] Figure 40 is an electrical schematic of an H-bridge amplifier of an example of a power transmit module according to the present invention;

[0049] Figure 41 is an electrical schematic of a tank coil of an example of a power transmit module according to the present invention;

[0050] Figure 42 is a schematic of a power amplifier tank cap of an example of a power transmit module according to the present invention;

[0051] Figure 43 is a schematic of a pickup coil of an example of a power transmit module according to the present invention;

[0052] Figure 44 is a schematic of a pickup coil resonating cap of an example of a power transmit module according to the present invention;

[0053] Figure 45 is an electrical schematic of the carrier logic and power amplifier gate drive electronics for an example of a power transmit module according to the present invention;

[0054] Figure 46 is a schematic of the gate drive and coil polarity relationships for an example of a power transmit module according to the present invention;

[0055] Figure 47 is a schematic of the variable frequency oscillator subassembly of an example of a power transmit module according to the present invention;

[0056] Figure 48 is a schematic of the chassis layout for an example of a power transmit module according to the present invention;

[0057] Figure 49 is a schematic of the load bank layout for an example of a power receive module according to the present invention;

[0058] Figure 50 is a schematic of the foil and conductive surfaces for an example of a power transmit module according to the present invention;

[0059] Figure 51 is a schematic of the electronics of an example power receive module according to the present invention; and

[0060] Figure 52 is a schematic of a strapping system for present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0061] Referring now to the drawings, wherein like reference numerals refer to like parts throughout, the present invention comprises a wireless automated vehicle energizing system, referred to hereinafter as WAVES. WAVES complements the current development of an electric vehicle fleet and provides a primary means for achieving national “energy security” for U.S. vehicular transportation. The present invention presents a clear path towards the near-and long term elimination of battery technology limitations regarding range, charging time and associated lifetime cost and real-time performance trades. The present invention also provides the U.S. with a way to leapfrog over potentially severe investments in conventional mass transit, by providing similar gains in efficiency and carbon reductions as it complements our currently flexible roadway transportation based infrastructure. WAVES can be a very large factor towards achieving U.S. international commitments regarding greenhouse gas reductions.

[0062] In general, the present invention provides a wireless means of charging "all electric" and "hybrid electric" vehicle batteries and is applicable to stationary and moving vehicles (in parking spaces and within the roadway). The present invention is also scalable

for both new production vehicles and as an add-on to existing vehicles. Intra-city use is an initial target, with inter-city and inter-state follow-on. Consistent with the needs of both private and public transportation vehicles, the present invention also includes a fee-based system whereby charges are automatically levied in proportion to energy use.

[0063] Figure 1 depicts a means for seamlessly charging batteries of all-electric or plug-in hybrid electric vehicles under a variety of conditions, both statically while a vehicle is parked or otherwise stationary and dynamically while a vehicle is in motion, using WAVES 10. A distributed network 12 of parking/road imbedded Power Transmit Modules (PTMs) 14 are connected to a power grid 18 for primary power and wirelessly linked to a Power Receiver Modules (PRMs) 16 located in a vehicle 20 that is within proximity to PTM 14 for magnetic power transfer. Vehicle 20 generally comprises an electric motor 22, controller 24, and battery supply 26. Vehicle mounted PRMs 16 are interconnected to battery 26 to recharge battery 26 while vehicle 20 is stationary or in motion via magnetic coupling with PTMs 14.

[0064] The charging operation is automatic when enabled by the driver of vehicle 20, employing a wireless data communication links between PRMs 16 and each/any PTM 14 supplying power. PTMs 14 are in turn LAN (Local Area Network) and subsequently internet connected for energy billing. The intent of the static infrastructure of WAVES 10 is to provide energy "hot spots" whereby WAVES equipped vehicles can partially or completely recharge using individual parking area located PTMs 14. Dynamic charging is accomplished by the concatenation of additional PTMs as necessary to provide continuous wireless charging.

[0065] When dynamically charging, vehicle 20 is both recharged and energized on a continuous basis while in transit, providing a power transfer capability greater than that required by electric motor 22. The result being that subsequent to a long range trip, requiring perhaps many times the energy nominally available from battery 26, vehicle 20 leaves the highway with a battery in a high state of charge.

[0066] In either stationary or mobile mode, the driver can be automatically charged for energy use (and tolls as they may apply), such as in a manner directly analogous to the current EZ Pass system where a credit card account is periodically charged for usage fees.

[0067] It should be recognized by those of skill in the art that safety standards must be adopted for the effective implementation of WAVES 10 so that the various components of the present invention, including PTMs 14, PRMs 16, and associated grid power and internet interfaces, are designed for safe operation, meeting transportation, fire, electrical and

magnetic field standards. For example, the Department of Transportation and National Traffic Safety Administration are pivotal sources of safety and compatibility standards that all U.S. based WAVES components must meet to insure roadway safety. Regarding magnetic field health standards, the present invention is designed to meet IEEE P1140 (a VDT standard) in the VLF band from 2 KHz to 400 KHz, with magnetic field strengths within the passenger compartment below 0.25 mG. Regarding electric field intensity health standards, WAVES meets IEEE P1140 with VLF band field strengths within the passenger compartment less than 2.5 Volts/Meter.

[0068] In a preferred embodiment, WAVES magnetic coupling fields alternate at a frequency at the upper portion of the VLF band. PTM 14 magnetic fields emanate through a Faraday shielded assembly with electrical fields of the power amplifier waveform and its harmonics attenuated to meet FCC radiated emissions limits. It is intended that all WAVES modules are U. L. approved as a first insurance of electrical safety. This implies that the design has been verified to prevent catastrophic fire and shock exposure under normal, worst case and failed modes of operation. Conservatively rated components, temperature control, rigorous power fusing, automatic shutdowns and fault detection and location are important design attributes in meeting overall electrical safety and reliability.

[0069] Reliable wireless data interlocking between PTM 14 and PRM 16 modules prevents power generation until a vehicle PRM 16 is in the immediate proximity of a given PTM 14. When immediate proximity is achieved, efficient power transfer is possible given that the vehicle has established a valid ID via two independent communications paths, i.e., a first proximity link 28 between the PRM 16 and PTM 14 and an internet or data link 30, as well as an additional and independent real-time check on vehicle presence via a valid second proximity link 32.

[0070] The inherently rapid attenuation of magnetic fields at distances beyond the 3 inch nominal roadway clearance between PTM 14 and PRM 16 means that the magnetic field strength is normally very weak at the floor level of vehicle 20. Free space magnetic attenuation can be expressed as proportional to $1/(\text{distance ratio})^3$. Additionally, if the floor of vehicle 20 contains a suitably magnetically permeable material, such as iron or ferrite, this already weak magnetic field will be significantly further weakened by being shunted away from the passenger compartment. Furthermore, when PRM 16 is effectively coupling power from PTM 14, the majority of the magnetic field is shunted through the vehicle's PRM 16 with a significantly weakened field left to propagate across the remaining distance to the floor of the vehicle 20 (again at an attenuation factor equal to $1/(\text{distance ratio})^3$). If desired, in-

vehicle magnetic field sensing can be employed to alarm and otherwise inhibit a valid ID from being sent via the first proximity link, thus disabling PTM 14 power generation such as in cases of an accident.

[0071] Power transfer can only be enabled by the condition of two valid ID requests, one in relatively non-real-time via the Wi-Fi (radio) Data Link 30 and the other in real-time via the first proximity link (magnetic) 28. Note that first proximity link 28 operates through the same PTM coil 42 of PTM 14 utilized for magnetic power transfer to insure correlation with the power transfer footprint. The second proximity link 32 verification is an additional condition that must be met for power transfer. It operates independently from both the first proximity link 28 and the Internet access link 30 by utilizing a radio sensing subsystem. This 3-way enabling function in combination with Exciter Control criteria insure that no magnetic radiation occurs from any Power Transmit Module - Coil Electronics Subassembly (PTM-CES) 34 whenever there is not a PRM 16 directly above (or within adequate coupling range) of a PTM-CES 34. The requirement that all three conditions be met makes certain that there will be a valid vehicle PRM 16 ready to absorb energy and the presence of highly attenuated magnetic fringe fields due to the large range, vehicle PRM 16 absorption and chassis between PTM fields and vehicle passengers.

[0072] From the broader standpoint of traffic safety, WAVES 10 provides a basis for real-time comprehensive traffic density and speed data that are vital to an efficient traffic management system. This can include active feedback to individual vehicles or to traffic signals as well as to law enforcement.

[0073] WAVES Energy Requirements

[0074] The energy required by electric vehicles 20 traveling on a highway is dependent upon many factors including size, weight, speed, acceleration demands. At city traffic speeds below 50 mph the energy requirements are dominated by mass acceleration and tire/rolling losses. The average of these energy requirements, with dynamic braking significantly normalizing acceleration demands is, on average, less than the energy required at constant upper-end highway speeds. Therefore, WAVES 10 energy requirements are set by the more demanding high speed conditions. At approximately 40 to 50 MPH wind losses begin to dominate vehicle energy demands and wind losses increase disproportionately with increases in speed. Maximum highway speed as defined for WAVES 10 energy transfer purposes is set at 70 MPH, which is at or above most maximum legal speed limits within the continental US.

[0075] Electric vehicle miles per gallon equivalent is often expressed in electrical energy per mile or kilowatt hours per mile. The continuous required power for a vehicle 20 is then kilowatt hours per mile divided by hours per mile or "watts". This continuous power requirement can be distributed equally across the number of coils within the vehicle's PRM 16 since its design efficiently combines individual coil powers to produce a single source of DC for vehicle battery 26 charging and motor energizing power. The vehicle PRM 16 insures that all of its pickup coils are energized (continuously) by sequentially enabling magnetic coupling from respective roadway PTM 14 transmitting coils as they pass under the PRM 16 pickup coils. It is then the net continuous power per PRM 16 coil that is at the core of the roadway electrical design requirement. The energy requirements for various scenarios may be seen in Table 1 below:

Table 1

Medium Sized Car	50 mph	60 mph	70 mph
Kilowatt hours / mile	0.2	0.25	0.433
Continuous Power - kilowatts	10	15	26
Total energy for 20 miles - kilowatt hours	4	5	8.66
Continuous Power Kilowatts per PRM Coil (coil PRM)	0.71	1.07	1.86
PHEV Bus or Truck	50 mph	60 mph	70 mph
Kilowatt hours / mile	0.8	1	1.73
Continuous Power - kilowatts	40	50	86.6
Total energy for 20 miles - kilowatt hours	16	20	34.64
Continuous Power Kilowatts per PRM Coil (42 coil PRM)	0.95	1.19	2.06

[0076] It should be emphasized that WAVES 10 provides significant utility in offsetting the normally high 26 to 86 kilowatt rates of discharge from vehicle batteries 20 during normal operation. Repeated high discharge rates can be especially problematic, leading to lack of capacity and early failure, as batteries age and as battery temperatures are lowered during winter. By continuously offsetting the need for long periods of high rates of discharge, WAVES 10 provides the ability to dramatically extend battery life as well as range. From the above chart it can be understood that the maximum continuous power per

PRM 16 coil, a core requirement, is 2 kilowatts. This is for practical purposes identical to the peak PTM-CES 34 magnetic field power requirement. Average PTM-CES 34 magnetic field power is less, dependent upon the traffic density induced energization duty cycle.

[0077] WAVES Roadway and Parking Lot Installation

[0078] Roadway 36 installations for the present invention may range from entire highway systems such as interstates to all or portions of local or intrastate highways to parking lots. Smaller scale installations can include segments of highways such as at traffic signals, waiting lines and other cueing areas where traffic densities are high and vehicle dwell times are sufficient to allow significant, although transient, battery charging intervals.

[0079] In the overwhelming majority of installations, roadways and parking areas already exist. Therefore an emphasis is placed upon existing roadway installations in a way that makes such installations cost-effective and as minimally intrusive as possible. This implies a set of national standards, an automated means of implanting PTM 14 modules and reasonable access to grid 18 and internet connection points. New roadway installations can however engineer required interfaces in a rigorous manner, thus avoiding retrofits and other perhaps more indirect methods to accomplish interconnectivity.

[0080] In either existing or new cases, subsequent to a WAVES 10 installation, the roadway 36 must provide a seamless transition across PTMs 14, with no effects upon drivability and safety. This implies that PTMs 14 have an ability to support worst case traffic loads, present a skid-free surface and be resistant to sun, oil, fuel, water, ice, salt, sand and temperature extremes. During roadway 36 installation, PTMs 14 are preferably imbedded within a V-shaped channel 38 cut along the centerline of each driving lane to form a PTM lane 40. The walls of roadway channel 38 are lined with salt resistant concrete, coated with asphalt or tar. The corresponding V-shaped bottom of PTM 14 is designed to fully seat into the roadway channel 38, continuously sealed along both side-walls, with the top surface of the PTM 14 matching the level of the roadway 36. Vertical traffic loads are thus translated to forces perpendicular to the side-walls of the V-Channel as downward pressure is exerted upon PTM 14, thus securing it within the roadway channel. This triangular implementation provides a robust installation, given that the trussed triangular cross section throughout the length of each PTM 14 translates load forces with minimal deflection.

[0081] As seen in Figure 2, a typical WAVES 10 system for roadway 36 is composed of continuous chains of PTMs 14 forming PTM lanes 40, with each PTM 14 containing many individual PTM coils and their associated PTM-CES units 34. PTM-CES units 34 provide the alternating magnetic fields that are the source of power coupled to vehicle mounted PRMs

16 as well as providing control and critical communications links. PTMs 14 thus create PTM Lanes 40 that are centered within vehicle driving lanes. A multi-phase primary power line 44 is routed within each PTM Lane 40, powering in parallel all PTMs 14 within a given PTM Lane 40. PTM Lanes 40 may in turn be paralleled for a given roadway to form segments 46 of WAVES 10. The boundary of each WAVES segment 46 becomes a potential grid interface point, implemented by grid power converters that bridge between the grid 18 and roadway segment 46. Due to the multi-phase nature of PTM 14 primary power interface provided by grid power converters, they are referred to as Grid Multi Phase Interfaces (GPMIs) 48.

[0082] The number of highway lanes and/or highway traffic density and type will determine the segmentation distance and the corresponding number of GPMIs 48 present. Combined Heat and Power (CHP) units 50 may be employed at GPMIs 48 to provide power backup to grid 18, peak power shaving for grid 18 during periods of intense overall usage (e.g. during rush hours and at noontime), or on grid 18 continuously, given favorable net metering contracting with the utility. It is not necessary to provide CHP 50 capability at each GPMI 48 to provide a significantly large margin of robustness to WAVES 10.

[0083] As seen in Figure 3, power transfer at intersections 52 is a critical first step in the process of establishing a WAVES 10 roadway infrastructure. Given priorities of traffic density and grid interface proximity, such installations provide a relatively low cost and compact roadway installation format with a significant return on investment. The approach is to install PTMs 14 that fully "energize" the normal lane lengths associated with cueing and acceleration through and surrounding intersection 52. This arrangement allows stationary electric vehicles 20 to receive maximum battery charging while waiting for an intersection light to change, and full charging energy plus acceleration energy transfer when vehicles 20 leave intersection 52. The energy demands of accelerating vehicles 20 represent a significantly disproportionate battery energy drain that can be nearly eliminated via a WAVES 10 energized intersection 52. Furthermore, electric vehicles 20 that are simply passing through intersection 52 on a green light also benefit by a relatively short period of full charge rate and full electromotive energization. Since the cruising energy demands for EVs are modest at urban speeds, a network of such WAVES intersections 52 within a city environment can nearly fully provide the energy needs traffic without having to electrify gaps between intersections 52 such as would be the case in a full WAVES roadway 36 installation.

[0084] Parking lots 54 can be served by single or multiple GPMIs 48. The power demands of vehicles 20 associated with parking lots 54 can be on the same order as the per

vehicle power demands of a highway, since battery charging alone can readily be in the kilowatt level. CHP units 50 may also be employed at parking lot systems, as seen in Figure 5, for the same reasons as for highway installations. Additional loads such as from vehicle air conditioning or heating could also be significant power additions. As seen in Figure 4, there is flexibility in PTM 14 and GPMI 48 configurations for parking lots 54.

[0085] As noted within Table 2 below, parking lot individual car charging rates are conservatively limited to 15 KW while larger vehicles 20 are limited to 45 KW such that the continuous per PTM coil power is limited to approximately half of a coil's peak power rating. Note also that a 1 to 10 ratio of Plug-in Hybrid Electric Vehicle (PHEV) or all electric (EV) trucks & buses to cars has been maintained for the purpose of this analysis.

[0086] Given approximately a 70%-30% split between battery charging power and auxiliary power (e.g. air conditioning and heating) there remains significant power to provide upwards of 10 KW or 10 KWh/hour of battery energy recovery. This would be sufficient for approximately 20 miles of travel in a car traveling at 70 mph, or correspondingly, 160 miles of travel for an 8 hour work day charge. The ratio of battery charging to auxiliary power for trucks and buses may be different depending upon refrigeration and other demands.

Table 2

Parking Medium Sized Car	100 Spaces	200 Spaces	400 Spaces
Per Vehicle Charging + Aux. Power - kilowatts	15	15	15
Continuous Total Power - kilowatts	1500	3000	6000
Total energy for 8 hours - kilowatt hours	12000	24000	48000
Continuous Power - kilowatts per PRM Coil (14 coil PRM)	1.07	1.07	1.07
Parking PHEV or EV Bus/Truck	10 Spaces	20 Spaces	40 Spaces
Per Vehicle Charging + Aux. Power - kilowatts	45	45	45
Continuous Total Power - kilowatts	450	900	1800
Total energy for 8 hours - kilowatt hours	3600	7200	14400
Continuous Power - kilowatts per PRM Coil (42 coil PRM)	1.07	1.07	1.07

[0087] It is useful to consider the case of retrofitting an average interstate highway system such as the New York State Thruway (I-90) as an example of the implementation of a WAVES 10 according to the present invention. The typical peak vehicle density for this particular highway under normal driving conditions is approximately 160 vehicles 20 per mile across a total of 4 lanes, 2 lanes running in each direction. With an average traffic mix of 90% cars and 10% buses or trucks traveling at 70 mph it is estimated that the instantaneous peak power demands of a one mile interval would be 5 megawatts. This 5 megawatt primary power demand is satisfied by a single power converter station or GPMI 48 that is grid interconnected at its input side and outputs multiphase power as primary power input to connected PTMs 14. Thus, a 6 phase GPMI 48 would produce 6 PTM primary power lines at 5 MW / 4 Lanes / 6 phases for approximately 200 KW per lane phase, as seen in Table 3 below:

Table 3

Vehicle Traffic @ 70 MPH 90% Cars 10% Trucks and Buses	Light	Medium	Heavy
Vehicles / mile (4 Lanes)	40	80	160
Avrg Vehicle Spacing within Lane - Feet	528	264	132
Average PTM-CES Duty Cycle - %	10.18	20.36	40.73
Kilowatt Hours per Mile	22.508	45.016	90.032
Continuous Power - Kilowatts	1280	2560	5120
Lane Power per Phase - Kilowatts	53.33	106.67	213.33
Current per Phase @ 4KV - Amperes	13.33	26.67	53.33
DC Ohmic Loss of #10 Gauge Wire per Mile - %	0.88	1.77	3.53

[0088] Four kilovolts (4 kVAC) has been chosen as the PTM primary power distribution voltage as a reasonable compromise between the need for low (I^2)*R losses and requirements for high voltage safety and reliability. At 4 kilovolt per phase, the maximum current drawn by each lane phase would be 50 amperes which is sufficiently low to ensure low losses with modest gauge conductors. Note that the #10 gauge conductor reference in Table 3 is an "equivalent" reference and will be made up of individually insulated metal foils with sufficient area to achieve bulk resistance and skin effect losses equal to the DC resistance associated with a #10 gauge solid round copper conductor. Skin effect begins to be

a significant loss factor for power transmission frequencies that are within the VLF band as detailed in Table 4 below.

Table 4

Aluminum Foil	Estimated Resistivity Incr.	Resistivity Increase	Combined Area	#10 gauge Area	Area required	Al Foil Width @1 skin depth thick
1 skin depth thick	due to skin effect	Ratio to Cu	increase factor	(inch^2)	for Al Foil eqv	t@ 60 kHz eqv DC Resistivity to #10 gauge Cu
0.0106	1.2	1.64	1.968	0.00817	0.01607856	1.51684528301887

[0089] A GPMI 48, spaced nominally at an interval of 1 mile along a highway, such as I-90, forms a 4 lane PTM segment 46. In cases where peak power demands of a particular segment might exceed the capability of a given GPMI 48, the connectivity between GPMIs 48 along the multi-phase PTM primary supply lines provides a means for borrowing energy from adjacent segments when available. The multiphase wiring of the PTM primary supply line provides an additional degree of redundancy since individual phase failures gracefully degrade the power transmission capability of any affected PTMs 14.

[0090] From a backup power perspective, natural gas/fossil fueled micro-turbine electrical power generation may be used and spaced strategically, at perhaps 20 mile intervals, in conjunction with a GPMI 48 located perhaps at service/rest stop areas. For example, a micro turbine generator capable of 1 MW available from Capstone Turbine Corporation of Chatsworth, California can be readily grid inter-tied to produce efficient (28% natural gas to electrical efficiency) and continuous grid power in parallel with an operating grid or as the case may be, emergency backup power for both a roadway segment and an associated service area. A 1 MW micro-turbine generator can also be configured as CHP unit 50, supplying the heating and air conditioning loads of the service area itself. A quantity of six such CHP units 50 can continuously provide 6 MW of electrical power (grid tied or backup) while also producing 100 million BTU per hour (@580 deg. F) of thermal energy. Given the availability of natural gas or another suitable fuel, such CHP units 50 can pay for themselves during normal operating periods, while insuring the availability of vehicle charging power under grid failure conditions. During grid outages the availability of backup lane segments spaced every 20 miles gives vehicles 20 an opportunity to acquire a full charge at an associated rest stop parking area or, if sufficient energy exists within the vehicle's

battery 26, continue on with the original journey with some assurance of periodic future boosts in charge.

[0091] From a renewable energy perspective, photo-voltaic (PV) powered grid inter-tied inverters, co-located along the highway, may be used to mitigate greenhouse gas generation as well as shave some of the peak grid loads during daytime periods. Shaving one half, or 2.5 MW of the GPMI's worst case vehicle traffic load, using PV power generation, would require an array (@ 20% efficiency) that is 1 mile long by 20 feet high (the entire segment length). This is not a totally unreasonable requirement for many areas along a typical interstate highway system and could readily pay for itself in energy savings alone over a 20 year period.

[0092] WAVES Household Installation

[0093] Referring to Figure 5, household WAVES installations 56 differ from roadway and parking lot installations by the need for lower cost and a more simplified PTM 14 installation. PTM 14 for household garage or driveway may be constructed as a raised mat-like assembly 58 that can be simply laid down upon a flat surface, over which the vehicle's PRM 16 is centered. The raised midsection houses a row of PTM-CES units 34 in a sealed, waterproof housing 60.

[0094] Transmitting coils are located at the top-most portion of the rib-like midsection 62 of PTM 14 such that it reaches within 3" of the vehicle's PRM 16 (while retracted). Rib 62 has a triangular cross-section pointed upward forming an easily cleaned top surface that prevents debris or animals from resting thereon. PTM 14 is designed to interface directly to 220 VAC 60 Hz power mains, and is capable of continuous vehicle charging at a rate of 6.6 kW. The design of household installation 56 could be similar to the electrical design of the current 3 coil demonstration prototype described below, with additional power amplifiers & Tank Coils, as also described below.

[0095] WAVES Light Rail and Electric Transit Bus Installation

[0096] WAVES technology according to the present invention provides a means for supporting light rail and electric bus systems by minimizing electrical and control infrastructure while enhancing efficiency. The use of PTMs 14 embedded within trackways or bus lanes facilitates the use of electric motor drives fed wirelessly, without overhead wires, hot rails or associated moving mechanical contacts. Control system automation uses the existing PTM data link 30 allowing spacing and other vehicle data to be managed in a way to provide real-time feedback for collision avoidance, scheduling and integration with other roadway traffic. Positional, velocity and vehicle ID data is particularly effective in

maintaining safety in cases where light rail or bus traffic is interspersed with normal traffic. In such traffic, vehicles 20 of all types share a common PTM 14, however may have individual PRMs 16 optimized for particular applications. Batteries 26 on board light rail and bus vehicles 20 provide a means for storing braking energy and otherwise limit peak energy demands. Distributing PRMs 16, motors and energy storage within each "car" of a transit vehicle 20, inherently scales its ability to meet transport propulsion needs. In this way, long trains of many cars are possible with minimal added integration.

[0097] WAVES Return on Investment

[0098] It is important to consider how investments in WAVES infrastructure will be paid for, and the fairness doctrine that can be employed to insure long term acceptance. Grid energy has a cost that varies with the type and location of power sources which in turn can vary throughout the day and days of the week. The instantaneous cost of energy to the driver can and should be adjusted both to provide fair price to the grid but also as a way to provide adaptive choices that drivers can use to minimize their driving expenses while at the same time providing the power grid with greater capacity margins. Thus at peak driving times such as early morning, noontime and early evening, the cost per kilowatt-hour passed to the driver may be substantially greater than at other times of the day. The driver may in turn choose other commute times or avoid engagement the PRM during these times.

[0099] The cost of the grid supplied energy is however only one factor in determining the final cost per kilowatt-hour passed along to the driver. A toll can be assessed in addition, that reflects the long term investment infrastructure required to put WAVES in place on a given highway as well as shorter term maintenance costs.

[00100] A third factor added to the final cost per kilowatt hour is that of the peak power utilized by vehicle 20 such as to achieve optimum utilization of WAVES power supplying equipments. The objective of the peak power utilization surcharge is to reduce the probability of having to increase existing capacity or of over-stressing existing power generation and distribution equipments. Such a surcharge can be dynamic in that the charge is traffic density based with a utilization cost assessed as a factor of the energy used at any one interval of time and associated with traffic density or instantaneous electrical load on the system. Thus, higher energy users such as trucks and busses end up with higher costs for the energy that they use during times and locations of intense overall energy use.

[00101] On-board vehicle computer controller 24 can be programmed to consider all of these cost factors in deciding what route to take or when to activate the vehicle's PRM 16, which of course would include the vehicle's battery and its state of charge.

[00102] Parking lot located WAVES 10 offer some additional billing considerations. Parking lots associated directly with businesses may wish to incentivize use based to attract customers. The cost of delivered energy could be made artificially lower to accomplish greater visitation and/or be based upon a customer's purchases or history. Other factors that may be additionally attractive or simply deemed parking services, is that of supplying energy for vehicle air conditioning or heating while the vehicle is left unattended. This promotes safety and comfort while at the same time reduces the amount of energy required to overcome the accumulated environmentally induced loads once the vehicle leaves the parking area. WAVES 10 provides opportunities to employers wishing to pass along perks or incentivize certain employee habits by providing smart parking lots.

[00103] And finally, it must be stated that as with highway GPMI grid power backup, CHP micro-turbine generation can be used at businesses local to parking lots. This grid parallel inter-tie form of connection not only provides emergency backup electrical power for both business and WAVES during grid failure events, but also increases the level of overall net efficiency of heating, cooling and electrical power to nearly 90% for CHP GPMI associated businesses and highway vehicles 20.

[00104] It is also viable to consider the addition of renewable energy sources as a way to reduce environmental impacts associated with fossil fueled power generation and shave daytime load peaks from the grid. Specifically, regarding the use of PV renewable sources, it can be noted that typical parking areas represent extremely large areas of real estate, capable of receiving PV arrays with minimal impacts upon vehicle 20 use. Thus such a large amount of renewable energy, in direct proximity to point of use represents an efficient power source while at the same time offering an additional source of revenue and payback.

[00105] WAVES Grid Power Interface

[00106] Referring to Figure 6, grid power 18 is interfaced nominally at mile lane intervals using high efficiency multi-phase solid state inverter units (GPMIs 48) that transform 60 Hz grid power to kV level high frequency multi-phase AC for PTMs 14. Normally a single GPMI 48 supports 4 lanes of PTMs 14 over a mile interval, providing up to 300 KW of high voltage & high frequency multiphase power to a nominal string of 5000 PTM-CES 34. GPMIs 48 also bridge fiber data to and from the internet for billing, status, control and other purposes. GPMIs 48 can be connected in parallel for added robustness and reliability within a given PTM interval or segment. This can be done at each GPMI by bussing one PTM string to the following one, simultaneous with each GPMI interface.

GPMIs have capabilities to disconnect from the power grid and from each other during failure conditions.

[00107] Normal grid power is in the form of high voltage and current 3 phase 60 Hz grid power to a set of lower voltage 480 VAC, 3-phase power, using 6 transformers 64 (or a single 3-phase transformer). A subsequent tie circuit 66 associated with each of the 480 VAC Phase Inverter 68 feeds allows for the decoupling of a given 60 Hz phase from the grid under failure or maintenance conditions, or the introduction of alternate sources of power. Such alternate sources can be an external CHP 50 whereby grid power 18 is supplanted entirely (grid failure mode) or simply "or-tied" for purposes of peak load sharing and net metering. Additionally, since the phase inverters 68 are insensitive to 60 Hz phase relationships (each having internal AC-DC rectification), there is the capability to simply bring in another source of 60 Hz power as a backup. The following set of 6 Phase Inverters 68 (A through F) are phase synchronized to produce properly phased relationships on their outputs that directly feed PTM 14 segments.

[00108] The design of the Phase Inverters 68 may be based on a "transformerless" IGBT approach. In a concatenated roadway segment implementation, each Phase Inverter 68 will be phase-locked to its respective incoming phase from the adjacent segment, thus allowing for a direct inter-tie between segments. This is not a firm requirement because segments can be operated independently; however, by inter-tying segments, power can be passed between segments or otherwise directly shared, thereby enhancing overall robustness of the roadway energizing system. Furthermore, such an inter-tie prevents an open transmission line effect which may require active termination (variable load via multi-phase AC to DC to grid (or other) inter-tie inverter(s)) to reduce reflections back through the segment.

[00109] Alternative GPMI 48 designs can be configured that do not employ transformers. This promotes reductions in GPMI 48 cost, weight and size. Figure 7 depicts a series of 6 half H-Bridges 70, one for each phase being generated. A common return is established by a split capacitor 72 on the 60 Hz primary feed. Figure 8 depicts a full H-Bridge configuration wherein separate returns are available from each phase bridge. In both configurations resulting high-frequency power carrier phases from each phase pass through respective output filters that reduce harmonics associated with the square-wave switched waveform. The full H-Bridge configuration is particularly attractive and fits nicely with proposed RTC magnetic connector based step-down transformers feeding PTM loads.

[00110] Power Transmit Module (PTM) Primary Power Distribution

[00111] Referring to Figure 9, high frequency multiphase (6 phase) PTM primary power is magnetically coupled to each PTM-CES 34 in a phase parallel configuration throughout a given energized roadway lane or parking area. Transformer/magnetic links for each phase at each PTM subassembly efficiently step down the multiphase 4 kVAC primary distribution voltages to the order of 400 VAC per phase at each PTM-CES 34. This same transformer mechanism provides a conductor-less connector for routing primary power to the input of each PTM-CES 34. The multiphase primary power frequency is preferably an exact division by 6 of the PTM carrier frequency to thus provide a rectified ripple waveform which is in exact synchronism with the switching waveform that generates the PTM coil magnetic power field. A way to guarantee such a relationship is to individually "phase lock" each PTM-CES 34 High Power Amplifier drive signal to the rectifier ripple frequency or incoming AC phase power waveform. In this way DC filtering requirements are significantly reduced by the matching coincidence between power amplifier peak power demands at each 1/2 cycle to the peak of the rectifier ripple/each of the rectifier conduction peaks. Subsequent DC filtering thus can be limited to that of the much higher frequency switching transients while at the same time the lack of significant mismatch between voltage and current demands maintains a unity power factor load on the 6 phase Primary Power. Unity power factor is particularly important in minimizing PTM primary power distribution losses associated with non-unity induced reactive currents. The multiphase nature of this power distribution also allows the AC transmission frequency to be lowered by a factor equal to the number of phases, thus reducing AC transmission losses including both dielectric and skin effect losses by using this lowered frequency. This intermediate 6 phase power remains significantly high to allow the manufacture of relatively small, efficient and low cost step down transformers within the RTC. Thus, the important factors leading to an efficient PTM lane based primary power distribution system that are addressed by the present invention are: KV level distribution voltages and associated PTM-CES local step-down transformation to reduce IR transmission loss; Sufficiently high phase frequencies to minimize step-down transformer size and loss but not too high (essentially providing a sweet spot in cost/performance); Multiphase rectification synchronous with magnetic field generation to achieve unity power factor with minimized filtering and conditioning electronics to prevent reactive current circulation; and Multiple phases to lower distribution frequency thus reducing AC skin effect, dielectric and radiated field losses.

[00112] Ripple in Full Wave Rectified Waveforms for Multiple Phases

[00113] Each phase of a multiple phase system is full wave rectified and the outputs combined to provide a DC power source. When all six rectified phases are combined the resulting DC waveform has a ripple as shown in the subsequent waveform of Figure 10. In high power applications it is especially difficult to effectively filter out such ripple.

[00114] Historically, all high power multiphase generation was achieved with rotating machinery. Under these conditions, mechanical constraints on coil winding and placement in the alternator forced generated phases to be uniformly spaced over 360 degrees. That is, the phase increment between adjacent phases was $2\ \pi/N_\varphi$ degrees, where N_φ is the number of phases. Thus a 3 phase system had 120 degrees between phases, a 4 phase system had 90 degrees between phases, etc.

[00115] With modern high-power solid state inverters, the interval between phases can have any desired value. This phase is no longer constrained as it was in the past with machinery based multiphase alternators. This flexibility is used within WAVES 10 to synchronize ripple peaks in the rectified dc output voltage with demands for maximum power transfer at the coil amplifier. This insures that maximum power transfer is achievable without energy storage or costly filtering requirements. In particular, in WAVES 10 it is desirable to have a phase increment equal half of what it would have been for rotating machinery. Table 5 below summarizes ripple peaks for electronic and rotating machinery generation, where N_φ = Number of Phases.

Table 5

Increment Between Adjacent Phases	Number of Ripple Peaks per Cycle of Power Input	
	Odd Number of Phases	Even Number of Phases
$2\ \pi/N_\varphi$	$2\ N_\varphi$	N_φ
π/N_φ	$2\ N_\varphi$	$2\ N_\varphi$

Thus, the number of ripple peaks per cycle is $2\ N_\varphi$ for all combinations of phase intervals and even or odd number of phases, except for the larger phase interval combined with an even number of phases (where it is reduced to N_φ).

[00116] Power Transmit Module (PTM) Magnetic Power Transmission Control

[00117] Vehicle mounted PRMs 16 contain a first proximity wireless link 28 that is used to enable power transmission at each roadway PTM 14 as PRM 16 passes over them. This power enabling signal is demodulated at each PTM 14 subassembly to reveal the vehicle's ID that is used in conjunction with a valid vehicle ID obtained from a fiber cable

based Data Link (routed internally within each PTM) to enable power transmission to vehicle 20.

[00118] The degree of power coupled to a given vehicle 20 is limited by the maximum power capability of each PTM 14, aggregated by the number of simultaneously enabled coils and their respective instantaneous magnetic coupling coefficient (as expressed between PTM 14 and PRM 16). Furthermore, due to the parallel resonant transformer primary formed at each PTM-CES Tank Coil 74, the power required by each coil driving amplifier within the associated PTN-CES 74 subassembly is directly equal (minus relatively minor losses) to the power coupled to the vehicle. The amount of energy (power x time) provided by each PTM 14 is thereby measured for each vehicle passage and reported over the internet for billing purposes, along with other status information that has been acquired both organic to PTM 14 and from wireless data link 30 derived data. It should be noted that PTM 14 segment power demands can be capped at a power limit, as for example during above normal traffic loading, by purposely inhibiting individual or groups of PTM-CES units.

[00119] There is seen in Figure 11 PTM-CES 34, including data links 28, 30, and 32, power control 76 and reporting 78 (note a Phase to Phase Input Power cable format is shown as an option, and other options include common ground and individual paired phases with respective grounds). PTM 14 coils "light up" in rapid sequence as a vehicle PRM 16 passes over, only to just as rapidly power down again after a given vehicle's passage, ready for the next vehicle. This forms "waves" of power transfer that travel with and under each vehicle.

[00120] A high bandwidth WiFi wireless Data Link 30 is maintained between vehicle PRM 16 and roadway PTMs 14 (providing 2-way internet access, using PTM 14 contained fiber optic cables) for purposes of supplying required vehicle validation, billing and Performance Monitoring and Fault Location (PMFL). Data Link 30 has sufficient additional capacity to provide vehicle occupants with direct access to the internet while en-route. The WiFi nature of Data Link 30 communications allows for continuous access while a vehicle is on a WAVES 10 equipped highway, even while crossing lanes or otherwise not in direct magnetic power coupling range of a PTM 14. It should be noted that all highway vehicles preferably need access to this wireless Data Link 30 , whether WAVES 10 equipped, fossil fueled or otherwise. Universal Data Link 30 connectivity enables features associated with traffic control, law enforcement and general communications to be available from to and from all vehicles 20 on the highway. Traffic safety, efficiency and related labor cost reductions strongly drive for the universal adoption of a generic WAVES wireless Data Link 30 standard.

[00121] Control signals are also sent via PTM 14 contained fiber optic cables to enable or disable individual or multiple PTM-CES 34 within a lane as may be required for maintenance or other purposes. Control and monitoring functions can be highly automated, centralized and remotely located from WAVES 10 equipped highways. Performance monitoring at each PTM-CES 34 is used to insure safe power generation under worst case loading and transmitted power levels as well as to report failures for future maintenance. PMFL includes thermal, over current and over voltage sensing to insure safe amplifier operating conditions at each PYM 14 coil subassembly.

[00122] Power Transmit Module (PTM) Spectrum

[00123] In a preferred embodiment of the present invention, PTM-CES 34 coils are nominally operating at 360 kHz. This is roughly in the middle of the U.S. FCC VLF sub-band from 305 kHz to 405 kHz allocated for the dual purpose of both Aeronautical Communications (radio beacons) and Aeronautical Mobile (communications). WAVES 10 will be treated by the FCC under radiated and conducted emissions regulations/standards similar to that of other electrical appliances, as in electric vehicles, computers, TVs, inverters etc. that have internal high power electronics operating within this radio spectrum. WAVES 10 wireless power is coupled as a magnetic field, through a magnetic window, with electromagnetic shielding and filtering designed to avoid unintended emissions from both PTM and PRM. The power carrier itself is narrowband with PTM-CES tank coil 74 Q's greater than 10 during full power coupling. Standard EMI verification can be conducted (similar to tests that are routinely performed on military electronics) to insure that all demonstration tests will comply with FCC regulations for both fundamental and harmonics of the power carrier.

[00124] Primary Power Distribution (6 phase) Spectrum

[00125] Direct division of six of the PTM 14 operational frequency, thus nominally 60 kHz each phase. Due to National Time Code usage of the 60 kHz channel, the suggested operational frequency should most likely be just below or above the time code spectrum. Thus, PTM 14 operating frequency would be above and below 360 kHz by a factor of 6 times the difference in primary power frequency respectfully above and below 60 kHz. The cable shielding and multiple phase nature of the primary power distribution should greatly attenuate any unintended RF radiation at 60 kHz.

[00126] Power Transmit Module (PTM) Roadway Interface

[00127] PTMs 14 are sealed and ruggedly built triangular "conduit-like" modules 80 containing 50 individual PTM 14 coils and their associated PTM-CES 34. Each PTM 14

contains a concatenated line of pre-installed PTM-CES 34 units along with associated internal power and data cables. Weather-tight electrical and fiber optic feedthroughs at each end of a PTM 14 provide the means to rapidly chain PTMs 14 in series as they are installed within a roadway.

[00128] Referring to Figure 12, installation involves preparing a V channel 38 into which PTMs 14 are laid. This operation may be performed by a trenching vehicle 82. Bulk delivered unconnected PTM modules are robotically offloaded from a bulk hauling vehicle 84 directly on to an Assembly and Laying Vehicle 86. The Assembly and Laying Vehicle 86 lays a primary electrical power cable (RTC) 88 followed by successive PTMs 14. PTMs 14 are nested end to end to form a continuous assembly within roadway 36. Joined PTMs 14 are then pressure and electrically tested prior to and after the last operation which lays the PTM 14 assembly into the previously prepared PTM Trench, sealing it against the trench walls and rolling it flush to the roadway surface. This process produces a contiguous, operational PTM lane from the rear of the Assembly and Laying Vehicle as it progresses down the highway.

[00129] Note that PTM-CES 34, pre-installed within each PTM 14, are designed to be separately removable/replaceable for in-field servicing of roadway installed PTMs 14. The multi-phase primary input power to PTM-CES 34 units utilize magnetically coupled transformer links and blind-mated electrical and fiber connections to promote ease and reliability of this process. Table 6 below details the preferred specifications for PTMs 14:

Table 6

PTM Physical Specifications	
Length - Feet	40
Width - Feet	1.3
Depth - Feet	1.5
Basic Shape - Cross Section	Triangular
Weight - Pounds	500
Volume - Cubic Feet	46.8
Pounds per Cubic Foot	10.68
Power Leads - #	7
Power Lead - Connections at Each End	Pigtails - Weldable
Data Leads - #	2
Data Leads - Connections at Each End	Pigtail - Fusable
Mechanical Connection at Each End	Flange - Weldable

Number of PTM-CES Units per PTM - #	50

[00130] Power Transmit Module (PTM) Interface to Roadway Transformer Cable (RTC)

[00131] PTM 14 electrical components include multi-phase power wiring that supports not only the entire electrical power demands of a given PTM but also carries significantly higher levels of power required to sustain an entire lane segment. Utilizing high voltage AC power distribution minimizes currents and respective I^2R and skin effect losses associated with powering PTM 14 segments. Each PTM-CES 34 is connected to the multi-phase distribution running through a given PTM 14 by a set of six magnetically coupled transformer links 90 that serve to provide a safe, weather resistant, contact-less and reliable connector. Thus, this multi-phase power wiring is referred to as a Roadway Transformer Cable (RTC) 92. Magnetically coupled RTC transformer power connectors 94 are located below each PTM-CES 34 of a PTM 14. Each individual phase link forms a transformer with a physically separable core that enables a tight magnetic flux connection from primary to secondary when the core halves are brought together as PTM-CES 34 units are seated within the roadway. The primary side of each transformer link 90 is connected between one of the six multi-phase power lines to a neutral or paired ground conductors and performs a voltage step-down function (current step-up), in addition to the connection function, as a result of the ratio of turns between primary and secondary halves of the transformer.

[00132] To facilitate the manufacture of the RTC 92, individual transformer primary windings contain programmable taps 96 that are welded to respective phase conductors within the RTC 92. Each primary within a 6-phase sequence will select a unique ground/phase pair via programmable bonds thus allowing for a common transformer primary and associated cable construction. The use of multiple ground in parallel, paired with an appropriate phase allows for further reliability in these phase connections. Final molding of a surrounding insulating weatherproof outer jacket during manufacture encapsulates bonds, conductors and transformer primaries, as see in Figure 13.

[00133] Multiple PTM-CES 34 sets of magnetically coupled transformer links 90 are thus molded directly into the primary power phase lines during RTC 92 manufacture. They form repeating sequences of qty 6 phase transformer primary links that align with above secondaries respectively located within each PTM-CES 34 unit, as seen in Figure 14. Mechanical fixturing associated with each 6 phase transformer link sequence allows PTM-CES 34 units to be guided into position as a blind-mate connection. This produces a Zero

Insertion Force (ZIF) connection to each PRM-CES 34 module while also facilitating individual module replacement for maintenance. Moisture at transformer link core physical interfaces have no effect upon the magnetic coupling and all electrical connections, both on the cable side and within the PTM-CES 34, since the cores of each transformer windings are highly insulated and electrically isolated from both primary or secondary voltages. Similarly, the manufacturing installed and mated blind-mated fiber optic data line connectors at each PTM-CES 34, co-located with the transformer connector, are also isolated from the effects of moisture due to high degrees of electrical and environmental isolation common to such connectors.

[00134] The employment of 6 multi-phase power lines allows the power frequency to be 1/6th that of a single phase power line while achieving the same rectified ripple percentage for an equivalent rectifier on each phase. This lowered power frequency in turn reduces skin effect losses on the power distribution cable and allows the Multiphase Power Interface Unit (MPIU) 96 to be designed using more readily available and lower cost components operating at higher operational efficiencies due to lowered switching transition losses at correspondingly lower phase frequencies. The relatively high operational power frequencies as compared to 60 Hz drive RTC phase conductors 94 to be able to compensate for the increased skin effect conduction loss. Phase conductors implemented as metal (e.g. aluminum) foil or thin film conductors can satisfy this requirement while simplifying cable manufacture and lowering costs. Such implementations include depositing a film conductor on insulating (e.g. plastic) ribbons, that can be sandwiched for lower cost and higher reliability. Large scale RTC 92 to PTM-CES 34 power interface connectors 94 can employ transformers at each phase to ensure safe, reliable voltage isolation combined with efficient voltage step-down within this power interface, such as that seen in Figure 14.

[00135] Some variants (e.g., a parking lot) of PTM-CES 34 can employ a more conventional direct wired connection to each PTM-CES 34 for smaller scale installations and lower cost alternatives, especially within initial prototypes and demonstrations, as seen Figure 15. In such installations, one can employ a 220 VAC 60Hz power distribution cable with suitable environmentally sealable connections to the PTM-CES 34. In either MPIU 96 or 60Hz configurations, a ground fault circuit interrupter can be utilized that provides immediate power shutdown and safety protection in the circumstance that an environmental breech has occurred either along/within the power distribution cable or PTM-CES 34.

[00136] Figure 16 depicts the cross-section of a triangular RTC 92 married to a PTM 14 in a configuration that fits directly into the apex at the bottom of the PTM trench 38.

Closely fitting the trench as such, this cable format reduces the overall volume involved in the total PTM 14 installation. It facilitates pre-connection of RTC 92 to PTM 14 prior to trench installation, particularly when PTM 14 is to be used as a "self-form" during installation, while still enabling separate RTC removal if so desired during maintenance.

[00137] Power Transmit Module (PTM) Design Trades

[00138] A fundamental trade space surrounding PTM 14 design is that of design center gap distance between roadway/parking lot PTM 14 and vehicle mounted PRM 16 coils. This gap distance drives many design factors and related reliability and costs. The size of the coils within PRM 16 and PTM 14 can be relatively equal for wide ranges of gap distance however there exists a relatively linear relationship between coil size and gap distance for a fixed amount of power transfer/coupled power. The cost of roadway or parking lot installation is at least directly related to PTM 14 coil size in that a doubling of the width or cross-lane dimension of the PTM 14 coil doubles the amount of material that must be removed and doubles the physical volume of the PRM 16 assembly. Coil size also impacts the upper resonant frequency limitation of the associated Tank Coil 74 perhaps lowering this by a factor of 2 for each doubling of coil aperture area. Higher resonant frequencies reduce power supply ripple filtering requirements and allow efficient and small sized power transformers on the primary power side of PTM 14 ensuring the availability of magnetic connectors.

[00139] On the other hand over four times the reactive PTM 14 transmit power is required if the power transfer between PTM 14 and PRM 16 is to be maintained over a doubled gap distance. This increased reactive power is in turn a primary stressor for PTM 14 electronics reliability and raises component costs perhaps by a factor of 8. The chosen design center for PTM 14 to PRM 16 coil gap within the current design is 6 inches which is sufficient to allow a net roadway clearance of approximately 5 inches. Clearances greater that this will result in a rapidly decreasing falloff of power transfer. Clearances less than 5 inches will cause a disproportionately greater coupling factor between PTM 14 and PRM 16 coils resulting in the need to regulate or "fold back" the reactive power within the PTM 14 coil to maintain a fixed power. Therefore the 6 inch gap specification really determines the maximum gap at which a specified maximum power can be transferred. Initial experimentation has been with PTM 14 (Tank) coil dimensions of approximately 12 inches long (along lane) by 16 inches wide (across-lane) allowing a nominal 16 inch wide trench requirement for roadway or parking lot installation. It is possible to gain some design margin or reduction in reactive power (a main cost driver for PTM 14 implementation) by increasing the PTM 14 coil aperture, to perhaps a 16 inch by 16 inch dimension without significantly

impacting the ability to operate at currently high magnetic power frequencies, specified maximum power transfer or roadway installation costs. This could result in an estimated 25% reduction in reactive power for the same gap specification. Table 7 below depicts an attempt to rationalize a set of basic ratios of PTM 14 size and power to cost.

Table 7

Gap coil-coil inches	Reactive power per coil	PTM coil width	PTM coil length	PTM coil area, square	Gap coil-coil inches (normalized	Reactive power per coil	PTM Coil width (normalized	PTM coil area, square	PTM Electronics cost basis
6	2	16	12	192	1	1	1	1	10.1
6	2	16	16	256	1	0.75	1	1.333333333	8.13333333
6	2	16	24	384	1	0.5	1	2	6.2
5	1.66666666666	16	16	256	0.8333333333	0.625	1	1.333333333	7.13333333
5	1.66666666666	16	24	384	0.8333333333	0.4166666667	1	2	5.53333333

[00140] PTM Assembly

[00141] PTM 14 is comprised of included PTM-CES 34 units which are themselves individually environmentally sealed. In the preferred embodiment, separately manufactured and individually tested PTM-CES 34 units are attached to one another, in numbers that establish the modularity desired (e.g. 14 for parking lots and 50 for roadway installations). Note that certain PTM-CES 14 end-caps contain a locking mechanism which both draws the entire PTM 14 down into trench and while also securing it into position, as described in further detail herein. While a minimum of 2 locking mechanisms at each end of a PTM 14 may be adequate for the short parking lot PTM 14 configuration, this may be too few to be adequate in continuous roadway PTM 14 applications. It therefore is desirable to maintain a periodic spacing of the locking mechanism (that is fixed, perhaps to the parking lot PTM 14 interval) within the roadway PTM 14 configuration. Gasketing and fasteners are employed to additionally seal interfaces between PTM-CES 34 end caps and locking mechanisms shell. Each of the PTM 14 contained PTM-CES 34 exterior allows the enclosed electronics from the lower apex of each PTM-CES 34 to protrude into the trench bottom thereby allowing it to maintain direct thermal contact with the trench walls and with the power cabling directly below, within the apex of the "V" trench 38. Use of metal thermal through-wall vias into each PTM-CES 34 enclosed electronics area promotes good thermal transfer of heat

generated from internal electronics while also providing possible electrical grounding and electromagnetic shielding for contained PTM-CES 34 electronics. For certain installations it can be desirable to "pre-mate" RTC 92 or other power cabling to the bottom of the PTM 14 assembly prior to installation within its trench. This insures proper physical and electrical mating while not inhibiting the "blind mating" capabilities of the PTM 14 during maintenance swapping, once initially installed.

[00142] PTM-CES Assembly

[00143] Individual PTM-CES 34 units are designed to be structurally rugged, with an internal truss structure that fully supports worst case traffic loading without significant deformation or degradation from environmental and load cycling. The top of the PTM-CES 34 incorporates a Tank and Link Coil 74 filled containment cavity which produces a flat and well supported underlayment for the top roof/roadway surface area PTM-CES 34 within a typical roadway installation. The Tank and Link Coil 74 underlayment is further sealed against moisture by the incorporation of an electrical insulating and encapsulating agent such as a resin, wax or oil filling, that ensures mechanical and electrical stability under all operating conditions. The Tank and Link Coil 74 subassembly further contains spacer material that adds compressive and shear strength to the truss supported roof structure, as seen in Figure 17.

[00144] PTM Trench Installation

[00145] A "V" trench 38 is used to mount PTMs 14 flush with the roadway surface. Preparation of the trench proceeds by initially rough cutting a "V" cross-section with saws or other means into the road bed or parking lot bed. This is followed by a finishing coat such as concrete to achieve accurate, smooth and debris free sidewalls. Vibrating forms can be used to compress and rapidly form this finish coating. To prevent water intrusion once PTMs 14 are installed (mainly for freeze and corrosion protection), a waterproofing sealant coating can be applied to the side walls of the trench prior to PTM 14 installation. (Note: appropriate gasketing as applied to the exterior of PTM 14 may accomplish the same sealing property) If desired a power cable can be separately laid into the bottom of the trench with connectors facing upward at a spacing that mates with each PTM 14 or PTM-CES 34 as the given configuration requires. Otherwise the power cable can be pre-attached to PTM 14 prior to installation within the trench. PTMs 14 are then mechanically secured within the "V" trench at strategic locking points, including at minimum PTM 14 ends, as well as periodically along the length of PTM 14 in cases where longer PTM 14 lengths, with greater numbers of PTM-CES 34 units are employed. Locking also secures all primary power connections. The

locking mechanism allows PTM 14 to be drawn down into the trench while simultaneously being secured to the trench walls as the locking mechanism is tightened. The locking (and unlocking) mechanism is operated from the roadway surface for both installation and maintenance.

[00146] An alternative to separately applying a finishing concrete or other appropriate material to the initially cut trench wall, necessitating the use of separate forms and possible added time, a more rapid finishing may be obtained by use of PTM 14 itself as the form. In this way a release coating can be applied to the sides of PTM 14 prior to it being pressed into the Trench which has had newly applied finishing material (e.g. concrete). PTM 14 locking pads or pawls are extended from their unlocked position upon installation, and serve as elements of the "selfform" for creating sidewall detents. Removal of PTMs 14 requires that these locking pads/pawls are first retracted away from Trench side walls and vertical mechanical force applied to lift PTM 14 out of the Trench.

[00147] PTM Locking Mechanism Design

[00148] Figure 18 depicts one means for implementing a PTM 14 locking mechanism 98 (within an end-cap or otherwise distributed throughout a given PTM 14) is with a rotatable screw rod 100, being vertically captured within a bearing 102 just below its head, being countersunk within the top of PTM 14, below the roadway. This upper bearing 102 locks the screw rod 100 vertically and is in the form such as can be implemented with a groove machined through the upper section of the rod, just above the threads wherein an attached lock ring 104 can be captured within the slip bearing 102 wherein rotation resultant upward and downward vertical forces are applied to the entire PTM 14 as the screw rod 100 is turned CCW or CW respectfully. A clearance hole 104, downward through the locking mechanism, allows the screw rod 100 to freely turn while being attached to a lower located set of linkages 106 and associated pads 108, which come into direct contact with the side walls within the trench 38. In this lower set of linkages the screw rod 100 is vertically captured at a top control rod bearing 110 such as can be implemented with a groove machined through a section of the rods threads wherein (as in the screw head located bearing) an attached lock ring can be captured within the bearing and via associated linkages to the upper pivot bearings of two opposing pads, can in turn release or apply pressure against opposing side walls of the "V" trench. The threaded screw rod 100 then passes down through a threaded nut 112, which is in turn attached to bottom pivot bearings 114 of each pad via lower linkages, such that when the screw rod is turned clockwise, both of the pads are tilted, under added leverage from the lower linkages, and digs into the trench side walls with great

pressure. This creates a locking pressure against which a simultaneously downward drawing force is produced to vertically drive the PTM into the trench. This locking pressure occurs as a result of screw induced pressure as transmitted through the lower pad linkages leveraged by the pivot spacing on the pads and the actuating force produced as the threaded nut moves upward towards the slip bearing.

[00149] The thread pitch and starting depth of the locking assembly is such that the vertical movement is sufficient to fully draw the PTM down into the trench being securely braced by both pads against respective side walls, conversely securing the PTM, within and against the trench, against traffic loads and other forces. The PTM is removed simply by a counterclockwise rotation of the screw rod inducing the reverse of the afore described locking action. A "detent" providing a more positive sensory indication of proper screw rod and pad depths, greater tolerance in the locking range and an enhanced locking force can be produced by an introduction of suitable parallel grooves down the entire length of each sidewall within the trench. Such grooves can mate to the top of each pad, fixing the desired PTM seating depth while accommodating significant locking by pad tilting and resultant detention of the pads within the side walls during installation/locking. Such grooves can be produced by cutting into finished, cured and/or partly cured side walls during trench formation.

[00150] The use of a recessed screw rod head, when combined with a uniquely keyed head and mating rotating tool or tool sets can provide a fundamental level of theft protection. Other electronic means and mechanical key locking means at sporadic intervals can provide a further deterrent.

[00151] Alternative PTM Locking Mechanism Design

[00152] Another embodiment of the end cap locking mechanism 116 is depicted in Figure 19. It is comprised of a flat slider-driven set of pawls that swing out into the trench wall as the slider is depressed downward. Such a slider mechanism can potentially be made cheaper (e.g. entirely of plastic and thinner to minimize roadway "dead-space" while at the same time serve as a PTM-CES End Cap or End Capsbetween adjacent PTM-CES units). Pawls on either or both sides of this Locking Mechanism apply direct frictional pressure to the trench sidewall(s) thereby securing the PTM within the trench. A trench wall inclusion designed to be located at the pawl engagement depth can further enhance the degree of the mechanical locking and seating forces that are generated during installation. Again access to such locking and unlocking can be protected by the need for a unique mechanical key and /or electronic controls.

[00153] Integrated Tank and Link Coil Design

[00154] Tank and Link Coils 74 can be integrated within a common assembly as shown in Figure 20. One such integration machines or otherwise forms spiral Tank and Link Coil 74 channels into opposing top and bottom sides of a solid sheet of insulating material such as plastic. Machining or forming grooves on each side to a total combined depth less than the thickness of the sheet insures that the assembly remains as a single sheet during all phases of manufacture. It also insures that an electrical insulating layer of material separates each coil once installed. Flat conductors such as metal foil are then inserted into each spiral channel to separately form Tank and Link Coils 74. Coils 74 can then be electrically connected to suitable leads and filled with a suitable electrical insulating resin or other compound to form a finished subassembly. The use of a physically robust sheet material within which channels are formed adds considerable strength - both compressive and sheer, to PTM-CES 34 unit once installed within its Tank and Link Coil 74 cavity. Additional coils such as used for magnetic field sensing can be also integrated within the same subassembly, in an analogous manner. Flat conductors facilitate significantly lower conduction losses at the higher frequencies utilized within this subassembly. Such foil conductors can be highly cost effective both in raw material costs and in assembly labor. Thin flat metal stock can be pre-formed into a spiral (e.g. via rollers) then conveniently fit into respective spiral channels. Alternatively, coils 74 can be formed by metal deposition within said channels, with top and bottom sides suitably machined or abraded to remove any possible winding to winding shorts. This deposition technique can accommodate further current crowding control due to magnetic field intensity by introducing conductive path scrambling within the metal deposited within grooves/channels by selective machining and/or periodically inserted bridging conductors within a channel. The sheet material within which Tank & Link Coils 74 are embedded can contain ferromagnetic material designed to enhance the generation and shape of the generated magnetic field as well as provide the overall electrical insulation properties required.

[00155] The Tank Capacitor 120 can also be integrated within the assembly of Tank Coil 74 as seen in Figure 21. Alternatively all or a portion of the required Tank Coil Resonating Capacitor 120 may be embedded within the PTM-CES 34 housing itself as seen in Figure 22.

[00156] WAVES Power Transfer Regulation

[00157] The loosely coupled air core resonating design of the WAVES power transformer dictates the generation of high reactive power within the PTM Tank Coil 74 and associated Tank Capacitor 120. This is problematic from a safety and reliability standpoint

as it increases the costs and development difficulties of these key components. Further adding to operational difficulties on one hand is the significant variability in magnetic coupling to the user vehicle and on the other hand the need for regulated, standard power waveforms at the vehicle charging or energizing interface. This prompts the need for an automated feedback based regulation approach developed for WAVES 10. There are two main aspects to this approach: first, the maintenance of a "safe operating area" for the PTM based power amplifier and, second, generation of a regulated standard voltage and frequency output to the user vehicle and associated electrical systems. These aspects are related to each other in the sense that the time varying vehicular waveform and load demands as modulated by varying magnetic coupling across the roadway gap will in turn reflect a time varying load demand upon the PTM Tank Coil 74 and associated amplifier which needs to be included within its "safe operational area" capabilities. This is further complicated by the loosely couple air-core design utilized by WAVES 10 as it avoids the use of high-permeability materials.

[00158] The key is that the voltage waveform experienced by the Power Amplifier/Tank Link side of the Tank Coil 74 may not indicate the waveform expressed by the Tank secondary winding which may experience significantly more variable voltage swings especially under light loads. To insure safe the establishment of a safe operational area, the Power Amplifier Drive 122 needs to be inhibited by feedback whenever this voltage waveform exceeds specific limits. Additionally, power amplifier current sampling infers real power (not reactive power) delivered in real-time. An added feedback loop around this current sampled signal can also inhibit the Power Amplifier Drive 122 thereby accomplishing regulation (and/ or safe high current shutdown under failure or faults) that is inclusive of both vehicle loading and safe area operation. On the vehicle side, a time varying waveform imay be generated by active circuitry within the PRM 14. This circuitry can also self regulate within an acceptable operational range of power transfer to insure proving a standard power waveform to the vehicle e.g. 220v @ 60Hz. The demands of PRM load power (waveforms et. al.) are, of course, reflected back to the PTM Power Amplifier 122 as a time varying real power demand that requires seamless incorporation within its regulation.

[00159] WAVES PTM Tank Capacitor Design

[00160] Referring to Figures 23 and 24A, a key critical component to the high power and long-term reliable operation of the WAVES PTM 14 is the Tank Capacitor 120. The reason for this is the extreme voltages (many thousands of volts) and high frequencies (many hundreds of thousands of cycles per second) coupled with high currents (ampere levels) that

that this capacitor is required to handle on a continuous basis during active power transfer. These requirements dictate a conservative voltage and power dissipation & loss design which is satisfied by the precision machined assembly of stacked components comprising the WAVES design. Low loss dielectric material is utilized throughout. The "nested" configuration captures and encloses interior plates to provide a high degree of corona resistance which is a major factor in reliable operation. A long and secure dielectrically encompassed path is thereby provided which is easily sealed from the outside environment. The parallel plate design of this capacitor lends itself to thick conductive foils or plates for the elimination of expensive metals, with corresponding lighter weight, and facilitates mechanical trimming to achieve precision capacitance values. The WAVES Tank Capacitor 120 design is easily scalable in electrical ratings to accommodate differing power transfer requirements even at multi-kilowatt levels. Additionally, as embodied in a split-plate design, the WAVES Tank Capacitor 120 provides an integrated, safe and low-loss means for sampling and measuring tank voltage during operation.

[00161] Referring to Figure 24B, a key critical component to the high power and long-term reliable operation of the WAVES PTM 14 is the real-time control of the output of the Power Amplifier 122. Figure 24B depicts a means for achieving an economical, efficient and small sized implementation of deriving such a control signal. In particular, a Litz Strand Transformer (LST) 124 design yields an important means for instantaneous sampling of Power Amplifier (PA) output current (as input to the Link primary of the Tank Circuit 74) in a small, efficient and voltage divided manner, with sample voltage in direct proportion to the LST turns ratio. Such a means limits the saturation of the LST 124 core by restricting the flux of the sampled current to a ratio of the PA output current. This ratio is set by the ratio of the total number of strands in the Litz wire 126 formed primary of the Tank Circuit 74 to the number of strands used/split off as routed through the primary of the LST 124, and the number of turns that these strands make in the primary of the LST 124. This approach takes advantage of the nearly equal current sharing that exists within the strands of the Litz wire 126 formed Tank Circuit Primary and resulting split off strands within the LST 124 primary. Obtaining such a PA output current measurement is key to the safe and regulated control of the PA within the PTM 14 and its subsequent variable loading imposed by any PRM pickup. As depicted, the LST 124 secondary provides a sample voltage output in direct proportion to the PA output current with this proportionality set by the number of strands within the Tank Circuit Link and the turns ratio within the LST 124. Such a sample voltage can be subsequently rectified to provide a real-time feedback control signal to the PA 122 to shut it

down in cases of safety or protection under adverse circumstances or simply to afford regulation thus insuring that a stable power is deliver to the PRM 16 load under normal variations.

[00162] Extruded PTM-CES Construction

[00163] Individual PTM-CES 34 units can be constructed from a continuous plastic or other insulating material extrusion that is subsequently sliced to the proper length to form the chassis for PTM-CES 34 units. Such an extrusion process allows the inclusion of internal 3D structure designed to be structurally rugged while minimizing overall weight. Extrusion promotes the low cost, mass-fabrication of PTM-CES housings. End Caps with appropriate gasketing then provides environmental sealing to contained integrated electronics. Single or multiple PTM-CES 34 containing units can be formed within each extruded slice, to be environmentally sealed by end caps during assembly. Heat sink and electrical vias can be formed with machining of chassis penetrations. Heat sink components can be inserted from internal and external areas of each PTM-CES 34 electronics area, through sealed penetrations to be subsequently joined or riveted together during unit assembly to form a complete thermal path from internal electronics to trench side walls. PTM-CES 34 contained units are separately tested and numbers of such completed units mechanically held together to form a PTM 14 assembly suitable for parking lot or roadway installation within prepared trenches.

[00164] Power Transmit Module (PTM) Environmental Heat

[00165] PTM roadway and parking conditions are exposed and can receive heat loading from ambient air temperatures and direct solar absorption. This heat gain can result in severe temperatures at the surface of the PRM 16 which can lead to lack of mechanical stability of related housing materials, especially when combined with vehicle traffic weight loading. The addition of reflective material along top PRM 16 surfaces may help reduce such increases in concert with appropriate housing material choices. This “cover” material could also have thermal insulation properties that isolate internal housing structure from potentially significant surface temperatures. Another possibility is a more active method of cooling, based upon phase transfer of heat at a common temperature, located within the internal housing volume. Materials such as wax absorb considerable heat in transitioning from a solid to a liquid. An active pumping system can be employed within the housing that allows a fluid (e.g. oil) to convey heat to from the exposed top area of the PRM to lower/subsurface areas. Heat sink vias located within these areas can then conduct heat to exterior side wall areas of the Trench that are at significantly lower temperature.

[00166] PTM & PRM Fabrication Material

[00167] High Density Poly Ethylene (HDPE) has important properties that are suited to the manufacture of PTM-CES 34 and PRM 16 housings. Fastening is one option, but various parts are preferably joined by hot air or nitrogen welding. Also, ultrasonic, laser, and infrared welding may be used. HDPE can be injection molded as well as being available from recycled sources at lower costs. Glass material can be embedded within the top layers to enhance strength and achieve a proper degree of UV and thermal protection. Furthermore the excellent electrical properties make it possible to create high voltage/high frequency resonating capacitors within the housing structure itself, inserting conductive plates within slot cavities formed within the housing material, thus eliminating the need for separate dielectric materials or associated mechanical fixturing. The lack of glue-ability does not preclude the use of glue or rubber-like compounds between components that serve in a sealing gasket function so long as additional mechanical means are employed to hold components together.

[00168] Alternative PTM-CES Laminate Construction

[00169] Individual PTM-CES 34 units can be constructed from a set of cross-sectional wafers, as seen in Figure 25, that when aligned stacked and laminated form a solid PTM-CES 34, complete with environmental sealing and heat sinking to form an integrated electronics module. Such a laminating process allows the inclusion of internal 3D structure designed to be structurally rugged while minimizing overall weight. Lamination promotes the low cost, mass-fabrication of the entire housing while enabling easily formed heat sink and electrical vias between laminate layers through machining of individual channels (shallow depth cuts). One way of producing such a PTM-CES 34 laminate stack is by the stamp cutting, router milling, or saw cutting of individual wafers from sheet stock plastic (including recycled plastic composite sheet stock). Wafers can then be stacked and bonded together along with included thermal and electrical vias to form a completed assembly with electrical components inserted prior to final assembly, testing and installation of environmental sealing end caps (also formed as wafers using the same machining process options referred to earlier).

[00170] Figure 25 shows a simplified representation of the laminating approach wherein 2 basic cross-section types of wafers (solid end cap type, internal type) are stacked to form a given PTM-CES 34 unit. PTM-CES 34 wafers are bonded to one another to form a structurally sound and water-tight unit. The use of a bonding agent effectively eliminates the need for gaskets. Sidelocking straps provide added strength to hold individually bonded wafers together within a unit. Individual units can be in turn joined to adjacent PTM-CES 34 units by use of extended side-locking straps. Such straps preserve the smooth continuous

side walls of the triangular exterior of the PTM 14 while making the entire assembly cohesive with a appropriate degree of rigidity. A bonding agent, mechanical hardware and high strength strap material can strengthen the degree of cohesiveness within and throughout a chain of physically linked PTM-CES 34 units. Once bonded, stacked and strapped together the resulting PTM-CES 34 units can be machined (e.g. sanded) on the exterior to enhance trench fit accuracy that can result in better distribution of roadway induced loading against the side walls of the "V" Trench. Furthermore if the slope of the trench makes the included angle of the bottom of the "V" slightly more acute than that of the respective "V" profile of PTM-CES 34 in this respective bottom "V" area then the bottom are of each PTM-CES 34 can be made to come under higher compression than that of the rest of the module as it is installed into the trench, thereby insuring good thermal contact in that area (as well as enhanced physical protection of bottom trench located power and data interfaces). The slightly increased fit tolerances on the remaining upper portions of the side walls can be easily overcome by intervening sealant and/or ultimate unit deformation under roadway loading. Heat sinking and electrical and optical vias can be introduced into the resultant PTM-CES 34 by suitably machining across the thickness of given wafer(s) of the stack prior to lamination. In this way both external and internal openings can be introduced at given locations wherein conductive material can be embedded and sealed during the lamination process. Considering the heat sink, a succession of vertical slots through both lower side walls of each PTM-CES 34allow the embedments of a series of "C" or "I" beam like metal heat conductors which can form nearly continuous internal and external heat transfer regions within the Electronics Module portion of each PTM-CES 34 unit. The center portions of such "C" or "I" beams provide the thermal vias through the insulating side walls of the Electronics Module. Again, the outer surfaces of the "C" or "I" beams form heat conduction to the "V" Trench walls and can be machined (including sanded" flush to the exterior of the module affording optimized heat transfer. Additional considerations of such formed thermal vias include machining/relieving exterior and perhaps interior module housing material under the non-via portions of each "C" or "I" beam thermal via. In this way the resulting depth allows for enhances sealing area and enhanced mechanical resistance to sidewall compressive forces, thus strengthening and better sealing these critical electronics containing areas of the module. Likewise, a similar approach can be utilized for the installation of other power and signal interface components to ensure reliability.

[00171] The Tank & Link Coil 74 is integrated with strong winding separators and a strong central core to form a robust component that slips into and fills the associated PTM-

CES 34 cavity during assembly (from an open side of a PTM-CES 34 unit). Additional intervening sealant then completely fills the cavity which when enclosed by end caps, the coil completes the formation of a solid strength member parallel to the its roadway exposed surface, being supported immediately below by truss-work within PTM-CES 34. The utilization of truss-work as opposed to solid cross sections is three-fold, high vertical strength at significantly reduced weight, overall material savings and the ability to form internal cavities and structure that fixture and fabricate internal components.

[00172] Heat Sink Via Designs Suitable for Laminate and Extrusion Implementations

[00173] Figure 26 illustrates two embodiments of the heat via 128 embodiment, both of which are suitable for laminate forms of constructions; however, the second embodiment is suitable for extrusion implementations because it can be inserted (e.g. like a staple) through an existing sidewall with minimal effort. The heat via 128 is designed to provide a good heat flow path from higher ambient temperatures of directly mounted power electronics (having high heat concentrations) and indirectly heat coupled internal electronics to PTM-CES 34 exterior and adjacent trench side walls of a lower ambient temperature without compromising the waterproof integrity of PTM-CES 34 housing.

[00174] The first embodiment is an I-beam configuration that neatly fits into prepared (2D) indentations within a laminate slice and is further captured and sealed by an opposing laminate slice within the stack of slices comprising a PTM-CES 34 unit. The second embodiment is a T-beam configuration for insertion through a relatively narrow opening through a PTM-CES 34 chassis side wall. In this instance the outside (or perhaps interior side) heat flow surface must be suitably fastened to the penetrating "T" end section to form the via 128. Suitable fasteners include riveting or otherwise cold forming T material or spot welding or screw fasteners. The intent is to provide a flush exterior with good sidewall contact for heat flow and minimal inclusions that may serve to inadvertently lock the PTM 14 in place preventing future extraction. An additional attribute to the second design is that of being capable of strapping across the multiple slices of a stacked laminate constructed PTM-CES 34, such as to provide individual unit integrity before being strapped or otherwise secured into a given PTM 14 configuration prior to subsequent installation.

[00175] Power Transmit Module (PTM) Electrical Specifications

[00176] PTM 14 electrical specifications include peak and average power for the entire module as well as average power dissipations from electrical/electronic losses which is manifested as heat. Heat will be conducted away from the PTM 14 along two paths, one is to the subsurface of the roadway (primary path) and the other is through the transmitting coil at

the roadway surface interface (secondary) which will only be significant when roadway surface temperatures are well below subsurface ground temperatures. Table 8 below details the electrical specification for PTM 14:

Table 8

PTM Electrical Specifications	
Electrical Power - Kilowatts Peak	125
Continuous Power - Kilowatts	75.00
Power Dissipation Total - Kilowatts	7.5
Power Dissipation Per Foot - Watts	187.5

[00177] It should be noted that the nearly 200 watts (peak) per foot dissipation is a significant amount of heat within a confined (0.75 cubic foot) volume as exists within a one foot long triangular section. This implies the need for a good thermal path between internal electronics within PTM-CES 34 components as well as a good thermal path to and through the side walls of the PTM 14 to the roadway subsurface. Also note that during the summer and in areas of direct sunlight the top or roadway surface of the PTM 14 is a potential source of high heat loading that must be avoided. Underlaying thermal insulation immediately below each PTM-CES 34 coil prevents this path being a major heat load to electronics below.

[00178] PTM-CES 34 units are the common denominator for transmitting the magnetic fields that are the source of power coupled to vehicle mounted PRMs 16, as well as the source for control and critical communications links to those vehicles. Multiple PTM-CES units 34, when simultaneously energized by a reasonably aligned passing PRM 16, couple increased power to the associated vehicle in direct proportion to the number PTM-CES 34 units energized, as seen in Figure 27. The coil drive waveforms at adjacent PTM-CES 34 coils are synchronized and phased to oppose magnetically, resulting in a bunched or vertical fountain-like structure to the resulting fields along the axis of the PTM 14. The vertical structure optimizes power transfer to respective pickup coils within the PRM 16 and eliminates any short circuiting of field lines directly to adjacent coils. This structure forms a rugged Magnetic Field Window 130 that isolates the Tank Coil 74 from the physical environment at the roadway surface while virtually magnetically displacing the coil to the very top surface of the roadway, thereby maintaining the smallest possible coupling gap to a vehicle's PRM 16 above. In this manner the coils on both roadway and vehicle are protected without adding the thickness of the PTM 14 housing/window to the air gap through which magnetic field coupling occurs.

[00179] PTM-CES 34 electrical specifications include required peak and average or continuous electrical power as well as loss related dissipation, manifested as heat. Heat is conducted internal to each PTM-CES 34 by both structure and insulating oil to its apex or lower triangular point. This apex area is thermally conductive and in good thermal contact, through adjacent PTM 14 side walls, to the sub surface at the bottom of the roadway trench. In this way cooling is maintained without sacrificing environmental integrity of the PTM 14 and its subassemblies.

[00180] The secondaries of magnetically coupled transformer links, located entirely within each environmentally sealed PTM-CES 34, feed rectifiers for the generation of DC power used by internal electronics. DC power is at nominally low voltages and moderate currents (see Table 9). Transmitting tank coil and capacitor AC voltages are however quite high due to associated Tank Coil Link transformer step-up and resonance effects. This is especially true when the Tank becomes lightly loaded under worst case low magnetic coupling instances. Therefore coil and capacitor components are high voltage insulated within the PTM-CES 34 by an internal oil bath and there is no direct exposure from coil to roadway as a result of employing a magnetic window material seal at this interface. The electrical specifications for PTM-CES 34 are set forth in Table 9 below:

Table 9

PTM-CES Electrical Specifications	
Electrical Power - Kilowatts Peak (incl. losses)	2.16
Continuous Magnetic Field Power - Kilowatts	2.00
Power Dissipation Total - Watts	160
DC Primary Power Supply Voltage - Volts	480
DC Primary Power Supply Current - Amperes pk	4.50
DC Secondary Power Supply Voltage - Volts	12
DC Secondary Power Supply Current - Amperes	5
AC Coil & Cap Voltage - VAC pk	6000

[00181] The determination of the exact number of PTM-CES 34 units that are energized at any one time is in turn the role of the proximity links. The first proximity link is initiated by a magnetic field based data transmitter located within the vehicle PRM, such that PTM-CES 34 fields are only produced when there is the potential for adequate coupling to the PRM 16. The first proximity link data transmitter within vehicle PRMs 16 operate on a frequency separate from that of the PTM 14 and employ a pseudo-random modulation

designed to limit power carrier interference. The signaling frequency is made appropriate to be easily combined with all coils of PRM 16 in a manner that each PRM 16 coil radiates a magnetic field from vehicle to roadway having a spatial shape and coupling factor nearly identical to that of the PTM 14 power carrier (emanating from roadway to vehicle). This independent signaling frequency allows first proximity link receiver within each PTM-CES 34 to detect a proximity signal in the same coil used for power transfer to the vehicle and in the presence of a power carrier, thus insuring that the pickup coupling is analogous to that experienced during power transmission. Filter networks within the first proximity link receive path of each PTM-CES 34 and each transmit path of the PRM 16 are designed to be anti-resonant at the power carrier frequency but series resonant at the signaling frequency. This design effectively isolates subsequent signaling components from the high level power carrier, allowing reliable signaling carrier to interference ratios. Furthermore, the bandwidth of the signaling channel thus formed is made sufficiently broad (nominally 30kHz) to accommodate transmission of multiple copies (10 minimum) of a psuedo-random modulated vehicle ID word within the minimum interval of a single PRM 16 coil to PTM 14 coil passage (nominally 0.01 seconds).

[00182] Since the proximity link 28 function is critical to both human safety and to the proper operation of PTM-CES 34 modules, insuring adequate magnetic coupling is always present before energizing, additional proximity link hardware is included such that two valid proximity links are required in real time to generate an enabling signal. This second (additional) proximity link operates on an entirely different principle and employs a separate PTM-CES 34 UHF transmit signal and receiver analogous to that employed in store antitheft security systems, wherein a very simple chip is embedded within each vehicle PRM 16 coil that is activated as it passes over an interrogating PTM-CES 16 coil. Thus, three separately generated enabling signals must be present before any energy activation occurs

[00183] Referring to Figure 28, the ability of PTM 14 to literally track a vehicle's PRM 16 via proximity links 28 and 32, only powering up a PTM-CES 14 when it will be able to usefully couple power to an external and specific PRM 16 load, maintains overall efficiency and safety. Proximity enabling produces energized magnetic field "hot spots" or waves of power that travel down the PTM Lane 40 at vehicle velocities, with power transfer maintained on a continuous basis directly under vehicle PRM 16. There may be more than one PRM 16 placed on a vehicle as may be the case for trucks, trailers and other articulated vehicles that require proportionally greater power transfer. This proportionality in power transfer is a powerful feature in that the power transferred is a direct function of the number

of PTM-CES 34 units that are energized. So a larger vehicle such as a bus having the requirement for a greater power transfer, also has an ability to carry a greater number of PRM 16 pickup coils (longer PRM). Large vehicles can thereby be effectively powered from the same standardized power PTM-CES 34 units that power lighter vehicles within a common driving lane.

[00184] Referring to Figure 29, the PTM-CES 34 magnetic field generation design incorporates a MOSFET power amplifier and direct coupling to an associated resonant tank circuit to efficiently generate very high AC magnetic fields within the space between roadway and vehicle PRM 16. The MOSFET amplifier is in turn fed from a lower level signal generated by a gated exciter.

[00185] The MOSFET H Bridge configuration utilized as a power amplifier output stage derives its name from the "H" formed when two sets of vertically stacked transistors are joined horizontally between their respective center connections by the load. The load in this case being the Tank Link Coil 74.

[00186] The use of a transformer coupled H Bridge MOSFET configuration 70 for the power amplifier allows the presence of an exciter output to directly enable the amplifier's power generation. With no exciter driving signal, all four of the amplifier's MOSFETs are turned off and virtually no current flows. This is true whenever the exciter output is gated off. Thus a (low level) "Transmit Enable" logic level signal is used as a low power, low voltage gating of the exciter output to energize each PTM-CES 34.

[00187] When the amplifier is gated on, diagonally opposite MOSFET pairs of the H bridge70 (pair #1- upper left & bottom right; pair #2 - upper right & bottom left) are alternately switched on and off during each half of the power carrier cycle (one pair switched on while the other pair is switched off). This switching arrangement causes high alternating currents to flow within the Tank Link Coil 74, currents that switch direction at each half cycle in unison with alternating MOSFET pair conduction. The resulting alternating magnetic field of the link coil 132 is tightly coupled to the resonant tank coil 74, a coil having a significantly larger number of turns than the Link Coil 132. This turns ratio produces a large voltage step up from link to tank. The tank circuit is made parallel resonant at the switching frequency by the paralleled Tank Capacitor 120. Therefore, the net result is that the tank voltage builds rapidly with each cycle of link current. In normal operation, tank circuit loading is primarily from nearby (passing) vehicle PRM 16 coils which act as a loosely coupled transformer secondary winding. Reactive currents within the tank circuit are passed alternately from Tank Coil 74 to Tank Capacitor 120 as the magnetic field collapses

through the Tank Coil 74 and back to the Tank Coil 74 as the increased rate of Tank Capacitor 120 charge occurs on the next half cycle. The relatively loosely coupled vehicle PRM 16 coil presents an increasing real power load in proportion to the level of reactive power exchanged within the tank circuit, until the amount of real power coupled to the PRM 16 load matches the real power provided by the MOSFET amplifier Tank Link Coil 74 circuit (less minor losses). At this point constant maximum real power is exchanged wirelessly by the alternating magnetic field coupling between Tank Coil 134 and PRM 16 coil. Once the PRM 16 coil moves out of range as determined by the Proximity Link 28 to the PTM-CES 34, the PTM-CES 34 is gated off again and de-energized, allowing the tank resonant energy to rapidly decay to zero based on residual coupling to PRM 16 and tank circuit losses. It should be noted that a vehicle PRM 16 may be many coils long, therefore a given PTM-CES 34, once enabled, will remain energized for the entire duration of passage (several PRM 16 coil times). At 70 mph, with a 14 coil PTM, this energization would be for a time duration of 0.11 seconds.

[00188] Power Transmit Module (PTM) Charge Controller Function

[00189] The vehicle charge control function can be addressed wholly or in part by the PTM-CES 34 units within the PTM 16. When a vehicle is coupling energy whether statically or dynamically there must be a throttle on the amount of energy transferred, such that the vehicle's battery is not overcharged or discharged when sufficient power is available, or charged at a rate that exceeds specifications. An on board, vehicle based charge controller can accomplish this battery charging control by inhibiting the flow of power in the battery charging circuit to exactly match the instantaneous needs of the vehicle. If the vehicle is in motion there are motor power demands added to battery charging power demands. There may also be demands from vehicle accessories such as lights and air conditioning. The charge controller monitors the battery's state of charge and motor power to establish a battery terminal voltage that continuously balances wireless power input with the needs of the combined total vehicle electrical load. This implies that there will be a variable amount of wireless power coupled to vehicles under both static and dynamic roadway conditions. If the PTM-CES 34 units were to do nothing in response, the tank coil and capacitor voltages would be higher under light loads and lower with heavier loads as they are energized by the passing vehicle. A range of loading is acceptable so long as tank and pickup coil voltages are maintained at safe levels and the fringe fields above the pickup coil are sufficiently attenuated before reaching vehicle or occupants. Over-voltage conditions at the PTM-CES 34 tank can be sensed and made to gate the amplifier drive to better match amplifier output energy to

light loads. Sensing means can be a sense coil within the Tank Coil 134 field or a capacitive or resistive AC voltage divider from the ungrounded side of the Tank Coil 134. A spark gap in conjunction with a fast acting over-current shut-down can be further employed as an added safety feature that puts an ultimate limit on tank voltage swings.

[00190] Current monitoring can be effectively monitored using a current sampling transformer in either or both of the Link Coil 132 leads to the high power amplifier. The resulting AC waveform can be rectified and filtered if necessary to be used in comparison with control derived threshold voltages to inhibit amplifier drive and thereby power.

[00191] A particularly interesting mode to consider is the incorporation of a greater degree of charge controlling functionality within each PTM-CES 34 such as to shift the majority of this function from vehicle to roadway or parking lot. This provides a means to simplify vehicle charge controlling while archiving a degree of commonality from vehicle to vehicle. This works by using the WAVES Data Link 30 to transmit vehicle power needs in conjunction with vehicle ID such as to allow programing of PTM-CES 34 amplifier drive gating. Programming will in turn cause the proper amplifier power output when it is subsequently enabled by the WAVES proximity links 28 and 32 during vehicle passage. This in effect produces a closed loop around the magnetic power coupled to the vehicle battery and motor (dynamic). In the dynamic case, the Data Link 30 is sufficiently real-time to prime upcoming PTM-CES 34 units with the proper power level, in advance of their being enabled by the passing vehicle. Since this forms a closed loop, errors in coupled power (from instance to instance) can be corrected by changing power level programming of power transfers from continuously engaged PTM-CES 34 units (static) or subsequently enabled PTM-CES units (dynamic). In initial applications, wherein parking lot and household operation is sufficient, a static charge control function is all that is necessary.

[00192] Power Receive Module (PRM) Design

[00193] PRM 16 is required by any electric vehicle choosing to receive magnetically coupled power from roadway or parking lot embedded PTMs 14. Referring to Figure 30, the PRM 16 contains pickup coils rectifiers 136, deployment actuator 138, and monitoring and communications electronics 140 in an environmentally sealed composite housing 142. Since the PRM 16 is suspended below each vehicle, exposed to the airstream and the environment, design considerations must address minimizing weight and cost, while being rugged, and corrosion resistant. Cost and weight push the PRM 16 (and PTM 14) coils to be made from copper-nickel clad aluminum stranded cable wherein each strand is separately cladded and insulated to minimize skin effects and corrosion.

[00194] PRM 16 length varies with the vehicle to be able to match driving power requirements. Two lengths are suggested 11 feet for mid-sized car vehicles, and 34 feet for trucks and buses. The width, 3 feet, is the same in each case to accommodate 3-coil rows, to make pickup coupling less sensitive to lane position errors. The 4 point actuator allows PRM 16 to quickly swing down, in a road-surface parallel manner, towards the roadway during deployment. Similarly, when disabled actuators swing PRM 16 quickly back up to securely nest into a cushioned pocket located along the horizontal underside of the suspension. This "gears up" action can be manually initiated by the driver or automatically initiated by improper roadway clearance and debris. Part of the automatic retraction can be accelerated by the inherent up-swinging motion induced by physical pressure exerted by obstructions during forward motion of the vehicle. A forward facing PRM brush 144 normally clears the roadway surface under normal driving conditions. This brush may augmented by an additional brush or "air dam" like appendage mounted directly beneath the front of the vehicle, in line with, but apart from, the PRM 16. In this way small roadway debris can swept away without retraction. Major debris, obstructions or unsafe clearance conditions will however cause the brush to trigger a retraction thereby preventing serious harm to PRM 16. The heads-up display provides an indication of the state of PRM 16 deployment or retraction. Table 10 below provided the physical specifications for a preferred PRM 16.

Table 10

PRM Physical Specifications	Car	Truck/Bus
Length - Feet	11.2	33.6
Width - Feet	3	3
Depth - Feet	0.5	0.5
Basic Shape - Cross Section	Rectangular	Rectangular
Number of PRM Coil Rows - #	14	42
Total Number of PRM Coils - #	42	126
Coil Width - Inches	12	12
Coil Length - Inches	9.6	9.6
Weight - Pounds	20	60
Volume - Cubic Feet	16.8	50.4
Pounds per Cubic Foot	1.19	1.19
Power Leads - #	2	2
Data & Aux Power Leads - #	8	16

Data & Aux Power Leads	Pigtailed Female Conn	Pigtailed Female Conn
Mechanical Connections - for suspension	4	8

[00195] A further consideration is the use of a "brush" mounted in a "V shaped cowcatcher" fashion at the front of the vehicle and/or on the leading edge of PRM 16 in a manner as to just clear the roadway, brushing small debris away from PRM 16 as well as assisting in and triggering the vertical movement of PRM 16 away from roadway obstructions as might occur at slower speeds. In this manner, PRM 16 vertical distance to the PTM-CES 34 is safely maintained at nominally 3 inches. Both PTM 14 and PRM 16 coils are sealed and covered with a thick layer of tough plastic, fiberglass, carbon fiber, asphalt or other like material, made magnetically permeable by being heavily loaded with ferrite. Table 11 below sets forth the preferred PRM electrical specifications.

Table 11

PRM Electrical Specifications	Car	Truck/Bus
Electrical Power - Kilowatts Peak	28	84
Continuous Power - Kilowatts	28	84
Power Dissipation Total - Kilowatts	1.4	4.2
Power Dissipation Per Foot - Watts	125	125
DC Primary Power Output Voltage - Volts	400	400
DC Primary Power Supply Current - Amperes pk	70	210
DC Secondary Power Supply Voltage - Volts	12	12
DC Secondary Power Supply Current - Amperes	5	20

[00196] The output voltage and currents shown above are nominal and can vary from vehicle to vehicle as a specific vehicle's battery charge controller interface requirements may dictate. A worst case power dissipation can occur when the vehicle is parked or static over an activated set of PTM-CES 34 coils. In these instances there may be no moving air to assist in cooling. Therefore parking lot magnetic power transfer is limited to 1 KW per coil. Secondary power is supplied to the PRM 16 to power internal electronics such as actuators, proximity links and Data Link.

[00197] Power Receive Module (PRM) & Vehicle Interfaces

[00198] A vehicle's PRM 16 consists of a set of pickup coils, each with associated inductive reactance canceling AC capacitor and following high frequency bridge power

rectifier and series parallel wiring of DC outputs to the vehicle's battery charge controller. Three wireless links - two proximity links and a data link provide for energy transfer interlocking, billing data and passenger internet communications. These components are housed in a rugged weatherproof enclosure that when enabled for power transfer by the driver, is lowered and suspended below the vehicle at a nominal 3" fixed distance above the roadway.

[00199] Mechanical interface is accomplished by a suspension from the vehicle's front and rear axels and further augmented by roadway brushes that normally end 1" above the roadway that serve both as a means for debris removal and as a means to trigger raising of the PRM 16 to a "stow" position when major obstructions are encountered, such as a bump at moderate speeds or a rough roadway condition at normal highway speeds. The front and rear ends of PRM 16 are tapered to a V-shape to further limit the impact from roadway debris under all conditions. A dash panel control is used by the driver to lower PRM 16 towards the roadway and otherwise enable PRM power transfer. The mechanical actuator and controller for this deployment mechanism is located within PRM 16 itself and operates through the mounting points where the vehicle's axel extensions meet PRM 16.

[00200] PRM control electronics insures that actual power transfer occurs only when the vehicle's ID has been deemed valid and PRM 16 is in a proper alignment with PTM 14 coils as determined by the proximity links 28 and 32. Proximity links 28 and 32 include a low frequency magnetic signaling transmitter that utilizes the vehicle's power pickup coils themselves as transmission elements. This arrangement naturally limits the coupling coefficient of the proximity signal to a given PTM 14 coil in a manner that corresponds closely to that of the actual power transfer coupling coefficient between PTM 14 and PRM 16 coils. This insures an efficient transfer of energy. Additionally, the Proximity Link 28 signal from the vehicle is modulated with the vehicle's ID, that is demodulated at each PTM-CES 34 within local magnetic coupling range. This allows a further check on the validity of transferring power during the period of a PRMs 16 actual proximity to a given PTM-CES 34 coil. Normally each PTM-CES 34 coil maintains a dynamic stack or list of valid IDs in its neighborhood as established via the Data Link 30, a wide band LAN based communications link between vehicles and the roadway. Real time Proximity Link IDs are then matched from within this list to enable real-time power transfer. Eventually, IDs are dropped from the ID list as a vehicle leaves a given PTM-CES 34 neighborhood and new IDs are stored from approaching vehicles. In this manner there is a real time ID determining element having a non-complex and low data rate requirement.

[00201] The data link 30, with its greater flexibility, is dedicated more towards non-time critical functions of enabling and billing functions and vehicular internet communications. The data link 30 is a wireless microwave RF link between PTM-CES 34 mounted and vehicle PRM 16 mounted transceivers with associated antennas. PTM 14 segment interfaces then contain necessary routers and network adapters that link PTM 14 fiber data lines (with data to and from passing vehicle PRMs 16) to the internet network in a manner that effectively achieves continuous connectivity between vehicles and the internet. The PTM 14 power control logic may be seen in Figure 31 and the data link interfaces in Figure 32.

[00202] The DC power output from PRM 16 is at a voltage and current which is directly compatible with the vehicle's battery charge controller. The charge controller is capable of handling the combined power for both battery charging and the vehicle's electric propulsion motor demands while underway. The vehicle's battery supplies energy in parallel with the charge controller, and is therefore able to cover peak power demands of the vehicle, leaving PRM 16 driven charge controller to supply the average demand for both battery charging and propulsion. This cooperative energy sharing arrangement takes advantage of the best of both energy sources while minimizing stressful requirements. The resulting net efficiency of the WAVES energy transfer is therefore high, nominally 80%. This efficiency can be broken down into two multiplicative components: (1) PRM 16 and magnetic field generation; and (2) PRM 16 and charge controller efficiency, both of which are better than 90%.

[00203] As explained above, there are both static and dynamic applications for WAVES 10. From a market development perspective it may be advantages to begin with static parking lot or household charging applications since they avoid the need for comparatively large effects upon infrastructure, cost and government involvement. Given that initially there will be no electric or electric hybrid vehicles available with an integrated PRM 16, PRM 16 may be offered as a manufacturer add-on or as an aftermarket add-on to the vehicle. As such it is important to minimize mechanical and electrical interfaces to the production vehicle thereby minimizing costs. Especially regarding electrical interfaces, it is useful to consider that PRM 16 be able to supply voltages and currents that are directly compatible with the vehicle's existing "plug-in" battery charging port, thus eliminating the need for vehicle charge controller modification and warrantee restrictions.

[00204] One way to accomplish this is to allow PTM 14 to be amplitude modulated (AM modulated) at 60 Hz such that the rectified and power carrier filtered PRM 16 output

delivers 60 Hz standard voltages e.g. 110VAC / 220VAC and currents e.g. 15A / 30A. Note that this offers respectable charging rates of 1,650 watts / 6,600 watts. AM modulation is simply and directly accomplished within each PTM-CES 34 by a 60 Hz logic level gating of the power carrier using the exciter "Carrier Enable" control signal. In this manner the parking lot or home market is served in a manner transparent to the magnetic link coupling employed by WAVES. Vehicle ID data within the PRM's Proximity Link 28 determines the use of this modulation. Thus the same PTM roadway 36 embedded hardware is made to work with both early static market PRMs 16 and later, dynamic and vehicle integrated PRMs 16 without change thereby providing a seamless path towards the end goal of a ubiquitous roadway infrastructure.

[00205] Power Receive Module (PRM) Magnetic Power Coupling and Control

[00206] PRM 16 unit is suspended below the vehicle in a manner that allows vertical deployment towards the roadway when the driver enables WAVES to be used to couple power from the roadway. It is preferred that PRM 16 be flexibly suspended such that roadway obstructions cause an immediate and dampened retraction and preferable that the main suspension be from the wheel axels as opposed to underbody to minimize vertical motion effects from the vehicle's suspension. In this manner PRM 16 vertical distance to PTM 14 coils can be safely maintained at nominally 3 inches. It can be noted that both PTM 14 and PRM 16 coils are sealed and covered with a thick layer of tough plastic or other like material, made magnetically permeable by being heavily loaded with ferrite. This magnetically permeable layer forms a rugged Magnetic Field Window that removes the Tank Coil 74 from the physical environment at the roadway surface while virtually magnetically displacing coil 74 to the very top surface of the roadway thereby maintaining the smallest possible coupling gap to the vehicle PRM 16. In this manner the coils on both roadway and vehicle are protected without adding the thickness of the plastic to the air gap through which magnetic coupling occurs.

[00207] PRM 16 consists of several coils made resonant at the PTM operational power frequency to cancel the inductive reactance of each coil and thereby maximize coupled power. The total power coupled is the sum of coupling to all the PRM coils at any one time. By arranging PRM coils in a contiguous line down the center of the vehicle, from front to back, one can achieve this maximum power coupling with a similarly arranged line of PTM coils, located along the middle of the driving lane, by centering the vehicle within the lane. The more PRM coils that are in alinement, the more power is coupled. This highly useful attribute of WAVES to essentially provide greater power coupling in proportion to a larger

number of coupled coils, such as on larger vehicles, inherently matches power demands across a range of vehicle types utilizing a common roadway PTM.

[00208] Integrated Power Receive Module (PRM) Design

[00209] An integrated pickup coil and rectifier assembly for PRM 16, as shown in Figure 33, can be designed using techniques described previously within the above referenced Integrated Tank and Link Coil Design section. Grooved channels for each pickup coil can be machined or otherwise formed within an electric insulator sheet and subsequently filled with conductor material as previously described. Such a sheet can then be used as the substrate for mounted/integrated electronics required to interface with the vehicle's electric system. Such a formed sheet assembly can contain one and up to an entire PRM's contingent of coils, machined and assembled as a single unit. An outer cover can serve to envelop, protect and stiffen the entire PRM producing a robust sealed unit suitable for suspension under a moving vehicle.

[00210] Additional coils can be integrated within PRM 16 sheet assembly to serve as magnetic signaling pickup sensors that for instance can enable roadway or parking lot power transfer or transmit vehicle ID and/or other data from the vehicle to PTMs 14. One interesting design using multiple overlapping PTM 14 coils an minimize scalloping or misalignment losses during power transfer from associated PTM 14 coils. Rectifier/DC outputs from such interstitial and overlapping coils are or tied with other outputs to achieve graceful power summation as alignments between PTM and PRM change, sometimes continuously. Separate coil channels can be made from both sides of an electrical insulating sheet as one way to achieve coil overlap consistent with the previous implementation.

[00211] Note that the sheet material within which PRM 16 Pickup Coils are embedded can contain ferromagnetic material designed to enhance the concentration and coupling of the received magnetic field as well as provide the overall electrical insulation properties required.

[00212] It is possible to integrate pickup coil resonating capacitors within each coil to reduce size and cost. Furthermore such capacitors can be fabricated within the same material utilized to form the PRM 16 chassis (e.g. HDPE) and could be compactly located within the center area of each pickup coil. One such fabrication is to mill vertical slots into the (insulating) chassis material to into which metal capacitor plates are subsequently inserted to form the resonating capacitor. The separation between plates forming the required dielectric separators between opposing plates of the capacitor.

[00213] PRM to Vehicle Interface Design

[00214] Initial PRM 16 design and demonstration development focuses upon static charging capability, capable of supplying up to approximately 6.5 kw of continuous power through the vehicles conventional 60Hz AC power connection. A PRM output interface can be provided that duplicates 220VAC 60 Hz input such as to minimize wiring changes to the vehicle's charging circuitry. This can be accomplished by PTM waveform control wherein either the magnetic power carrier waveform is modulated or preferably, PRM 16 rectifier outputs are switched in polarity at a 60Hz rate to form a (filtered) square wave suitable for direct connection to the vehicle's grid compatible input. Regulation to maintain standard peak to peak AC voltages can be accomplished by circuitry within PRM 16 (e.g., duty cycle modulation of rectified output) or within a feedback loop to PTM 14 magnetic waveform power regulation or both.

[00215] As requirements to demonstrate greater energy transfer to the vehicle are presented, there will be a need to interface high DC power transfer to the vehicle's propulsion battery. Depending upon the vehicle's existing charge controller design and battery technology, separate charge controlling circuitry may be required within PRM 16 battery interface, along with associated wiring, software and circuit changes within existing vehicle components. The issue becomes one of making sure that the battery is always protected from receiving more energy than it can safely or effectively use. If the vehicle is under motion, some or perhaps all of PRM 16 power can be utilized by the vehicles motor with any excess power available for battery charging.

[00216] The preferred embodiment is that an additional (Class III) charging port is available within the vehicle's onboard charge controller and that this can be enabled while the vehicle is underway. In this way significantly high power charging can occur at all times and under proper supervision to insure safety and battery lifetime. PRM 16 electronics would then appropriately interface to this port as required (e.g. several hundred VDC at high currents netting high power transfer capability). Baring the availability of such a high capacity port, it may be possible to slave PRM 16 charge control circuitry to the vehicle's charge controller current regulation signal or other proxy signal such that a parallel battery charging circuit can be wired directly from PRM 16. This parallel circuit would of course be separately fused and current controlled to inhibit catastrophic failure from occurring. Alternatively, there may be a way to essentially mimic the operation of the vehicle's dynamic braking energy recovery system wherein associated circuit paths can be energized by PRM 16 in lieu of the vehicle's motor-as-generator energy source.

[00217] Dual Mode - Power Receive Module Charging or Physical Plug in Charging

[00218] There may be a need to be able to support both wireless and hardware plug in charging at a common parking site. This could be a way to ease market penetration, especially during the early phases of market acceptance where the majority of EVs are set up to only interface with plug charging. Referring to Figure 34, a dual mode may be accomplished by essentially locating an auxiliary PRM 16 pickup coil(s) and associated rectification/60 Hz waveform generation within/near the roadway located PTM 14 and appropriately combining and interfacing the embedded PRM 16 power to a plug station mounted adjacent to the parking area to be serviced. Figure 34 depicts one such method of achieving dual mode charging. A WiFi billing interface normally associated with PRM 16 can also be co-located with this kiosk or plug station to serve as an external energy metering and billing interface for the vehicle's driver. PTM internal charge control logic automatically adapts and insures that an appropriate power level is utilized in charging, same as would occur during wireless operation, however in this case the coupling between internally mounted PRM 16 and the tank coil 74 of the PTM 14 would be significantly higher. Therefore when the plug mode is enabled the external magnetic (leakage) field would be very low.

[00219] Conversely, when the wireless mode is desired, the vehicle's PRM 16 is utilized, the Plug and associated WiFi is disabled and PTM pickup coil within PRM 16 simply idles with essentially no power being supplied to an external (plug) load. The influence of the imbedded idling PTM pickup coil can be controlled in terms of capacitance within the design by appropriate spacing from the Tank and Link coils 134 and 132, respectively. Furthermore, due the availability of significantly greater coupling between these co-embedded coils, one may dispense with a resonating cap on the internal pickup coil, thereby decreasing it's influence in this regard, even further.

[00220] Roadway Intersection Installation

[00221] Intersection installations as depicted in Figure 35 offer a key transitioning and long-term solution to urban wireless electrification for vehicular traffic. It allows vehicles that are waiting at intersections to receive high rates of charging as well as receiving energization and charging during acceleration upon leaving. Through or opposing traffic can also receive high rates of energy transfer while passing through such intersections. Given that successive intersections are electrified, vehicles traversing a series of such intersections can be entirely compensated for, indeed net charged, for their energy needs while traveling. Since a continuous PTM roadway installation is not required, intersection electrification becomes an excellent intermediate step in highway electrification, requiring significantly less

investment in infrastructure while at the same time having good grid access. It is important to note that this city environment can also benefit from the incorporation of CHP for WAVES in cooperation with the needs of heating, cooling and powering of nearby buildings.

[00222] Referring to Figure 36, a simple "heads up" indicator notifies the driver where to steer within the lane to achieve maximum energy transfer based upon field sensing within the vehicle's PRM 16. It is anticipated that following a relatively few hours of use the driver will unconsciously refer only sporadically to this display, having been accustomed to driving with PRM 16 centered on lane and with knowledge that it is not critical that power transfer needs to be present 100% of the time. This sensing, in the future, can linked to steering and automated to the degree allowed by the safety and reliability of a future WAVES coordinated traffic flow system. In the initial phases of such development a servo-like linkage from lane sensing to steering would induce a "sweet spot" or slight inclination torque that gives the driver a steering wheel based sensory feedback that indicates steering for optimal power transfer.

[00223] Note that the future is very bright with regards further driving automation. Since individual PTM-CES 34 modules relay real-time vehicle ID and position within the roadway and operate as a 2-way data link to the vehicle, a highway system could indeed issue real-time commands to the vehicle to control steering, velocity and spacing to adjacent vehicles. This type of system would of course require safety backups such as now being deployed with vehicular radar, in a manner that produces a truly robust automated system.

[00224] Referring to Figure 37, the ability to widen the coupling aperture of PRM 16, such as to reduce driving accuracy requirements, requires additional parallel lines of PRM 16 coils. Each parallel line of coils effectively adds directly to the cross-roadway pickup aperture in a passive manner given an appropriately designed interconnection between pickup coils.

[00225] For the 1.0 foot wide x 0.8 foot long coils at both PTM 14 and PRM 16, the useful lateral driving accuracy requirements are 1.0 foot (+- 0.5 foot) per line of parallel PRM 16 coils. The nominal number of parallel PRM 16 coils on a vehicle is 3, yielding a 3 foot driving accuracy requirement for optimum power coupling, or +- 1.5 feet either side of the center of a given lane. This is a minimal system for accommodation of driving errors and could be linearly expanded by the addition of parallel lines of coils with minimal additional cost to PRM 16.

[00226] An appropriately designed interconnection non coherently combines the AC power from separately roadway coupled individual PRM 16 coils. First the AC power carrier

frequency resonant PRM 16 coils are individually rectified to produce DC power at nominally 200 V RMS @ 10 A RMS per coil. Then, individually rectified (potential) coil power sources are then parallel wired laterally across the three lengthwise running (column) PRM 16 lines of coil rectifiers to instantiate the required widened coupling aperture. This widened aperture is achieved since any one or more of the three lateral (row) coil sources can feed DC power to the PRM's output. This paralleling of coil rectifiers creates Row-DC power outputs, one for each row of PTM 14 coils (laterally across the vehicle's direction of travel). Row-DC outputs are then wired in a series parallel arrangement to achieve the desired voltage and current for input to the vehicle's battery charge controller.

[00227] WAVES 10 is a way to immediately normalize peak battery energy demands to allow them to become, at most, average energy demands for the majority of driving modes and applications. This energy normalization increases overall transportation system efficiencies while at the same time eliminates electric vehicle "range anxiety", charging time and effort. Thus WAVES accelerates DOE's critical drive to electrify ground transportation by the promotion of a broader and more robust electric vehicle market through lowered cost, increased performance and convenience.

[00228] Wireless Automated Vehicle Energizing System (WAVES) Prototype

[00229] An aggressive prototype development program has resulted in the design, construction and testing of a 3 Coil Demonstration Unit (3CDU). 3CDU Prototype Performance - Testing has produced a compact 115 VAC powered prototype capable of being transported to a non-laboratory based meeting where 115 VAC 20A fused standard wall plug power is available. It is capable of wirelessly transmitted (magnetically linked) power transfer of approximately 1.5 kW across a 6" gap to a resistive load bank consisting of 36 incandescent light bulbs. The operational frequency is nominally 360 kHz. In addition to the power transfer function, power management circuitry is incorporated to maintain a fixed power transfer at gaps less than 6 inches so as to maintain a safe power level at these closer coupling distances. Internal remote actuation, GFI and fusing are added safety features embodied within the design. The overall operational efficiency is estimated to be greater than 90% based upon light brightness and DC power levels input to amplifier modules. Lack of significant heating in power electronics and Tank Coils and Capacitors provides confirming evidence of very high operational efficiency.

[00230] 3CDU Prototype Detailed High Level Design

[00231] Figures 38 and 39 illustrate the 3CDU as comprised of 3 power amplifier modules, each with associated power transformer-less power supplies (AC-DC

3.5A@150VDC). A common oscillator and 12VDC control electronics power supply module provides carrier drive and control electronics power to each amplifier module. This subassembly forms PTM 14. A separate pickup coil and load bank subassembly forms PRM 16. PRM 16 is "floated" above PTM 14 on roller spaces to establish a 6" air gap between them.

[00232] 3CDU Prototype Power Amplifier Schematic

[00233] Figure 40 shows the 3CDU power amplifier as an H-Bridge configuration 70 of 4 commercial off the shelf low cost power MOSFET transistors. A current sensing transformer within one leg of the H-Bridge 70 is used to provide feedback to associated power control electronics that can suppress 1 or more half cycles of carrier generation to accomplish power regulation. Also shown are tuning capacitors that cancel Tank Coil Link 132 inductance to enhance efficiency. Tank Coil 134 and Tank Cap 120 are shown in a parallel resonant configuration (important to minimize power and voltages with under-coupled of PRM load cases) to complete the magnetic energy generation process associated with the PTM function. High frequency toroidal gate drive transformers provide the voltage isolations, phase relationships and low impedances necessary to adequately drive power MOSFET gates.

[00234] The use of an H-Bridge 70 effectively doubles the voltage swing on the Tank Link as related to the HBPA DC supply voltage, thereby allowing a factor of 4X power increase over single ended switch configurations. This is very important in reducing PA primary supply voltages for any given power output demand. Furthermore the ratio of Tank Coil 74 turns/Link (or autotransformer primary) turns is a further source of voltage increase and resultant V^2 increase in reactive power availability within the Tank Coil 74 field. Thus, by halving the number of Link turns for a given Tank Coil 74, the reactive/magnetic field power will increase by 4. This of course places voltage related stresses upon the Tank Coil 74 and Tank Cap 120 and corresponding insulation requirements all around, including link to Tank Coil 74 insulation. Furthermore, not immediately obvious, the net reactive energy cycling and stored within the parallel resonant tank circuit, similarly increased by such means, and available for (PRM) load coupling can also feed back in reverse, back to the power MOSFET switches during periods of normal (gate drive modulation for power control) and abnormal (load failure or rapid changes) conditions. Thus stored energy related transients can generate reverse voltage spikes and current surges that can be immediately and catastrophically destructive to MOSFETs within the HBPA. Reverse voltage spikes can defeat the nominal capability of intrinsic MOSFET diode designs and stimulate the parasitic

generation of a destructive avalanched transistor within the FET junction monolithic structure, permanently destroying said structure and producing severe current surges in surrounding components. Furthermore, gate "shoot through" due to before mentioned load related "spikes" can also destroy FET junctions with similar catastrophic results. High-voltage ultra-fast diodes have been paced in reverse bias across each MOSFET to inhibit the introduction of reverse voltage "spiking". Direct gate transformer drive connections are also made to a low inductance secondary and low voltage step up toroid transformer driven by a low impedance bipolar transistor driver configuration as a means for reducing the possibility of "gate shoot through". Additionally (discrete and other) capacitance has been reduced surrounding each MOSFET and high voltage rated (2X to 4X supply DC) MOSFETs are employed to reduce transient current requirements while increasing intrinsic voltage standoff capability. It has also been learned that it is important to maintain phase matching between (especially) adjacent HBPAs and associated Tank Coils 74 in order to reduce the possibility of outer Tank Coil winding to adjacent Tank Coil arcing and transient generation. This phase match is controlled by both HBPA drive signal phase relationships and by Tank resonant frequency matching (not immediately obvious). Future designs can mitigate such Tank to Tank phase shifts by closing a phase locked loop solution around a measurements of instantaneous phases within each tank magnetic field such as to accommodate load dynamic and circuit related phase mismatch.

[00235] 3CDU Tank Coil Design

[00236] Figure 41 illustrates the Tank Coil 74 design associated with each 3CDU Power Amplifier Module. High frequency AC skin effect and resistive losses are important factors to control within the design. The design is a single spiral coil constructed in a flat plane from hand formed Litz wire 126 comprised of 4 strands of #20 insulated coated solid copper of circular cross-section. Winding to winding separation and insulation within the Tank Coil 74 is important to withstand high voltage per turn differentials.

[00237] 3CDU Prototype Tank Cap Design

[00238] Figure 42 shows the 3CDU Tank Cap 120 design that provides critical high voltage rated and low dielectric and conduction losses necessary for reliable and efficient operation. Note the center "trimmer" section critical to being able to match Tank resonance to desired operational frequency.

[00239] 3CDU Prototype Pickup Coil Design

[00240] Figure 43 illustrates the 3CDU pickup coil design within PRM 16. This is a critical function in achieving a maximal coupling and efficient energy transfer from PTM 14

to PRM 16. High frequency AC skin effect and resistive losses remain important factors to control within the design. The design is a single spiral coil constructed in a flat plane from hand formed Litz wire comprised of 6 strands of #20 insulated coated solid coper of circular cross-section.

[00241] 3CDU Prototype Pickup Coil Resonating Cap Design

[00242] Figure 44 illustrates the 3CDU pickup coil resonating cap design within PRM 16. This is a critical function in cancellation of the pickup coil's inductive reactance and achieving a maximal coupling and efficient energy transfer from PTM 14 to PRM 16. High frequency AC dielectric and resistive losses are important factors to control within the design. Note the center "trimmer" section critical to being able to match Tank resonance to desired operational frequency.

[00243] 3CDU Prototype Power Amplifier Control Electronics

[00244] Figure 45 illustrates the 3CDU control electronics design within the PA 122 Module. The functions include PA 122 waveform over-current threshold detection and associated PA drive gating. PA 122 waveform over-voltage threshold detection and associated PA drive gating. Drive signal inhibit from externally derived control signal. Transistor drivers suitable for driving high MOSFET gate capacitance via PA 122 located transformers. The PA gate drive and coil polarity relationships may be seen n Figure 46.

[00245] 3CDU Prototype Variable Frequency Electronics

[00246] Figure 47 illustrates the single Variable Frequency Oscillator and associated 12VDC power supply for it and the 3 PA 122 module Control Electronics. The functions include carrier waveform generation and associated external/operator inhibit switch for PA 122 drive gating.

[00247] 3CDU Prototype PTM Chassis Layout

[00248] Figure 48 shows the physical relationship between major subassemblies within the PTM chassis and relationship to PRM 16 and co-located load bank.

[00249] 3CDU Prototype PRM Chassis Layout

[00250] Figure 49 illustrates the physical relationship between major subassemblies within the PRM chassis with co-located load bank and relationship to PTM 14. Three sets of pickup coils associated resonating caps and 12 incandescent bulbs are shown. Bulbs are wired as 3 subsets of 4 bulbs in series, with all subsets wired in parallel to form a single resistive load for each pickup coil. Thus a total of 3 x 12 or 36 bulbs comprise the total load bank. This load bank is capable of safely dissipating 1.5 kW for reasonably long periods of steady state/CW wireless power coupling during demonstrations.

[00251] It is significant to note that metal foil covered plastic has been used in the construction of the 3CDU Prototype. Rectangular cell sheets of plastic were covered with aluminum foil tape and electrically connected to power and module grounds to form a cohesive termination of residual ground current loops and shielding to help attenuate any unintended RF radiation. The additional use of individual heavy aluminum foil covers over control electronics at each PA 122 module is a means to protect sensitive electronics from power carrier magnetic field induced interference. The use of such foil conductive materials is a fundamental means for reducing weight and cost, while allowing the use of plastics and other lightweight, tough and flexible structural materials for the body of PTM 14 or PRM 16 construction. The use of foil materials are especially relevant to a resultant conduction verses weight efficiency match to the relatively shallow skin depth of the majority of conducted currents at Power Carrier frequencies.

[00252] Note that the completed prototype was successfully operated and total coupled power levels were estimated to be in excess of 1000 watts, while the operational efficiency was estimated to be greater than 90% from line to load over a 6" air gap.

[00253] Power Transmit Module Energy Transfer and Waveform Management Features

[00254] One important aspect of the present invention is the inclusion of fail-safe & self-protection features integrated within each PTM-CES 34 enable low failure rates, performance monitoring and autonomous fault location. Included among these are the automated power fold-back and/or shutdown to protect against abnormal load conditions or component failures.

[00255] Another important feature of the present invention is the soft adaptability to flexibly meet Differing Vehicle Interfaces and Operation with minimal or no added vehicle hardware are provided by the RF Data Link 30 interactivity with vehicle electronic control systems. Critical real-time operational control is facilitated (via software) to accommodate variations in battery state of charge, apportionment of energy between battery and motor, acceleration and braking operations, traffic status and other. The ability of PTM 14 to electronically modulate bursts of energy to create 60 Hz/50Hz or other AC power frequencies and voltages as direct output from PRM 16 allows direct charging or vehicle powering from conventional "plug in" interfaces. A "smart roadway" and "smart parking area" is created by such an environment, delivering only appropriate levels and formats of energy to the vehicle or otherwise effecting vehicle systems behavior to achieve the safe and efficient operation.

[00256] Yet another important aspect of the present invention is the high power generation efficiency achieved by power amplifier gating and parallel resonance within the Tank Coil 74. The Power amplifier 122 remains gated off when no vehicle loads are present or enabled. The MOSFET amplifier configuration allows near zero power dissipation whenever gate drives are removed. The inhibiting of Power Amplifier 122 gate drives for all times except for when the vehicular load is present is therefore a primary way of limiting losses. Additionally, the use of a parallel resonant tank circuit as the magnetic radiator allows losses at this high power point to be a percentage (small) of the power coupled to the vehicular load and not constant, thus further facilitating efficiency.

[00257] A further advantage of the present invention is the closed loop charging power regulation via interactivity between PTM 14 and PRM 16 over the Data Link 30 with data from vehicle charge sensors providing a means for controlling delivered power and consequently reducing the need for vehicle charge control hardware while increasing safety and efficiency. In this way PTM-PRM power is transmitted directly to battery 26 without passing through added high power electronic control systems onboard the vehicle, in the amount dictated by real time battery storage and environmental needs.

[00258] As seen in Figure 50, yet another important aspect of the present invention is the integration of the Tank Coil 74 and Tank Cap 120 into a common single integrated component utilizing conductive foil or otherwise high area conductors with dielectric spacing to establish parallel resonance. This approach minimizes high voltage wiring and high voltage Tank Cap 120 requirements. Further integration of drive link coupling as an autotransformer at the grounded end of the Tank Coil 74 is a further reduction in discrete components (note that foils can readily serve as effective conductors within both capacitors and coils at the frequencies nominally employed within power electronics). Foil construction is especially relevant to maintaining low weight and cost while reducing skin effect losses associated with AC current transfer.

[00259] Roadway Physical Locking can be accomplished by a centralized vertical bolt with special keying to inhibit theft at each PTM-CES 34 module. This bolt travels within central reinforcement structural strength member that is environmentally isolated from internals of module. The bottom end of bolt engages with bottom of roadway trench to secure module to roadway. The attachment to roadway trench can be indirect via the RTC wherein the RTC is independently and periodically secured to the roadway trench and provides an appropriately located and spaced socket for the vertical bolts from the top of PTM-CES 34 modules.

[00260] The present invention also involves Faraday and non-resonant shielding of PTM 14 and roadway surface located Tank Coils by the use of nonmagnetic metal skins, including foils and films that surround individual PTM-CES 34 and PTM 14 components. The purpose being to significantly reduce the unintended emission or radiation of RF energy, especially at the GPMI and power carrier frequencies and related harmonics and sidebands, without significantly effecting magnetic field coupling to vehicles, either at power or signaling frequencies. The use of a metallic skin overlay over the top (roadway level) of the Tank Coil is especially significant in this regard, this skin can be patterned to provide RF attenuation while at the same time remain transparent to magnetic fields utilized by WAVES. Patterning in effect can be non-resident at power carrier and magnetic signaling frequencies thereby minimizing respective induced currents.

[00261] The present invention also includes thermal transfer and high voltage insulation by the use of an oil that surrounds high voltage & high power components (especially power carrier components such as Tank Coil Cap 120, high power amplifier components and perhaps Tank Coil 74). Oils such as silicon based oil have both excellent thermal conduction/ convective/ distribution properties and excellent high voltage insulating properties that when properly employed internal to PTMs 14 allows corona suppression and heat dissipation to outer and lower subsurface areas of the roadway trench where lower temperature promote efficient heat transfer at correspondingly lower operational temperatures. Such a design limits moisture penetration ant related corrosion and electrical conduction issues. Furthermore the potential exists to eliminate solid dielectrics within critical capacitors such as within the Tank Cap 120. Such oils can serve this function directly while again promoting heat transfer from high power capacitors.

[00262] The "V" Shaped PTM 14 of the present invention promotes efficient design for heat transfer from "V" bottom areas of PTM 14 to external side-walls and trench. The "V" shape is also an efficient volumetric match to the needs for a relatively large surface for roadway-level Tank Coil 74 at the top of the "V" and the relatively smaller dimensioned and volume associated with power electronics potentially located lower down within the "V" cross-section. The Tank Cap 120 could be conveniently integrated as a distributed capacitance within the Tank Coil 74 itself or given the need for added capacitance could be a separate component located directly below Tank Coil 74. High area as available within this region of the "V" is an advantage in lowering the cost and mounting of such capacitors especially at the frequencies nominally employed by the power carrier. Advantage can also be made of the vertical dimension of the "V" for such Tank Cap 120 location while overall

volume is conserved over other perhaps rectangular cross-sections. The "V" cross-section also promotes ease of installation minimizing additional or difficult filing of roadway material both at surface and subsurface of PTM 14. Additionally, and critically, The "V" cross-section is inherently mechanically strong, easily internally cross-brace able to further strengthen and allows direct downward weight and related traffic loads to be distributed to the vertical side-walls of the receiving trench, providing crush resistance with minimal distortion. Such "V" trench sidewalls can readily receive sealant/cushioning/tolerance absorbing/weatherizing/sealing/heat conducting material during installation to insure proper installation and tolerances to roadway surface.

[00263] Primary Power Distribution Features

[00264] The present invention includes an efficient PTM-CES 34 power distribution architecture that minimizes GPMI 48 conversion losses from the grid 18 and/or CHP 50 and associated roadway or parking area transmission cable 92 and related PTM 14 primary power losses. The high voltage transformer-less design of GPMI 48 reduces conversion losses and the modularity allows subdivision of the load by the number (or effective number) of phase lanes of provided as load. This subdivision reduces GPMI 48 design requirements to where current technology is able to cost effectively implement this function. This subdivision also introduces redundancy within the transmission and load architecture where phase failures represent a "soft" system failure, degrading PTM 14 power generation in a more or less linear fashion. The ability to electronically optimize GPMI 48 phase power generation, based upon roadway loading, increases conversion efficiency. The provision of multiple phases at transformer primaries within RTC 92 reduces current by the number of phases thereby making the size and material of each related phase transformer practical and cost effective. The relatively high frequency (60 kHz nominal) makes the implementation of each phase transformer practical for this application. The design of RTC 92 negates skin effect losses associated with this relatively high frequency by the use of metalized plastic or metal foil conductors that in turn can provide a low cost light weight alternative to conventional cabling such as copper wire. Further geometry considerations within RTC 92 cabling allow a shielded transmission line ducting of transmitted energy enhancing EMI shielding and reducing losses. Furthermore, internal geometry of foil conductors facilitates connections to imbedded transformer primaries thereby enhancing reliability and lowering costs of manufacture. The ability of high speed turbines as utilized within current CHPs allow the migration of some or all GPMI 48 power conversion into CHP 50 function with appropriate associated electrical generator design.

[00265] The present invention also encompasses grid back-up configurations with distributed generation and peak shaving that is facilitated by the CHP 50 grid inter-tie functionality and WAVES 10 ability to "smartly" interact with vehicle loading. Grid inter-tie further enhances reliability beyond load sharing to being able to completely supply roadway or parking needs under periods of grid failures or vice-versa under CHP failures. RTCs 92 can be terminated into RTCs 92 in adjacent roadway or parking segments to produce a combined network of power distribution and distributed generation and grid connectivity that further enhances redundancy for failure mitigation. The phase locking mechanisms within each GPMI 48 readily facilitates such segment to segment inter-tie.

[00266] The present invention also provides inherently weatherized interconnection to PTM-CES 34 units by utilizing magnetic fields as the power transfer mechanism and thus allows liberal use of waterproof electrical insulation surrounding RTC 92 imbedded phase transformer primaries and associated secondaries within PTM-CES 34 units. Only the physical parting interface is exposed to the roadway/parking environment. Such magnetic material is readily formulated and/or coated to resist corrosion at these parting interfaces with minimal effect upon power transfer efficiency.

[00267] The present invention further accomplished simplified and efficient PTM 14 coil and related electronics implementation due to the modularity and construction of individual PTM-CES 34 units. The relatively large number of PTM-CES 34 units activate able per vehicle (nominally 14 for small vehicles) allows the use of low cost and electrically efficient power generation and control electronics such as power MOSFETs and diodes etc. The Tank Coil 74 is a critical component in the establishment of the roadway/parking magnetic field source for energy transfer. Since the operational frequency is in the region where skin effect is an important source of losses (nominally 360 kHz) the design of this component requires careful consideration. Current Litz wire 126 construction can be replaced with metal foil implementation wherein a spiral of metal foil and associated interwinding dielectric or other geometry coil is fabricated. The depth of this coil from the roadway can be made to accommodate the foil width required, to suitably reduce resistive losses (bulk conduction and skin effect). Furthermore, the design of this coil can be tuned to resonance at the operational power frequency through the control of dielectric spacing and material and by the number of foil turns within the coil. This can accommodate the Tank Coil 74 and all or part of the Resonating Tank Capacitor 120 function thereby decreasing cost and overall volume while simplifying the architecture.

[00268] Power Receive Module Features

[00269] The present invention may provide for passive driving error mitigation by the use of multiple PRM 16 receive coils. The energy received by two or more PRM 16 receive coils on an plane parallel to the roadway and on an axis relatively perpendicular to the vehicle's direction of travel can be coherently (AC) or noncoherently (DC) combined such as to effectively increase the PRM's energy receiving aperture in direct proportion to the combined area of the individual receive coils. In this manner, driving errors can be mitigated with minimal loss in efficiency and no physical tracking by PRM 16.

[00270] The present invention may additionally provide simplified physical and electrical integration vehicle steering sensory feedback adjuncts via the sensing of roadway magnetic fields in relation to vehicle path enables feedback to both driver and automated steering systems onboard vehicles to either allow errors to be sensed and easily manually corrected or fully automated steering. This includes automatic alerting and drive mitigation with regards adjacent lane or fore and aft vehicles in a WAVES connected roadway environment. Knowledge gained from energized PTM-CES 34 units can be collected, aggregated and disseminated by the WAVES (system) to roadway vehicles to address roadway navigation and safety issues.

[00271] The present invention further provides an integrated pickup oil and resonating cap combined into a common single integrated component utilizing conductive foil or otherwise high area conductors with dielectric spacing to establish parallel resonance. This approach minimizes high voltage wiring and high voltage PRM Resonating Cap 120 requirements (note that foils can readily serve as effective conductors within both capacitors and coils at the frequencies nominally employed within power electronics). Foil construction is especially relevant to maintaining low weight and cost while reducing skin effect losses associated with AC current transfer.

[00272] The present invention includes parallel and otherwise resonated load specific to the power carrier frequency(s) employed allow for selective power transfer to vehicle loads. This represents a fundamental means for limiting power transfer to non-intended loads such as passive metallic objects on the roadway or vehicles. This feature can be employed to selectively supply energy to specific classes of vehicles or to otherwise differentiate the power transfer mechanism.

[00273] Like the roadway surface, the present invention includes Faraday and non-resonant shielding of PRM 16 and located pickup coils by the use of nonmagnetic metal skins, including foils and films that surround individual PRM 16 and PRM 16 components. The purpose being to significantly reduce the unintended emission or radiation of induced RF

energy, especially at the power carrier frequency and related harmonics and sidebands, without significantly effecting magnetic field coupling to the vehicle and roadway, either at power or signaling frequencies. The use of a metallic skin overlay over the bottom (roadway level) of PRM 16 coils is especially significant in this regard, this skin can be patterned to provide RF attenuation while at the same time remain transparent to magnetic field frequencies employed by WAVES 10. Patterning in effect can be non-resident at power carrier and magnetic signaling frequencies thereby minimizing respective induced currents.

[00274] The present invention also employs imbedded DC rectification with power summing capability for the passive mitigation of driving errors and the accommodation of different voltage/current outputs to meet differing EV energization needs. Or-tying of power carrier rectified power can in turn sum respective outputs from several PRM 16 coils with minimal loss from coils not fully excited magnetically. This is deemed non-coherent power summation. Series parallel combinations of rectified coils, in turn, provide combinations of voltage/current outputs from PRM 16 to meet differing EV energization requirements.

[00275] Referring to Figure 51, the present invention provides imbedded synchronous rectification with power summing and AC voltage generation capability for the passive mitigation of driving errors and the accommodation of different voltage/current outputs to meet differing EV energization needs. Synchronous rectification is an efficient means of rectification since fast high power switching transistors such as power MOSFETs can nearly eliminate the diode voltage drops associated with power diodes, which may be typically 1.2 volts for fast high voltage diodes. By dynamically synchronizing to alternating phases of the power carrier frequency picked up by PTM 14 coils, AC waveforms of lower power frequencies can be synthesized. Of particular interest are 50 and 60 Hz which are standard AC power frequencies world wide. Such converted power is useful for direct application to existing EV charging circuitry so as to provide hardware minimal interfaces to existing charging ports.

[00276] By phase synchronizing drive signals (transformer isolated) to the power carrier waveform as received by PRM 16 from PTM 14, the polarity of the output can be controlled in both static and dynamic senses by way of the switching of appropriate power MOSFETs on each side of the output circuit. Furthermore, gate drives can be duty-cycle modulated or otherwise shaped to effect net instantaneous power transfer to the output, thereby allowing sinusoidal or other net waveform generation at sub-carrier output frequencies (e.g. 60 Hz) including DC. Note that power carrier related components of the

output are smoothed/integrated/filtered/sufficiently eliminated by carrier filter capacitors or other output filtering that leave desired sub-carrier waveform intact.

[00277] WAVES Strapping Approach to PTM Assembly and Fabrication

[00278] Referring to Figure 52, it is important to be able to easily and robustly assemble at least three levels of PTM 14 housing to insure integrity and strength while minimizing costs. The use of heavy duty strapping allows the levels of housing components to be placed in compression awith great pressure thus insuring that components remained sealed under lifetime of use with heavy traffic loads. Strapping can be removed for maintenance as necessary. Tensioning of straps during manufacture is easily and cheaply accomplished as the straps are inserted through various slots within the PTM cross-section and looped or otherwise secured following compressive tensioning.

CLAIMS

What is claimed is:

1. A wireless energizing system for charging an electric battery positioned in a vehicle, comprising:

a power transmit module positioned in a fixed location and including at least one transmit coil for transmitting power via a magnetic field;

an interface magnetically coupling said power transmit module to a power source; and

a power receive module attached to said vehicle and interconnected to the battery, wherein said power receive module includes at least one pickup coil for receiving said power from said power transmit module via said magnetic field when positioned proximately to said power transmit module.

2. The system of claim 1, wherein said transmit coil and said pickup coil are formed from conductive foil.

3. The system of claim 1 wherein said interface comprises a grid power multiphase interface comprising a set of phase inverters that are phase linked to transform power received from said power source to six phase if nominally multi-kHz power.

4. The system of claim 3, wherein said interface further comprises a transformer cable having a set of magnetically coupled transformer links for transmitting power from said set of phase inverters to said power transmit module.

5. The system of claim 4, wherein said interface comprises conductors formed by conductive foil.

6. The system of claim 3, wherein said grid power interface enables distributed generation power sources in parallel with grid power sourcing.

7. The system of claim 1, wherein each said transmit coil comprises a power amplifier for energizing a link coil having a first predetermined number of turns that is magnetically coupled to a tank circuit including a tank coil having a second predetermined number of turns that is greater than said first predetermined number of turns of said link coil and a tank capacitor.

8. The system of claim 7, wherein said tank capacitor includes a plate split into first and second sections, and wherein said first section is coupled to an external capacitor for monitoring the voltage of said tank capacitor in real-time and regulating power inductively coupled to a load based on said monitoring.

9. The system of claim 8, further comprising a transformer with primary formed from a set of conductors within a Litz wire primary.

10. The system of claim 8, wherein said transmit coil is formed from conductive foil.

11. The system of claim 1, wherein said power transmit module further includes a microprocessor programmed to establish a proximity link to said vehicle that triggers the transmission of power from said transmitter when said vehicle is located proximately to said power transmit module.

12. The system of claim 1 further comprises a display configured to indicate to a driver of said vehicle the location of said vehicle relative to said power transmit module.

13. The system of claim 12, further comprising a series of power transmit modules, each of which is triggered to transmit power when said vehicle is located proximately to said power transmit module.

14. The system of claim 13, wherein said series of power transmit modules are concatenated and positioned along a section of a roadway.

15. The system of claim 14, wherein each of said concatenated power transmit modules are energized only when said vehicle is proximity thereto.

16. The system of claim 1, wherein said power receive module includes a microprocessor programmed to establish said first and second proximity links and said data link with said microprocessor of said power transmit module.

17. The system of claim 1 wherein said power receive module includes a predetermined plurality of pickup coils, the number of which are based on the power demands of the vehicle.

18. The system of claim 1, wherein said power transmit module is located within a V-shaped groove.

19. The system of claim 18, wherein a plurality of said power transmit modules are concatenated and removeably positioned within said groove.

20. The system of claim 19, wherein said groove is formed in a roadway lane.

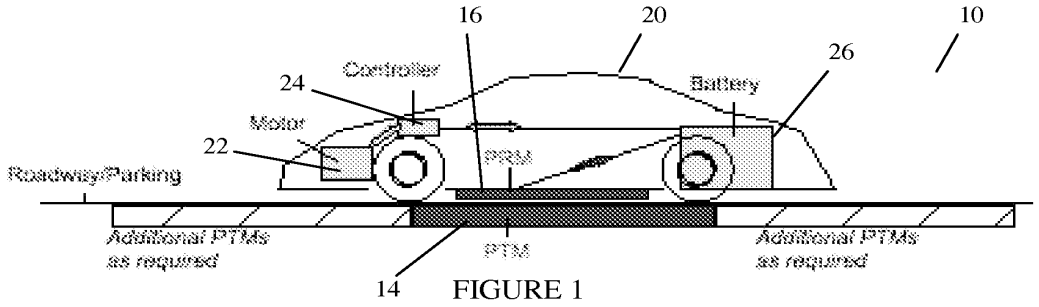


FIGURE 1

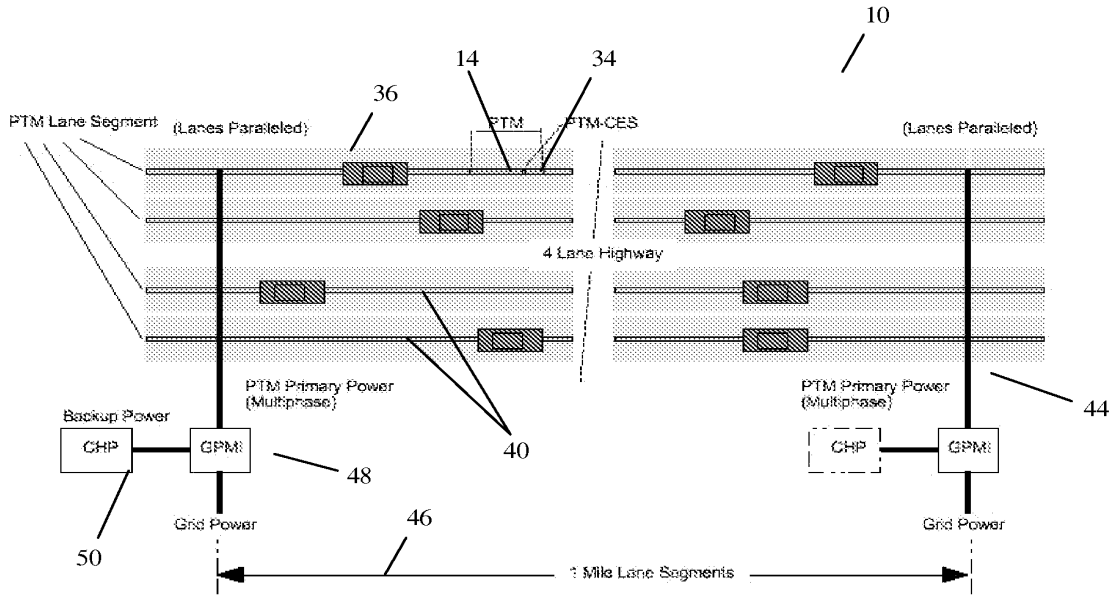


FIGURE 2

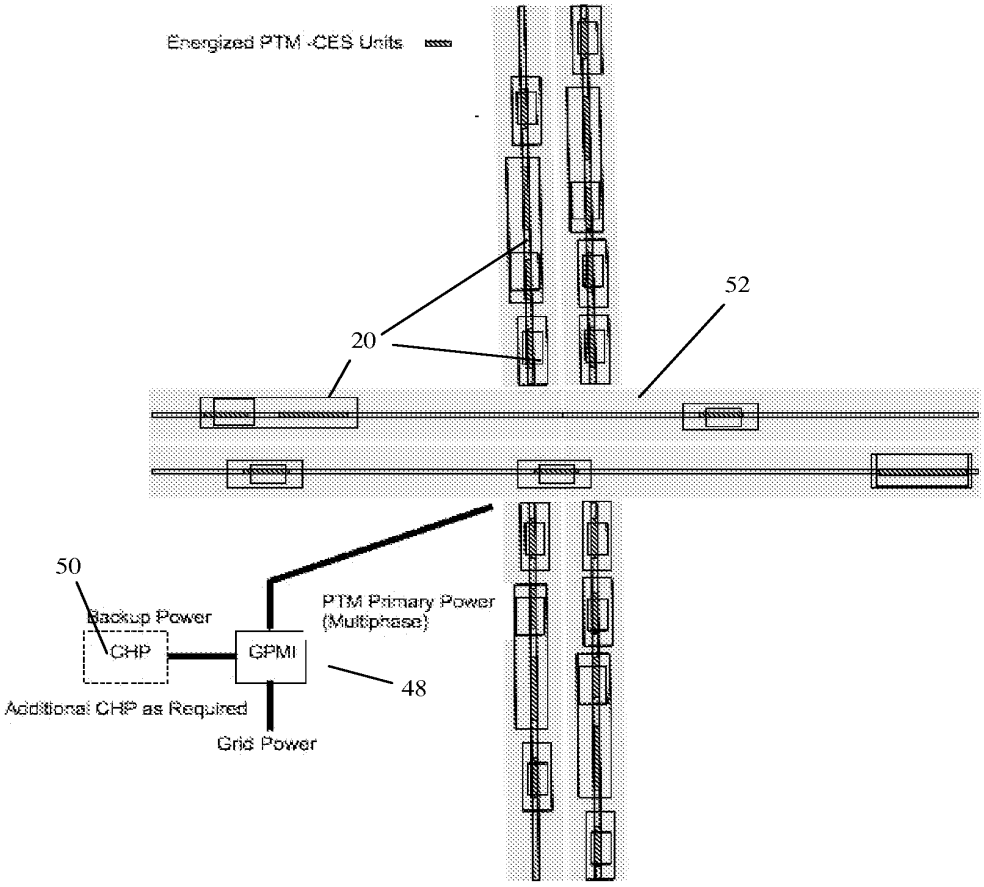

Energized PTM 4CES Units
20
52
50
Backup Power
CHP
GPMI
PTM Primary Power
(Multiphase)
48
Additional CHP as Required
Grid Power

FIGURE 3

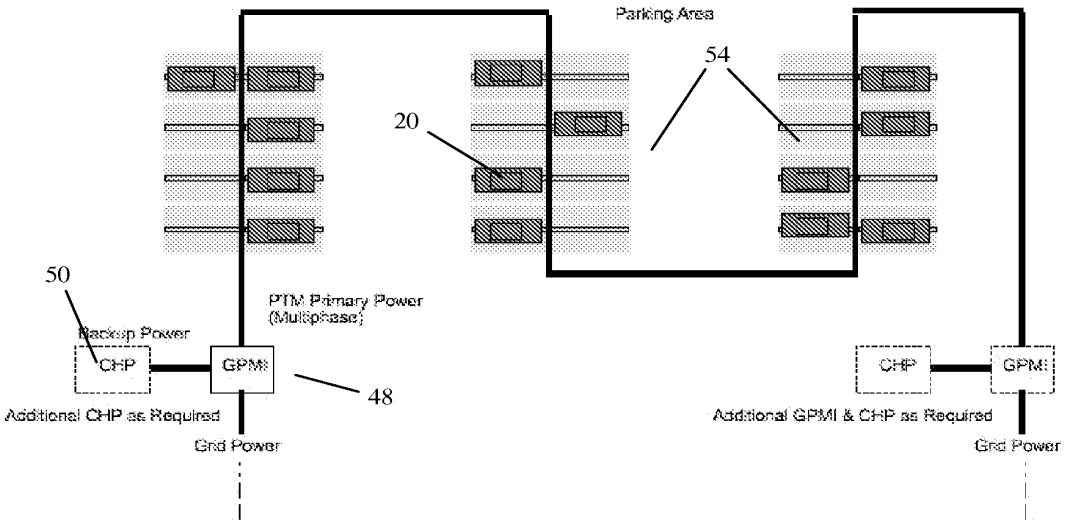


FIGURE 4

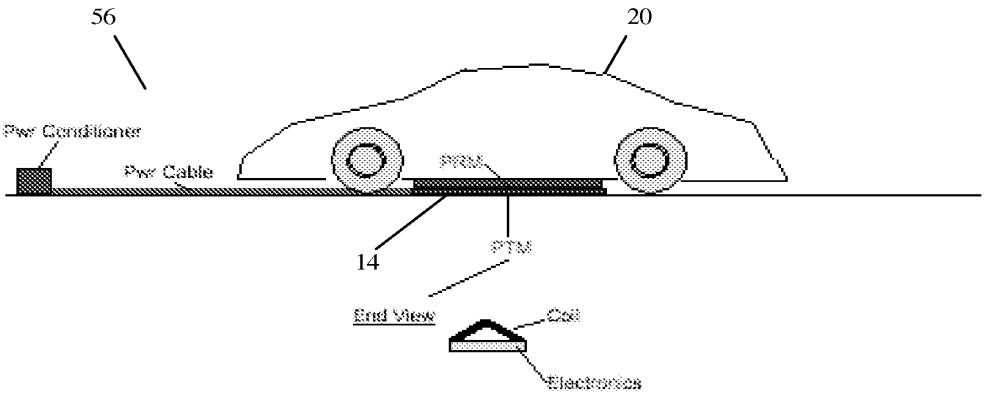


FIGURE 5

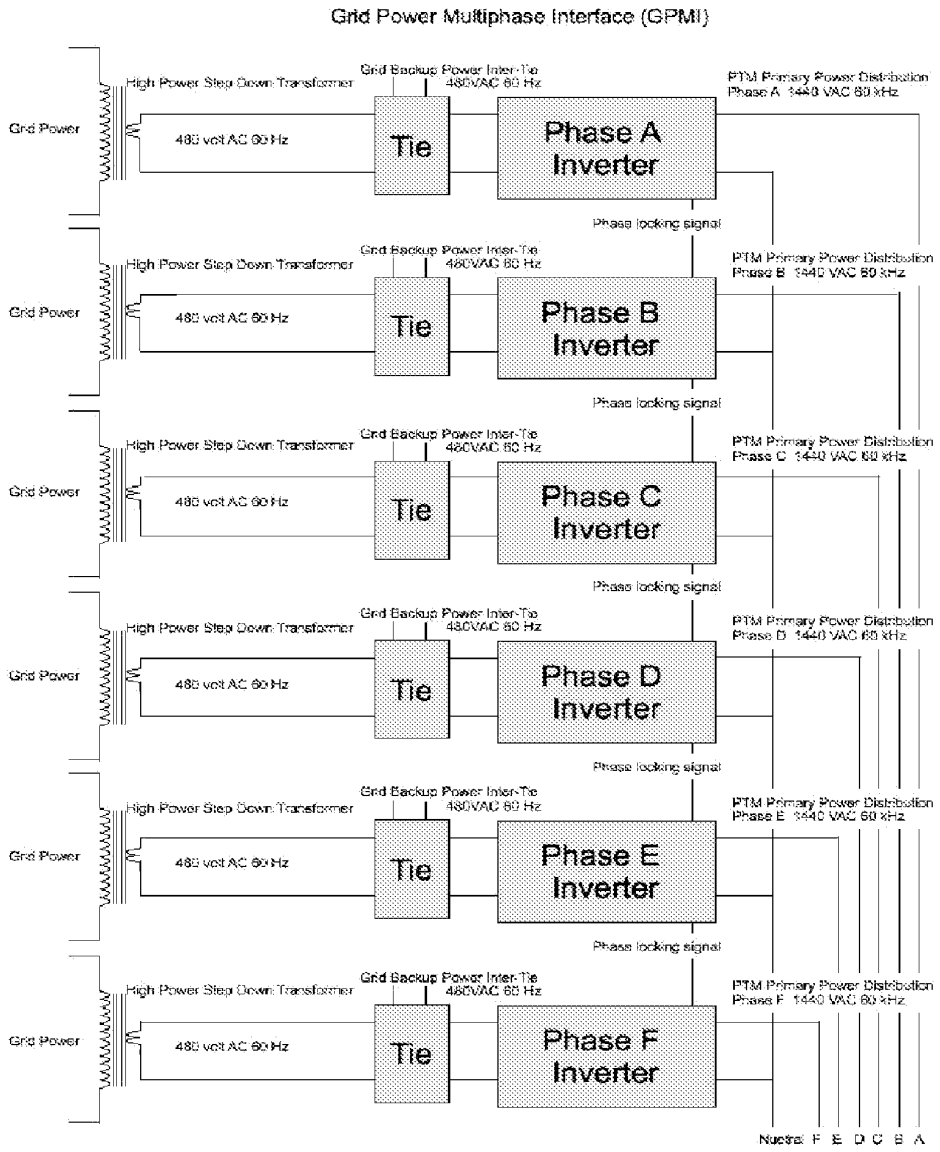

Grid Power Multiphase Interface (GPMI)
Grid Power
High Power Step Down Transformer
480 volt AC 60 Hz
Grid Backup Power Inter-Tie
480VAC 60 Hz
Tie
Phase A Inverter
Phase B Inverter
Phase C Inverter
Phase D Inverter
Phase E Inverter
Phase F Inverter
Phase locking signal
PTM Primary Power Distribution
Phase A 1440 VAC 60 kHz
Phase B 1440 VAC 60 kHz
Phase C 1440 VAC 60 kHz
Phase D 1440 VAC 60 kHz
Phase E 1440 VAC 60 kHz
Phase F 1440 VAC 60 kHz
Neutral F E D C B A

FIGURE 6

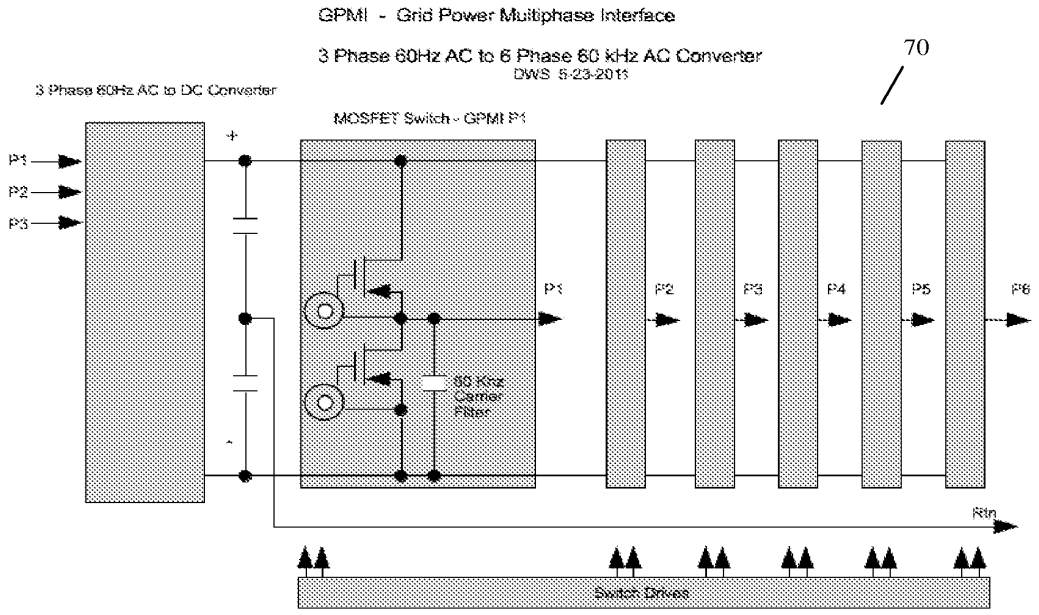


FIGURE 7

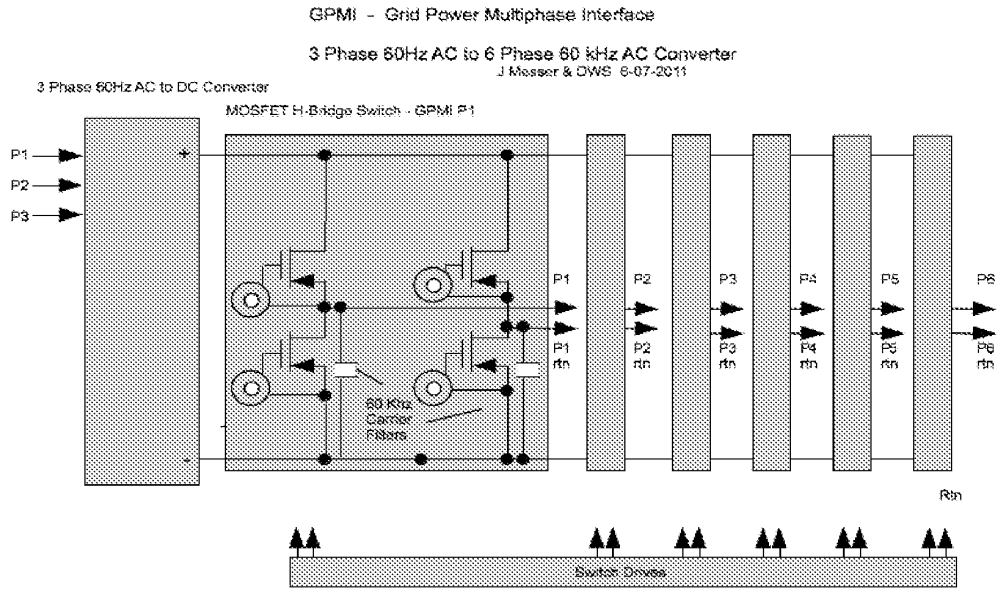


FIGURE 8

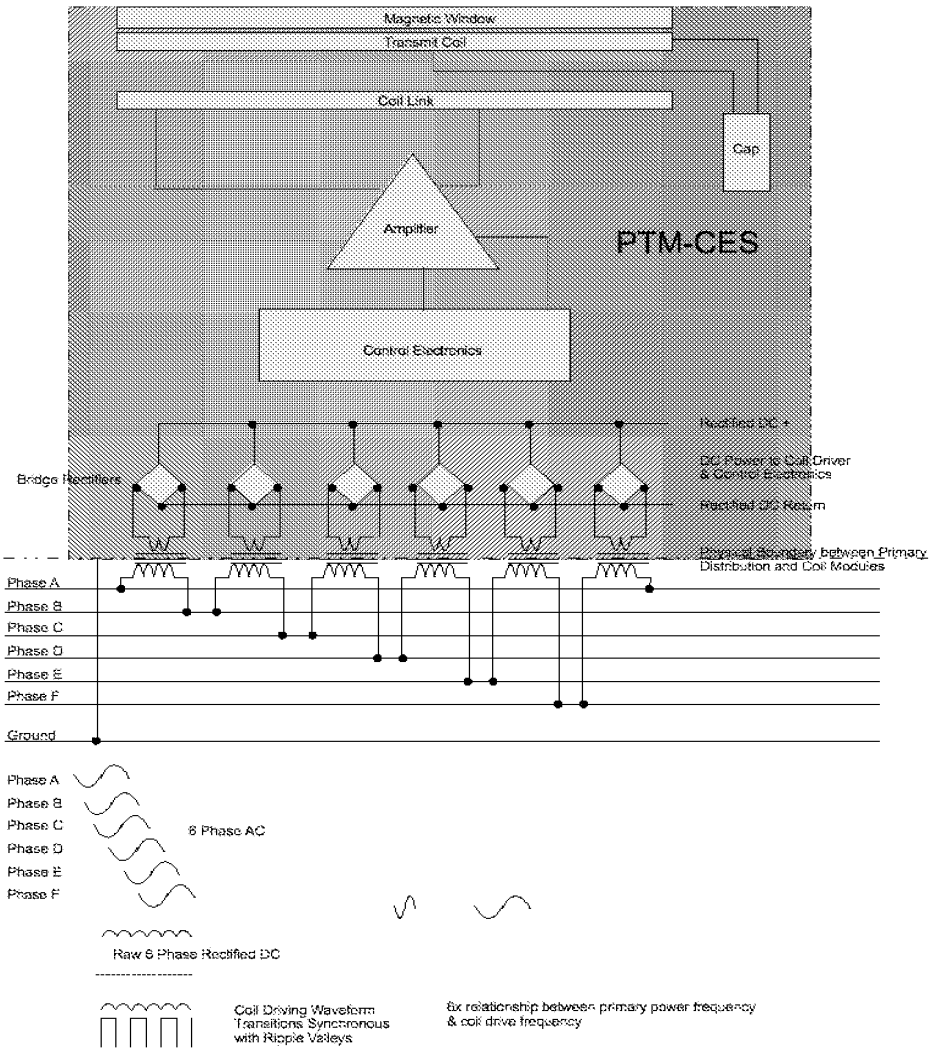

Magnetic Window
Transmit Coil
Coil Link
Cap
Amplifier
PTM-CES
Control Electronics
Rectified DC +
DC Power to Coil Driver & Control Electronics
Rectified DC Return
Bridge Rectifiers
Physical Boundary between Primary Distribution and Coil Modules
Phase A
Phase B
Phase C
Phase D
Phase E
Phase F
Ground
Phase A
Phase B
Phase C
Phase D
Phase E
Phase F
6 Phase AC
Raw 6 Phase Rectified DC
Coil Driving Waveform Transitions Synchronous with Ripple Valleys
fix relationship between primary power frequency & coil drive frequency

FIGURE 9

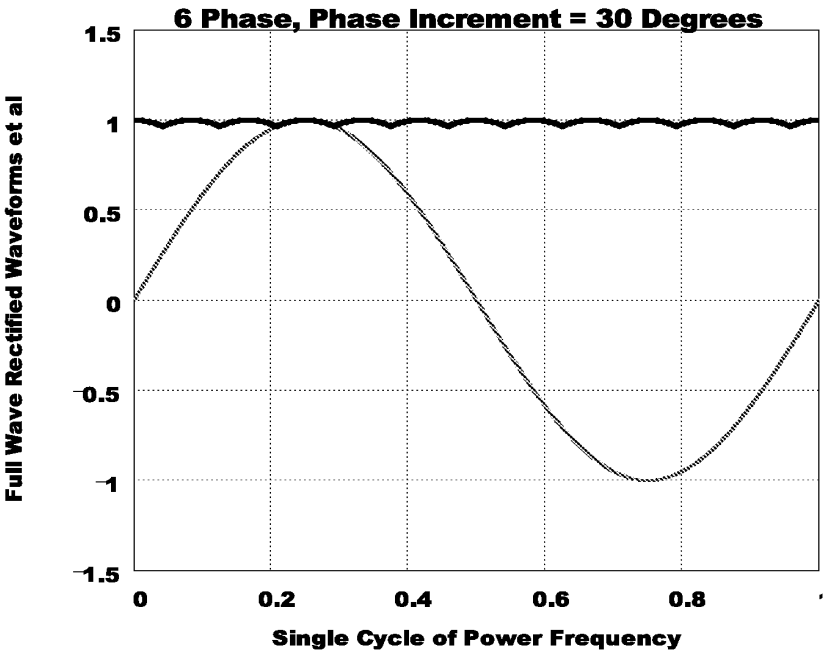

6 Phase, Phase Increment = 30 Degrees
Full Wave Rectified Waveforms et al
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.2
0.4
0.6
0.8
Single Cycle of Power Frequency

FIGURE 10

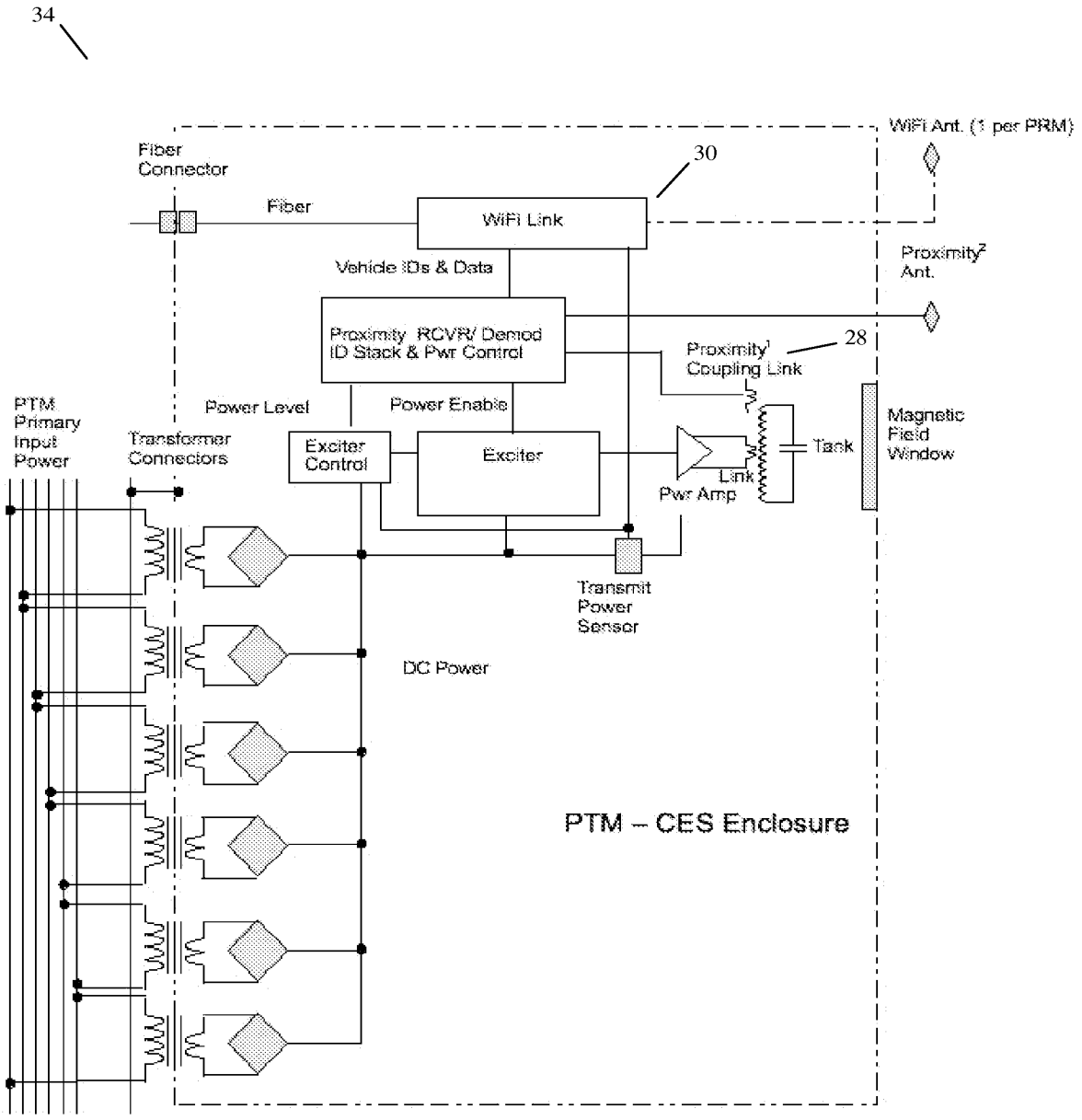

34
WiFi Ant. (1 per PRM)
Fiber Connector
30
Fiber
WiFi Link
Vehicle IDs & Data
Proximity² Ant.
Proximity RCVR/ Demod ID Stack & Pwr Control
Proximity¹ Coupling Link
28
PTM Primary Input Power
Power Level
Power Enable
Transformer Connectors
Exciter Control
Exciter
Link Pwr Amp
Tank
Magnetic Field Window
Transmit Power Sensor
DC Power
PTM – CES Enclosure

FIGURE 11

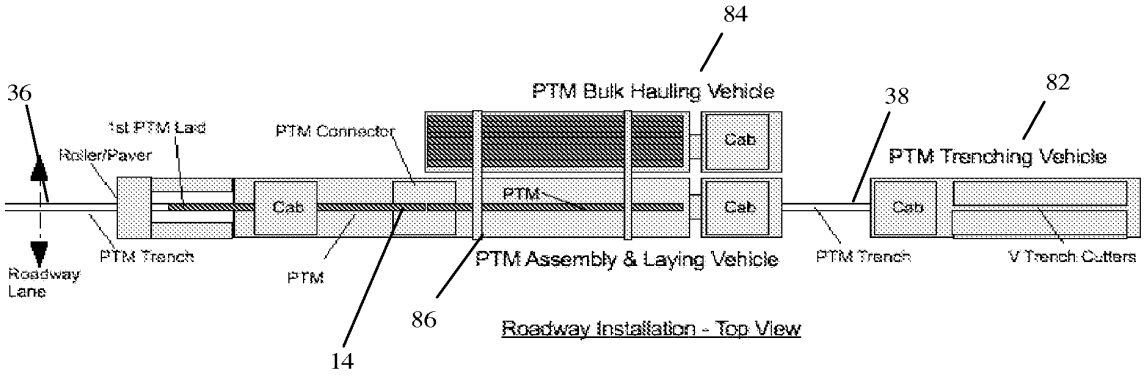


FIGURE 12

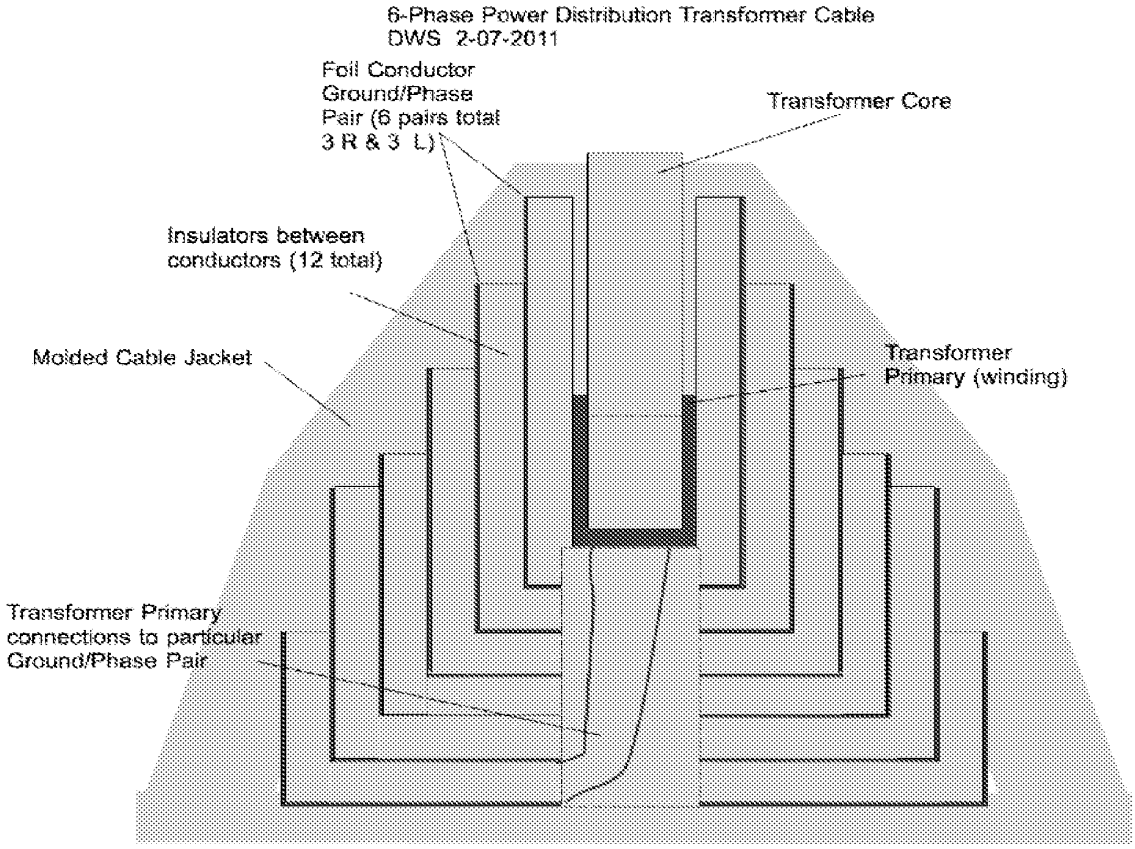


FIGURE 13

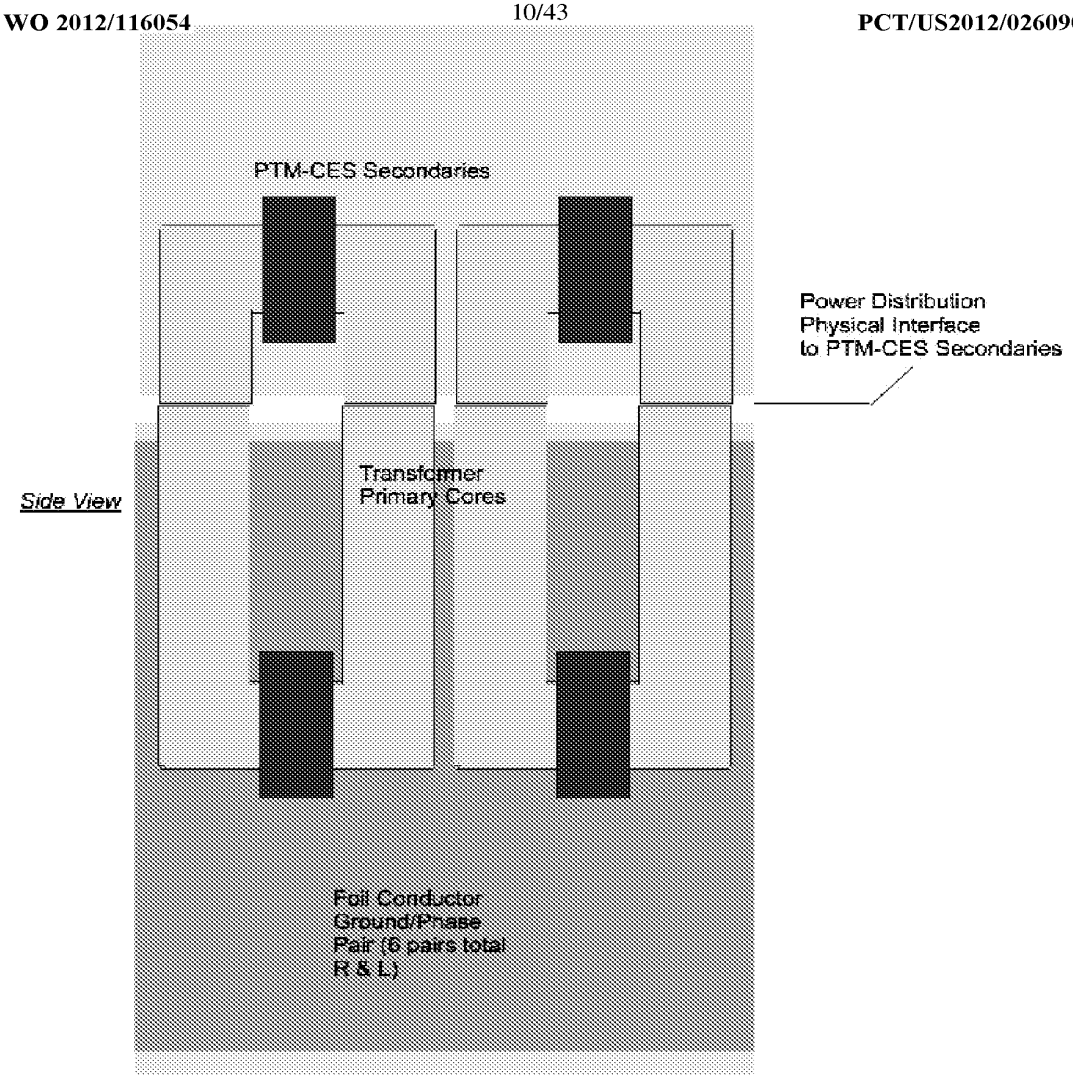

PTM-CES Secondaries
Power Distribution
Physical Interface
to PTM-CES Secondaries
Side View
Transformer
Primary Cores
Foil Conductor
Ground/Phase
Pair (6 pairs total
R & L)

FIGURE 14

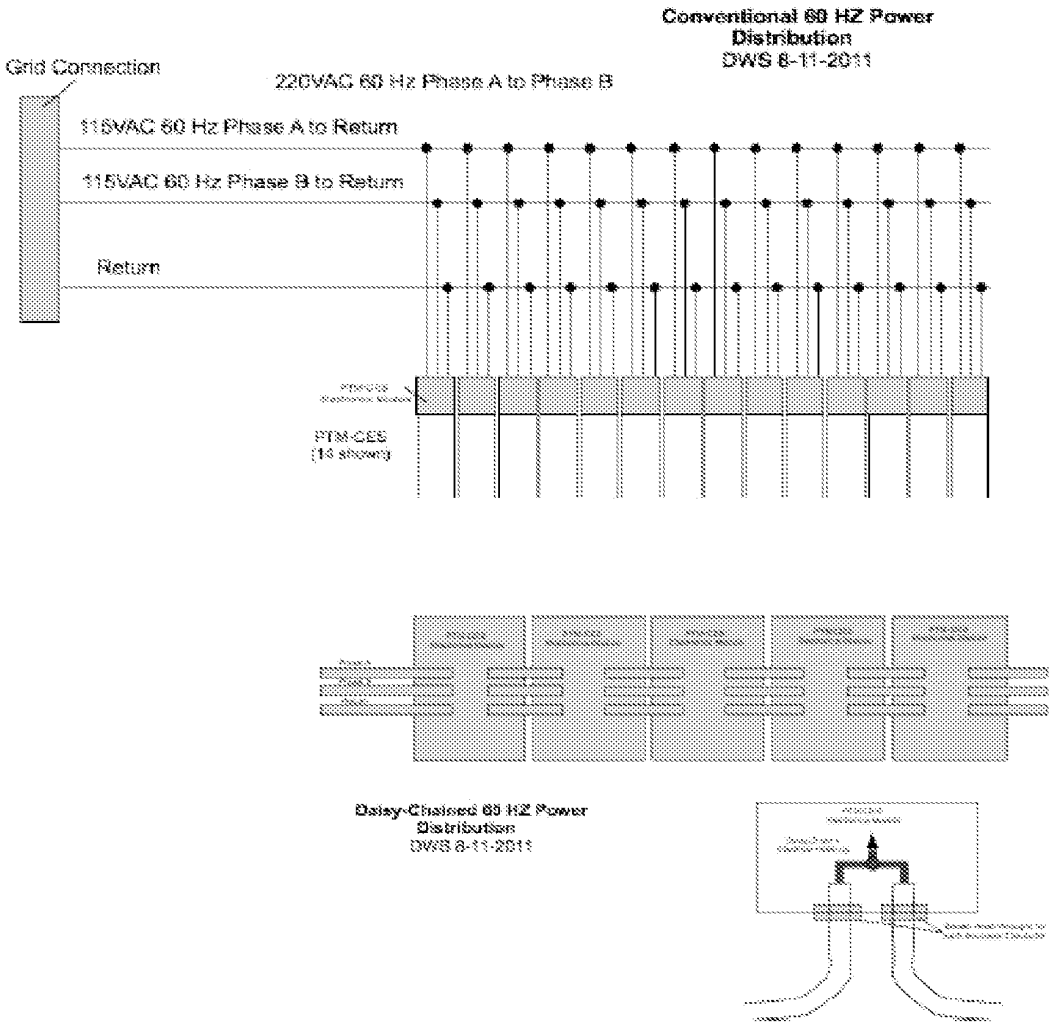

Conventional 60 HZ Power Distribution
DWS 8-11-2011
Grid Connection
220VAC 60 Hz Phase A to Phase B
115VAC 60 Hz Phase A to Return
115VAC 60 Hz Phase B to Return
Return
PTM-CES
(14 shown)
Daisy-Chained 60 HZ Power Distribution
DWS 8-11-2011

FIGURE 15

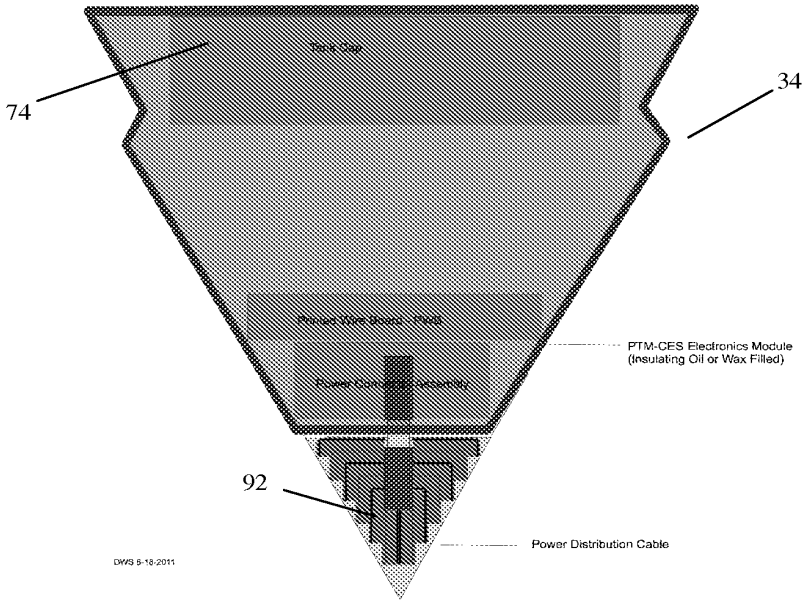


FIGURE 16

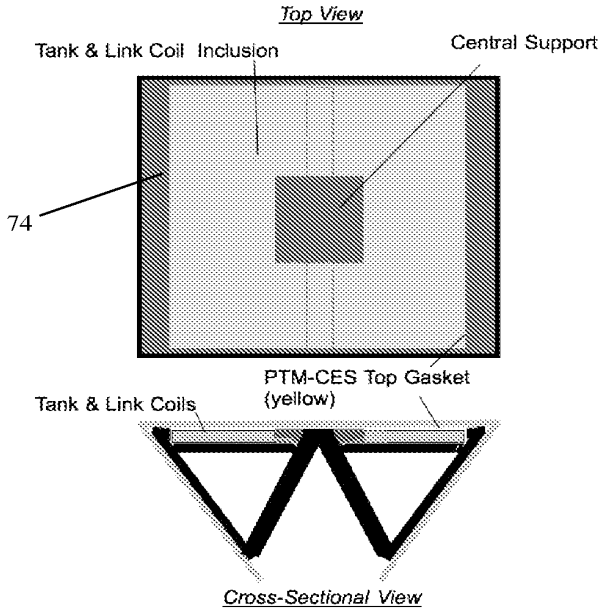


FIGURE 17

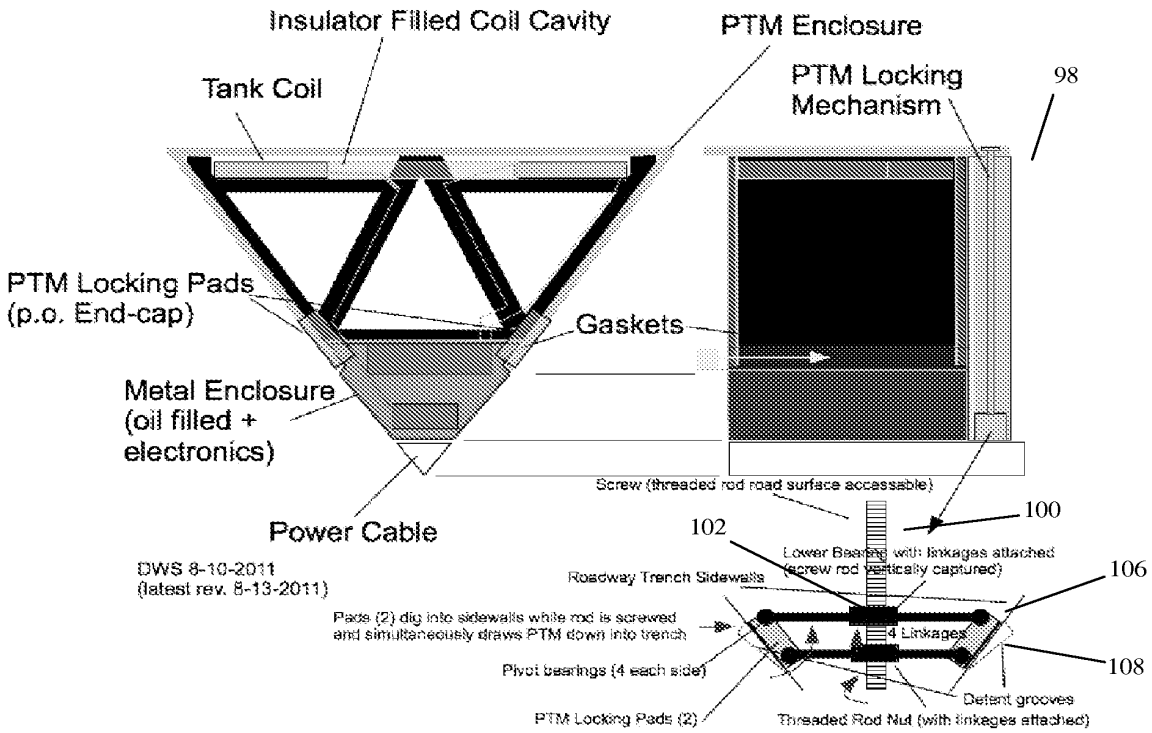


FIGURE 18

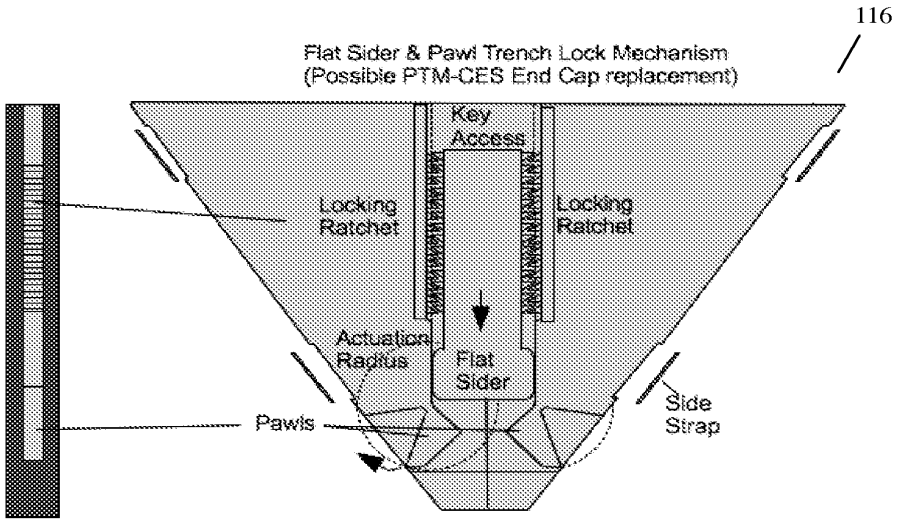


FIGURE 19

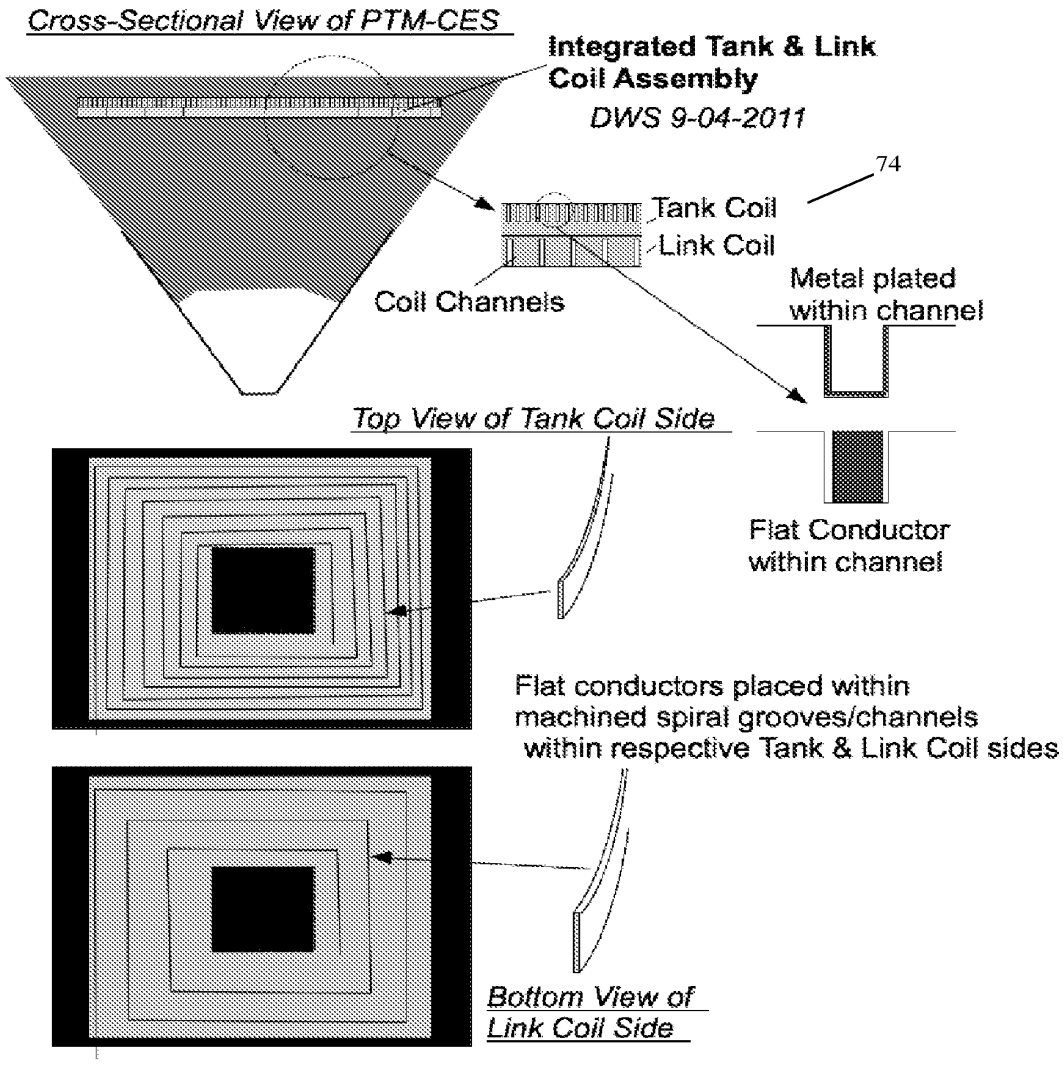

Cross-Sectional View of PTM-CES
Integrated Tank & Link Coil Assembly
DWS 9-04-2011
74
Tank Coil
Link Coil
Coil Channels
Metal plated within channel
Top View of Tank Coil Side
Flat Conductor within channel
Flat conductors placed within machined spiral grooves/channels within respective Tank & Link Coil sides
Bottom View of Link Coil Side

FIGURE 20

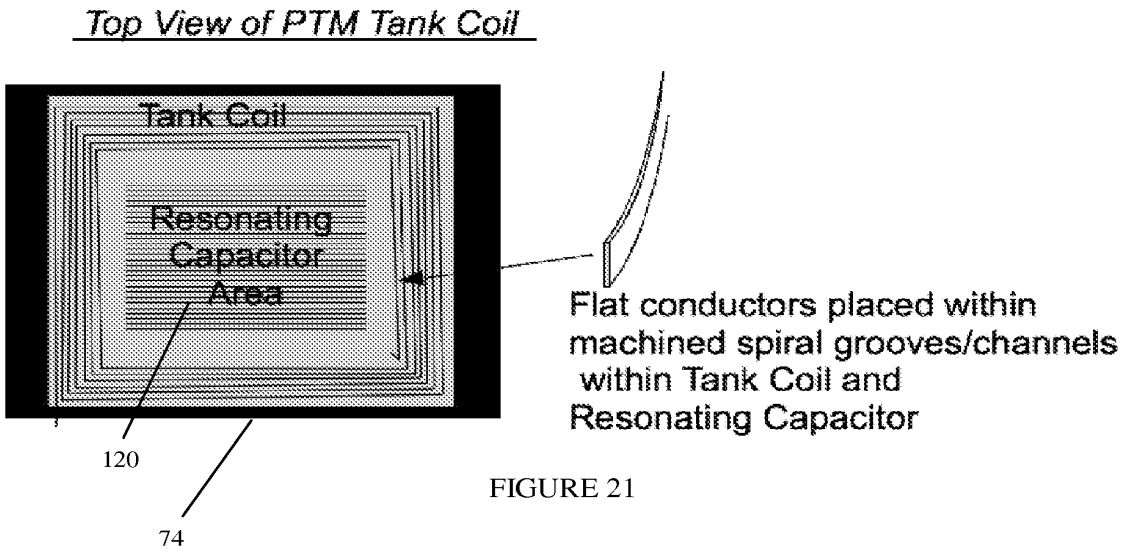


FIGURE 21

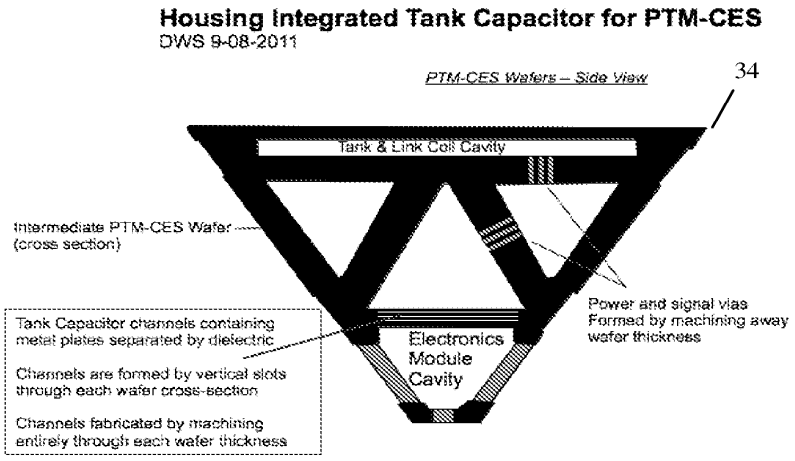
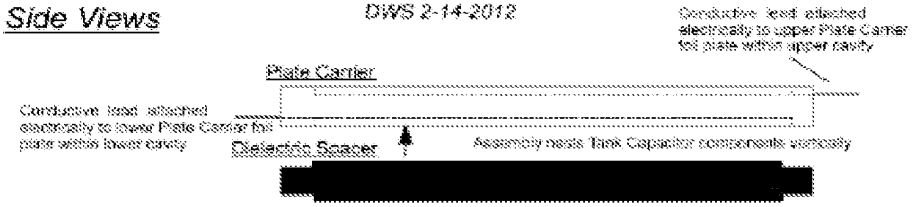


FIGURE 22

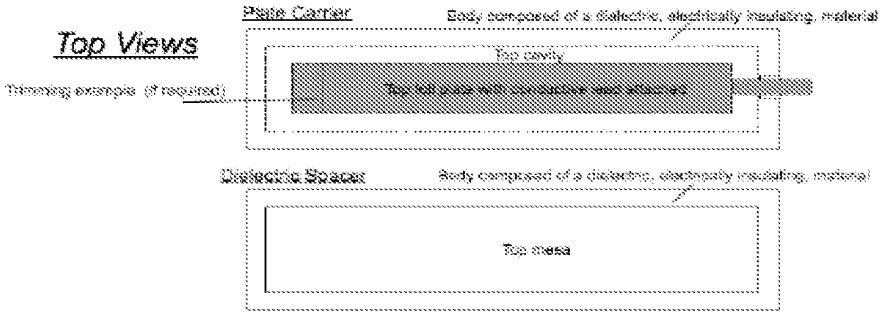
WAVES Tank Capacitor Design

Side Views DWS 2-14-2012



Tank Capacitor Stack, or portion thereof, showing lower "Dielectric Spacer" with top and bottom mesa's that nest into (when assembled) respective top/bottom dielectric cavities of an opposing dielectric material formed "Plate Carrier" which hold conductive foils within each top and bottom cavity thus forming opposing plate pair components of a Tank Capacitor/section thereof. The Dielectric Spacer is designed such as to present the same plate to plate spacing to each added section or as necessary to serve as a top or bottom lid of a completed Tank Capacitor assembly. This completed stack then forms a Tank Capacitor assembly that can be suitably welded, glued, sealed or otherwise mechanically held together and electrically insulated to withstand severe environments. Such an assembly can be made intrinsically self aligning and easily scalable to maintain precision and high-voltage high-current and high-frequency capacitor ratings. Such plate design is easily mechanically trimmed to yield precise values of capacitance.

Top Views



The figure below depicts a refinement of the Tank Capacitor Stack with a top plate split to yield an additional terminal lead for instantaneous sampling of the tank capacitor voltage in an efficient and voltage divided manner in direct proportion to an externally supplied capacitance, thereby allowing a safe and convenient real-time tank voltage measurements. (this could be accomplished multiple times within each section for a greater net coupling factor)

Top View

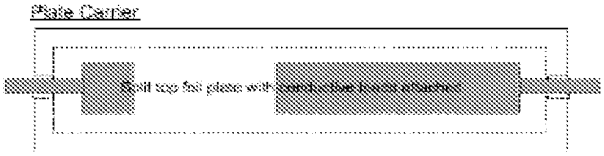


FIGURE 23

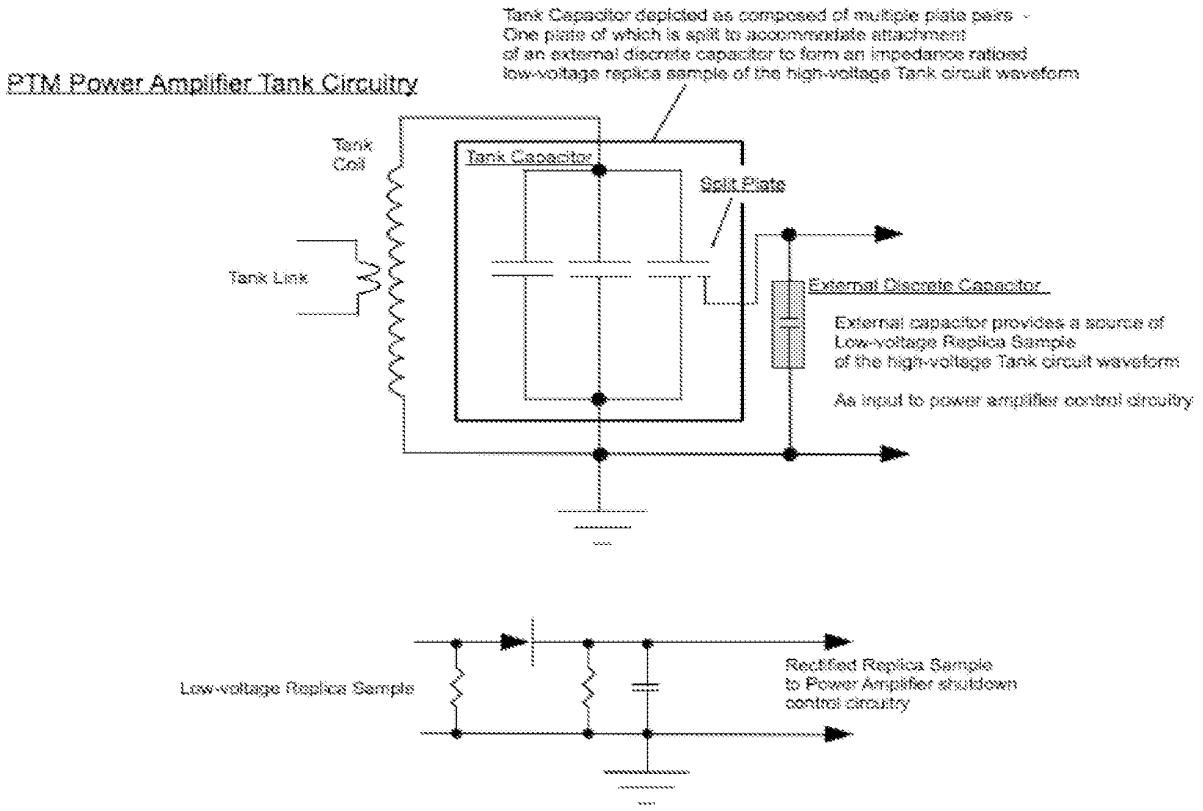

PTM Power Amplifier Tank Circuitry
Tank Capacitor depicted as composed of multiple plate pairs - One plate of which is split to accommodate attachment of an external discrete capacitor to form an impedance ratioed low-voltage replica sample of the high-voltage Tank circuit waveform
Tank Coil
Tank Capacitor
Split Plate
Tank Link
External Discrete Capacitor
External capacitor provides a source of Low-voltage Replica Sample of the high-voltage Tank circuit waveform
As input to power amplifier control circuitry
Low-voltage Replica Sample
Rectified Replica Sample to Power Amplifier shutdown control circuitry

FIGURE 24A

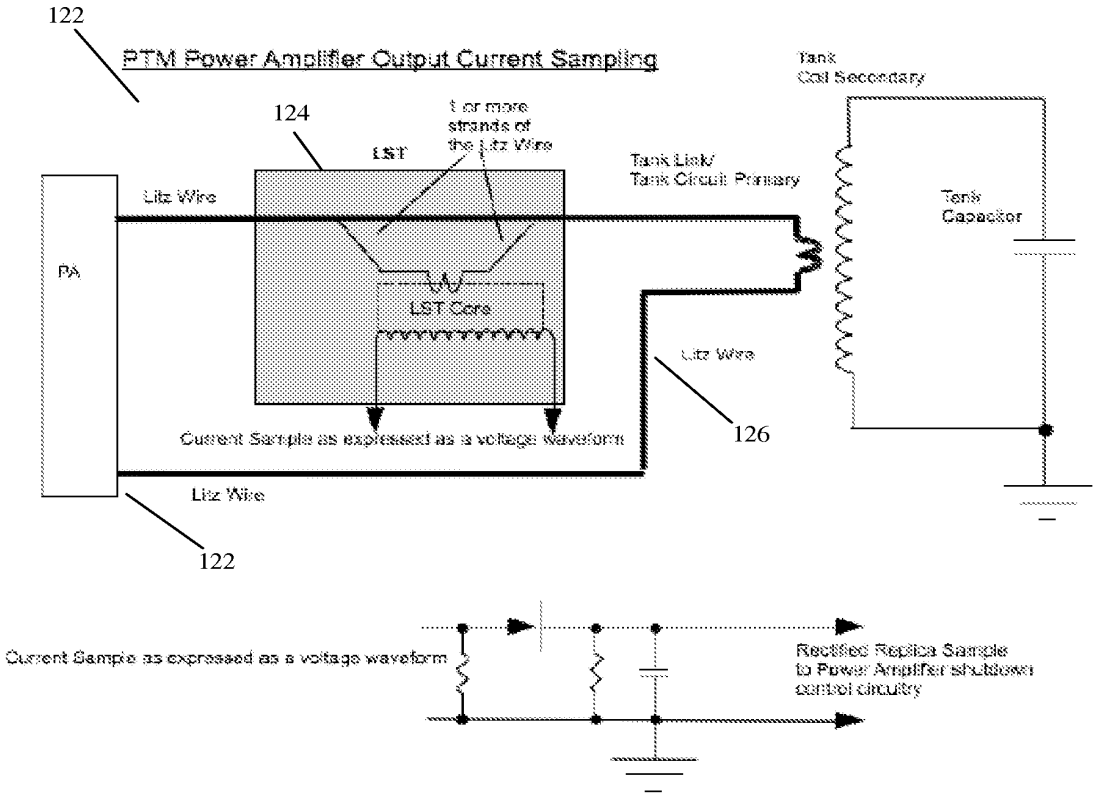

122
PTM Power Amplifier Output Current Sampling
124
1 or more strands of the Litz Wire
LST
Litz Wire
PA
LST Core
Tank Link/ Tank Circuit Primary
Tank Coil Secondary
Tank Capacitor
Litz Wire
126
Current Sample as expressed as a voltage waveform
Litz Wire
122
Current Sample as expressed as a voltage waveform
Rectified Replica Sample to Power Amplifier shutdown control circuitry

FIGURE 24B

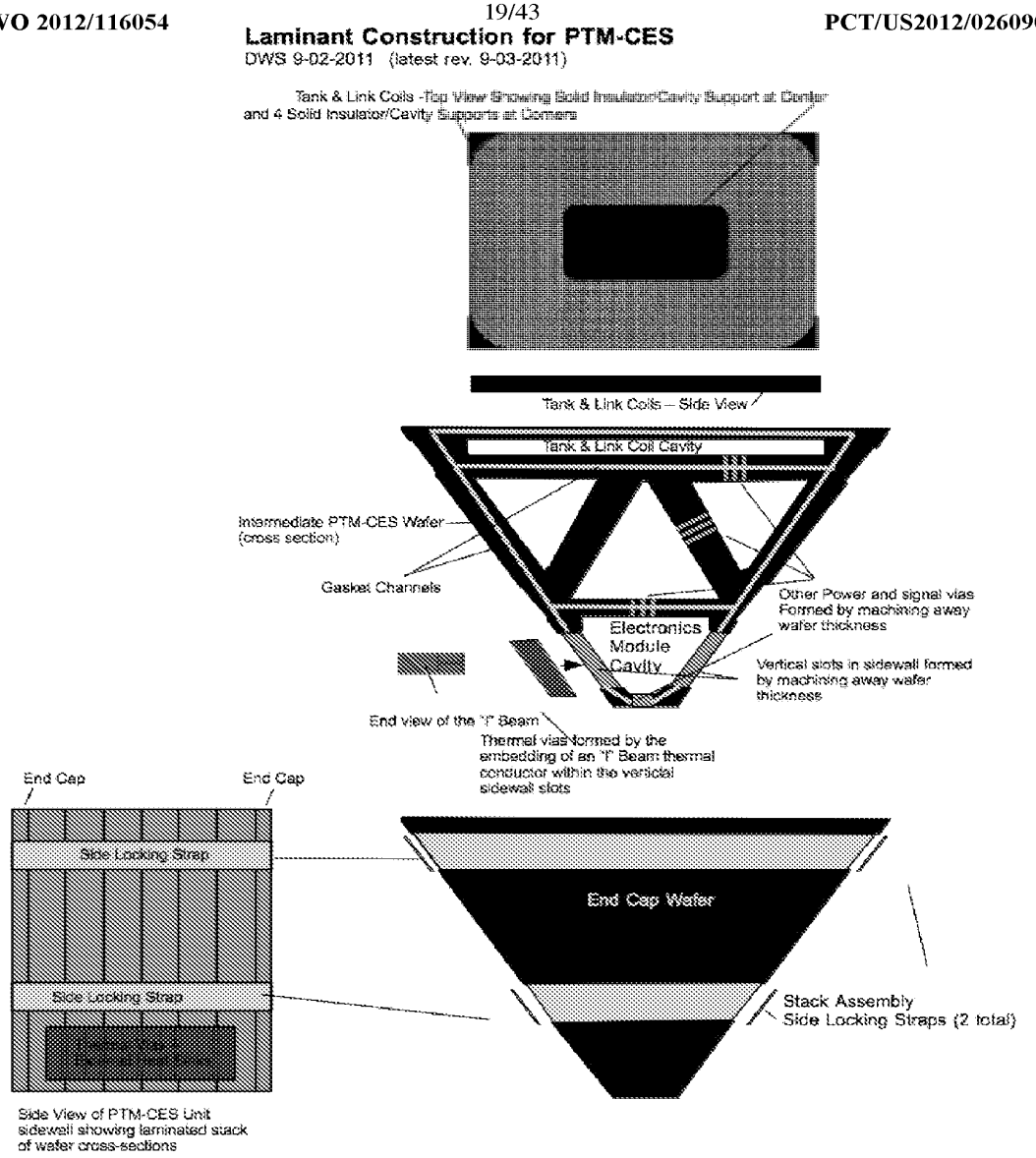

Laminant Construction for PTM-CES
DWS 9-02-2011 (latest rev. 9-03-2011)
Tank & Link Coils -Top View Showing Solid Insulator/Cavity Support at Center and 4 Solid Insulator/Cavity Supports at Corners
Tank & Link Coils – Side View
Tank & Link Coil Cavity
Intermediate PTM-CES Wafer (cross section)
Gasket Channels
Other Power and signal vias Formed by machining away wafer thickness
Electronics Module Cavity
Vertical slots in sidewall formed by machining away wafer thickness
End view of the "I" Beam
Thermal vias formed by the embedding of an "I" Beam thermal conductor within the vertical sidewall slots
End Cap
End Cap
Side Locking Strap
Side Locking Strap
End Cap Wafer
Stack Assembly
Side Locking Straps (2 total)
Side View of PTM-CES Unit sidewall showing laminated stack of wafer cross-sections

FIGURE 25

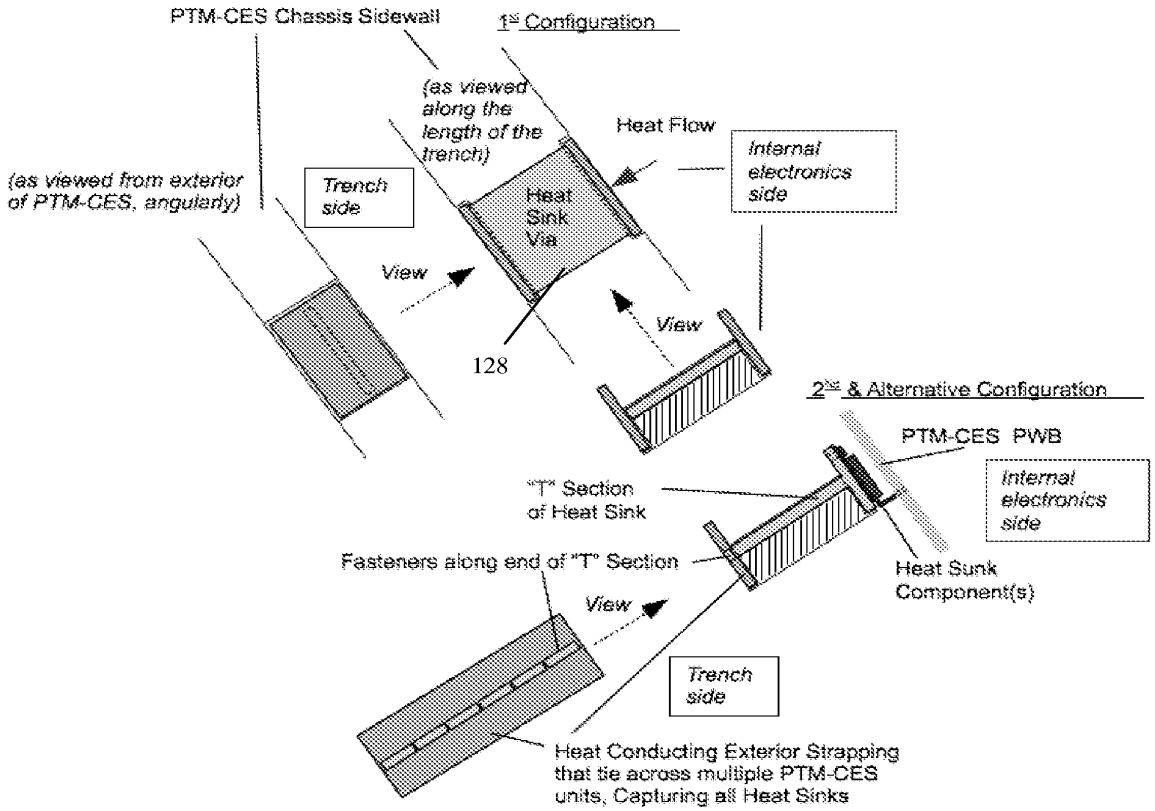

PTM-CES Chassis Sidewall
1st Configuration
(as viewed along the length of the trench)
Heat Flow
Internal electronics side
(as viewed from exterior of PTM-CES, angularly)
Trench side
Heat Sink Via
View
View
128
2nd & Alternative Configuration
PTM-CES PWB
"T" Section of Heat Sink
Internal electronics side
Fasteners along end of "T" Section
Heat Sunk Component(s)
View
Trench side
Heat Conducting Exterior Strapping that tie across multiple PTM-CES units, Capturing all Heat Sinks

FIGURE 26

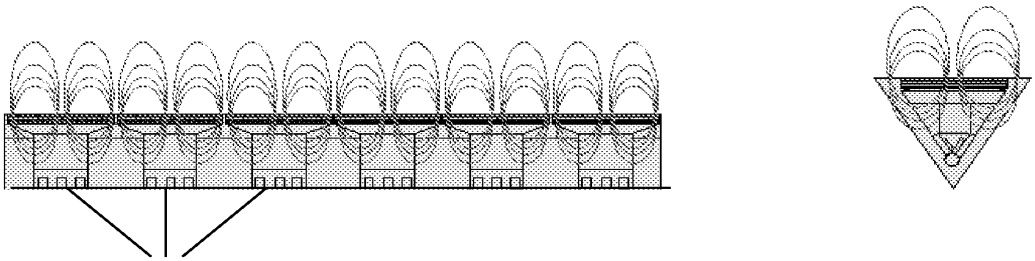


FIGURE 27

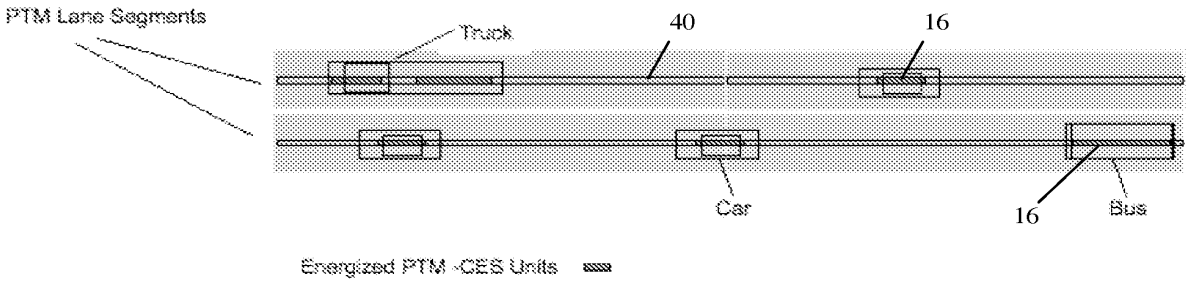


FIGURE 28

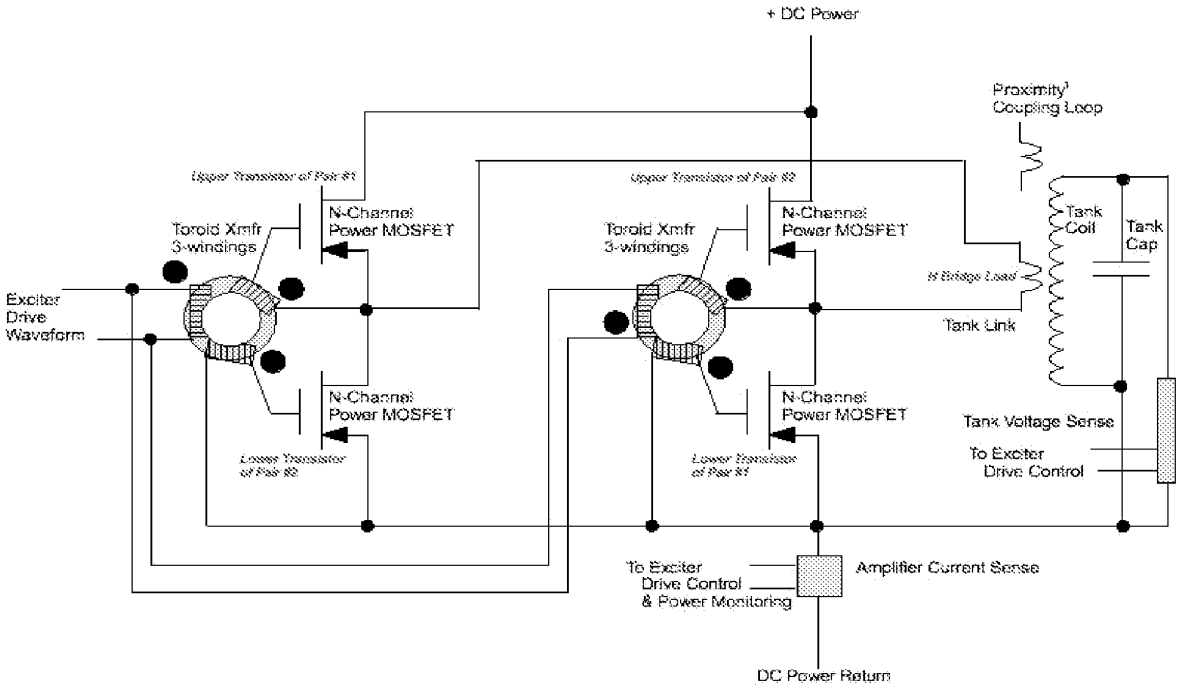


FIGURE 29

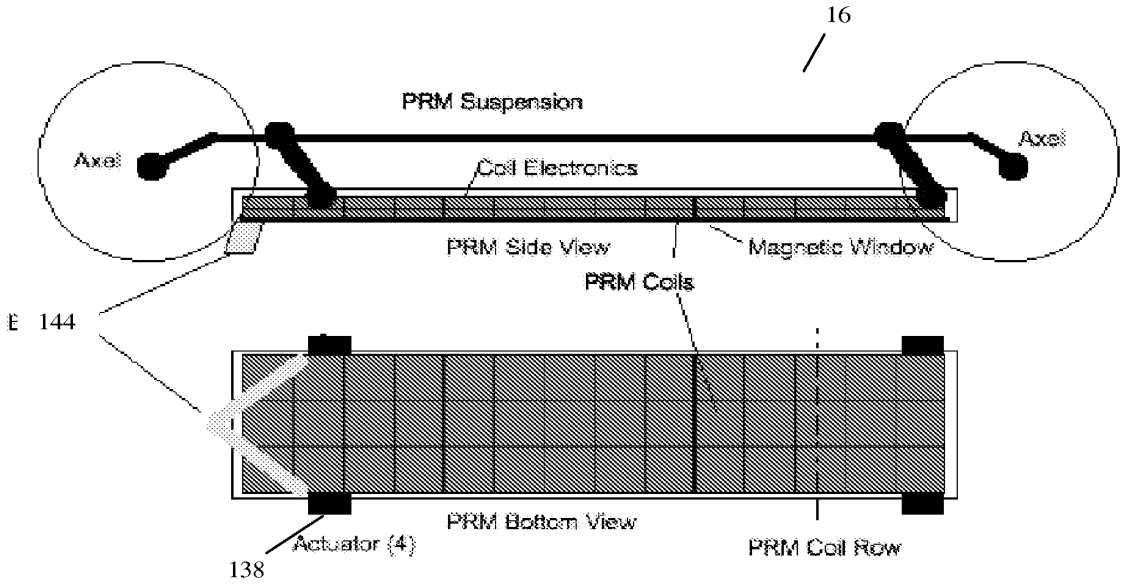


FIGURE 30

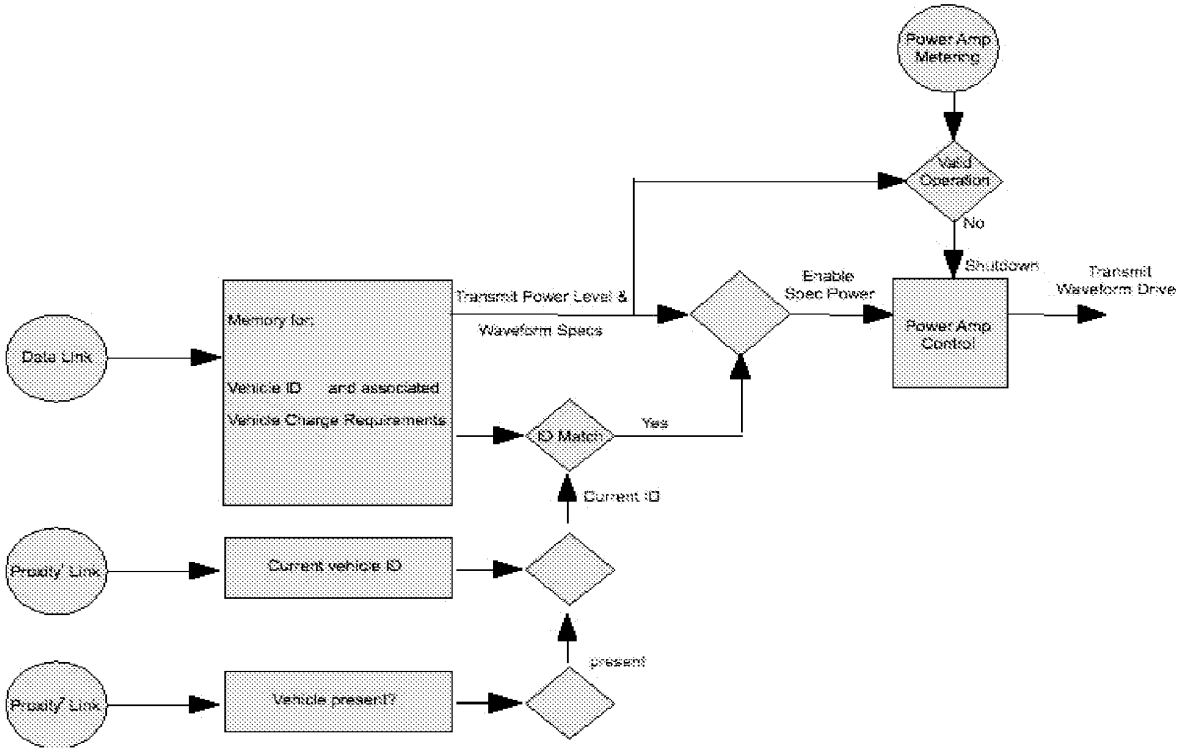

Power Amp Metering
Valid Operation
No
Shutdown
Transmit Waveform Drive
Enable Spec Power
Power Amp Control
Transmit Power Level & Waveform Specs
Data Link
Memory for:
Vehicle ID and associated
Vehicle Charge Requirements
ID Match
Yes
Current ID
Proxity Link
Current vehicle ID
present
Proxity Link
Vehicle present?

FIGURE 31

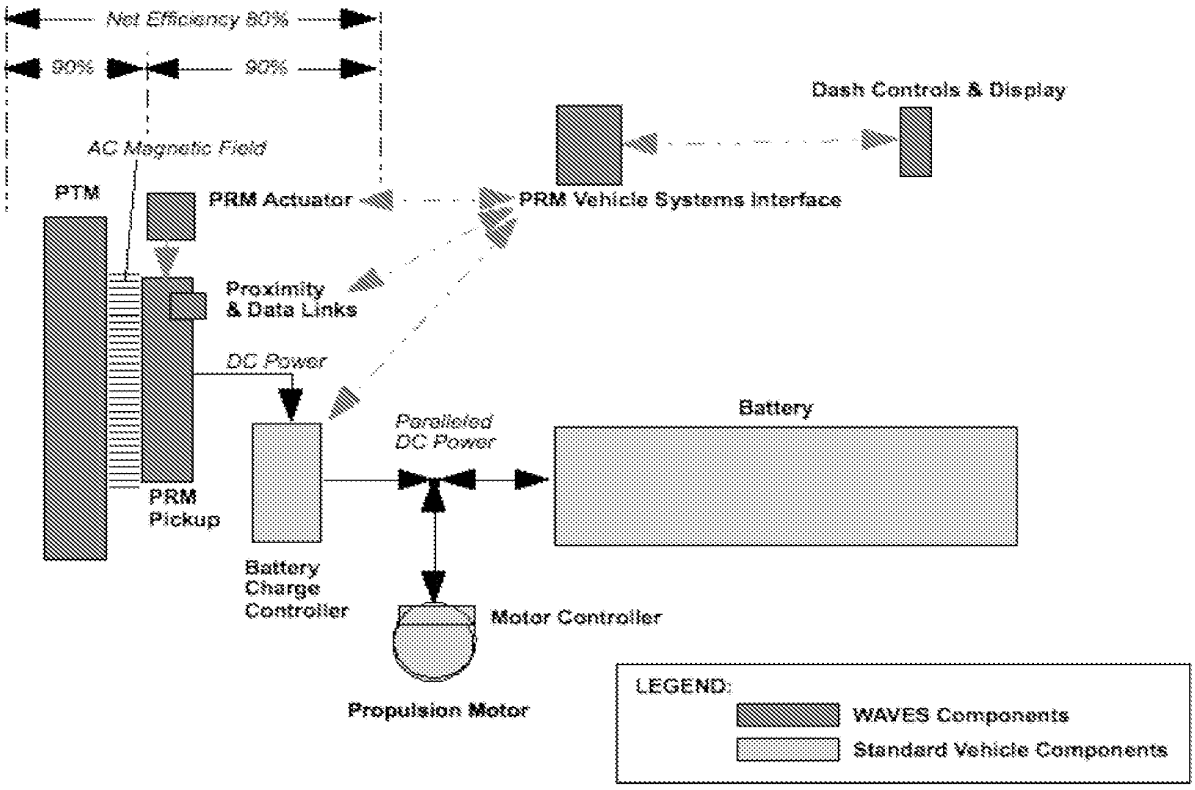

Net Efficiency 80%
90%
90%
AC Magnetic Field
PTM
PRM Actuator
PRM Vehicle Systems Interface
Dash Controls & Display
Proximity
& Data Links
DC Power
Paralleled
DC Power
Battery
PRM
Pickup
Battery
Charge
Controller
Motor Controller
Propulsion Motor
LEGEND:
WAVES Components
Standard Vehicle Components

FIGURE 32

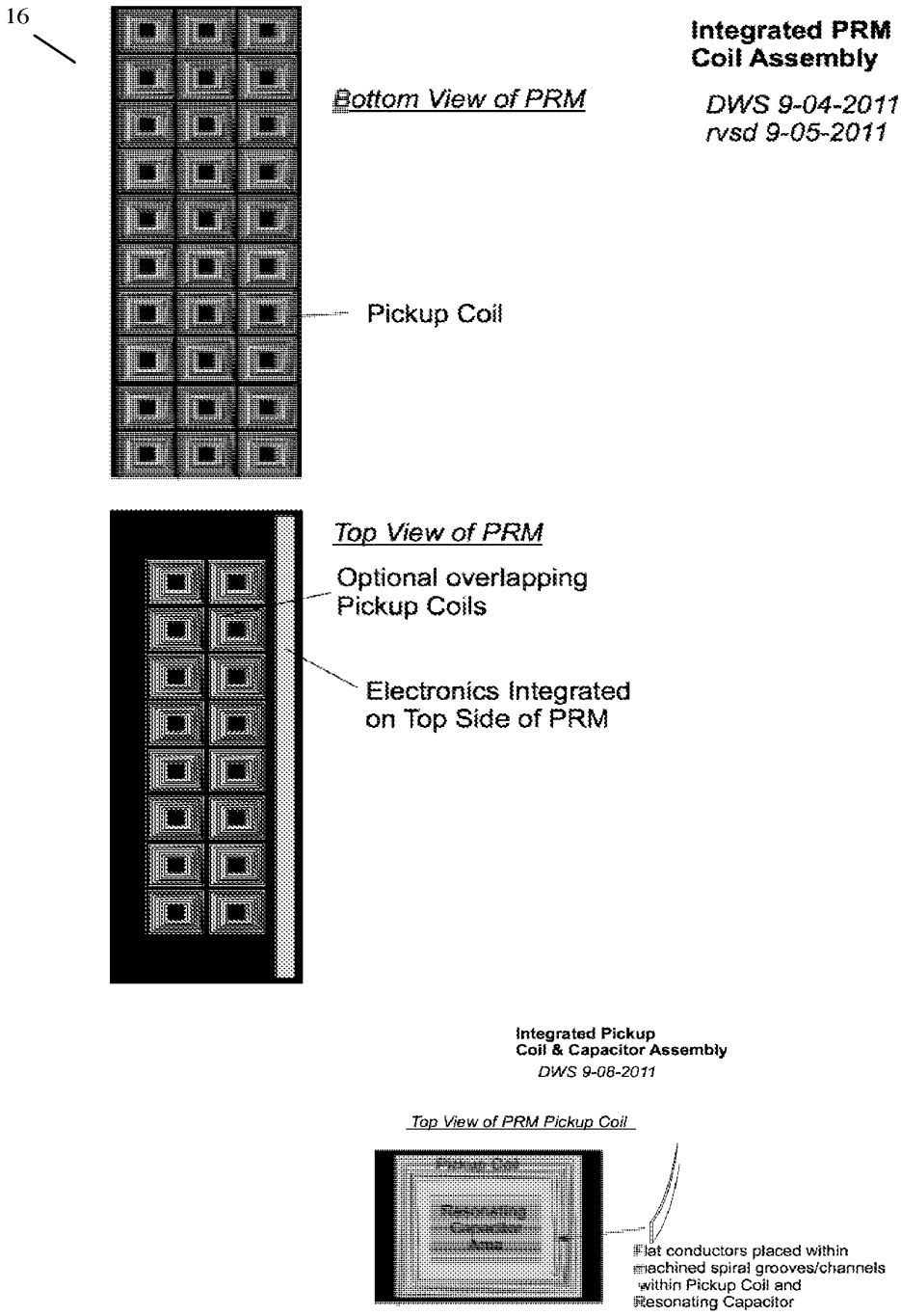

16
Integrated PRM
Coil Assembly
DWS 9-04-2011
rvsd 9-05-2011
Bottom View of PRM
Pickup Coil
Top View of PRM
Optional overlapping
Pickup Coils
Electronics Integrated
on Top Side of PRM
Integrated Pickup
Coil & Capacitor Assembly
DWS 9-08-2011
Top View of PRM Pickup Coil
Flat conductors placed within
machined spiral grooves/channels
within Pickup Coil and
Resonating Capacitor

FIGURE 33

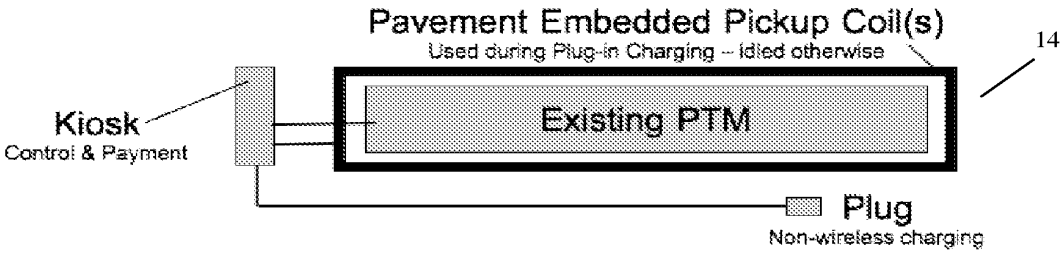


FIGURE 34

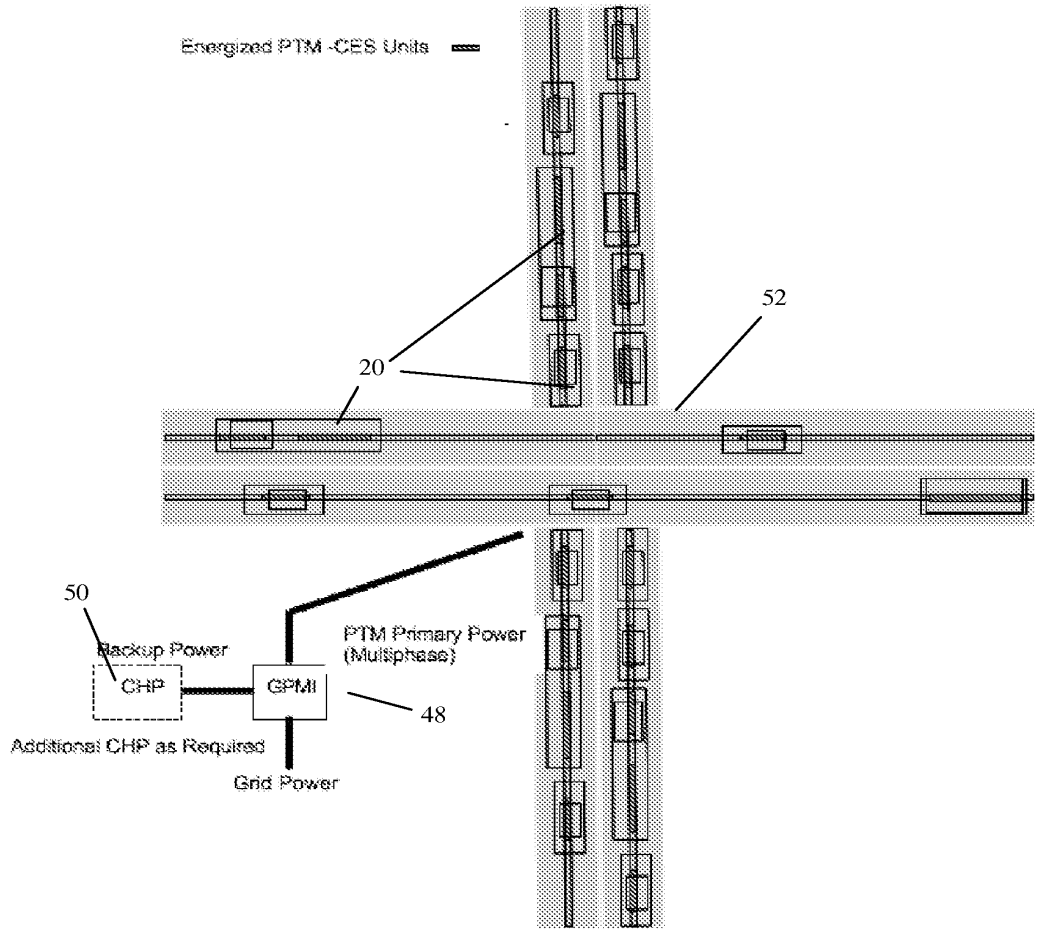


FIGURE 35



FIGURE 36

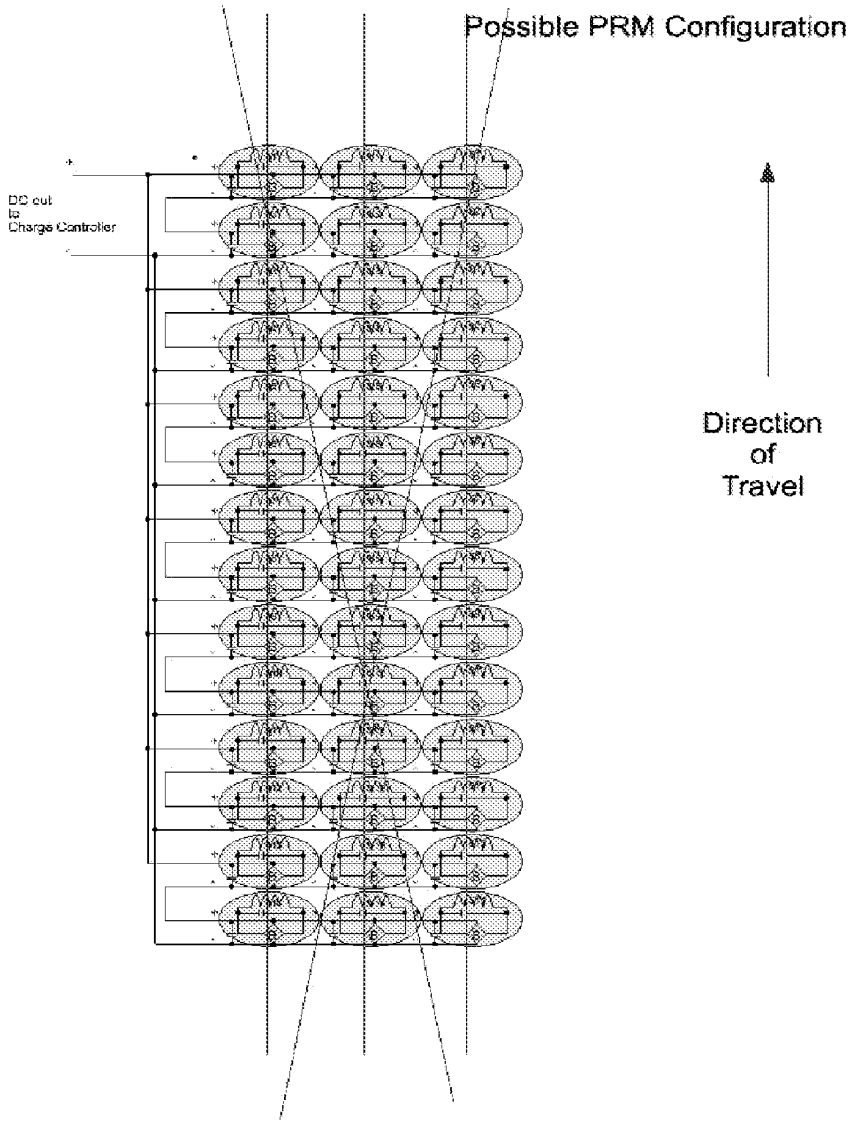

Possible PRM Configuration
DC out
to
Charge Controller
Direction
of
Travel

FIGURE 37

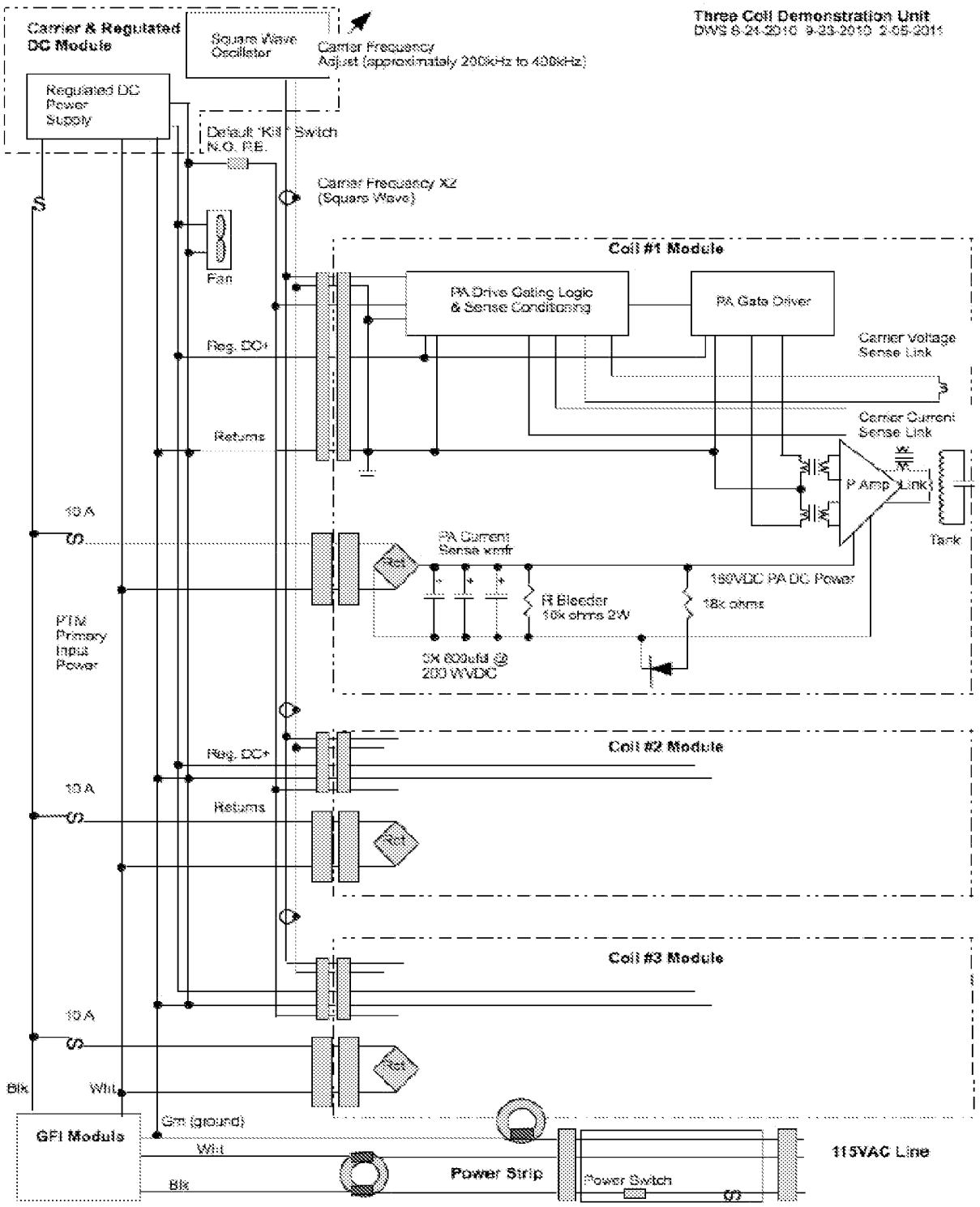

Three Coil Demonstration Unit
DWG 8-24-2010 9-23-2010 2-05-2011
Carrier & Regulated DC Module
Square Wave Oscillator
Carrier Frequency Adjust (approximately 200kHz to 400kHz)
Regulated DC Power Supply
Default "Kill" Switch N.O. P.B.
Carrier Frequency X2 (Square Wave)
Fan
Coil #1 Module
PA Drive Gating Logic & Sense Conditioning
PA Gate Driver
Reg. DC+
Carrier Voltage Sense Link
Returns
Carrier Current Sense Link
P Amp
Link
Tank
10 A
PA Current Sense xmfr
Rect
150VDC PA DC Power
R Bleeder 18k ohms 2W
18k ohms
PTM Primary Input Power
2X 820ufd @ 200 WVDC
Coil #2 Module
Reg. DC+
10 A
Returns
Rect
Coil #3 Module
10 A
Rect
Blk
Wht
Grn (ground)
GFI Module
Wht
Blk
Power Strip
Power Switch
115VAC Line

FIGURE 38

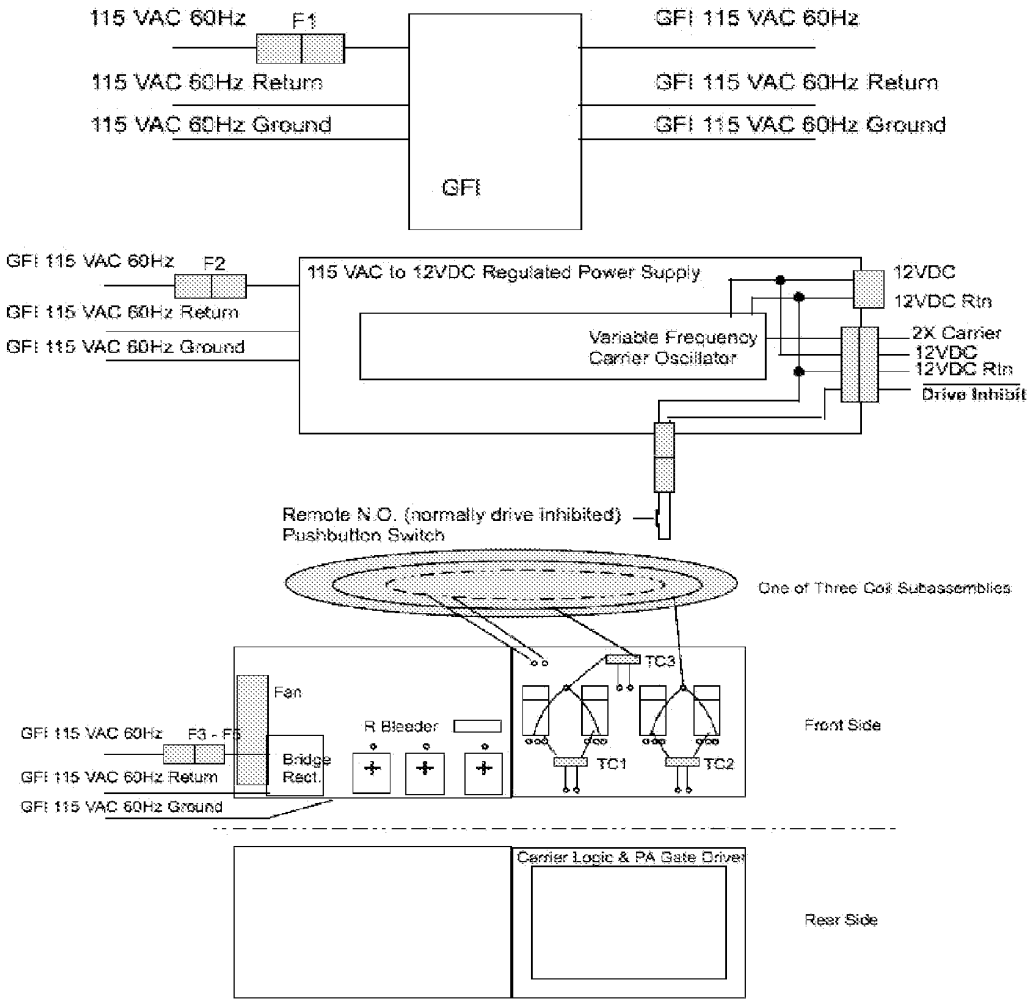

115 VAC 60Hz
F1
115 VAC 60Hz Return
115 VAC 60Hz Ground
GFI
GFI 115 VAC 60Hz
GFI 115 VAC 60Hz Return
GFI 115 VAC 60Hz Ground
GFI 115 VAC 60Hz
F2
GFI 115 VAC 60Hz Return
GFI 115 VAC 60Hz Ground
115 VAC to 12VDC Regulated Power Supply
Variable Frequency Carrier Oscillator
12VDC
12VDC Rtn
2X Carrier
12VDC
12VDC Rtn
Drive Inhibit
Remote N.C. (normally drive inhibited) Pushbutton Switch
One of Three Coil Subassemblies
TC3
Fan
R Bleeder
GFI 115 VAC 60Hz
F3 - F5
GFI 115 VAC 60Hz Return
GFI 115 VAC 60Hz Ground
Bridge Rect.
TC1
TC2
Front Side
Carrier Logic & PA Gate Driver
Rear Side

FIGURE 39

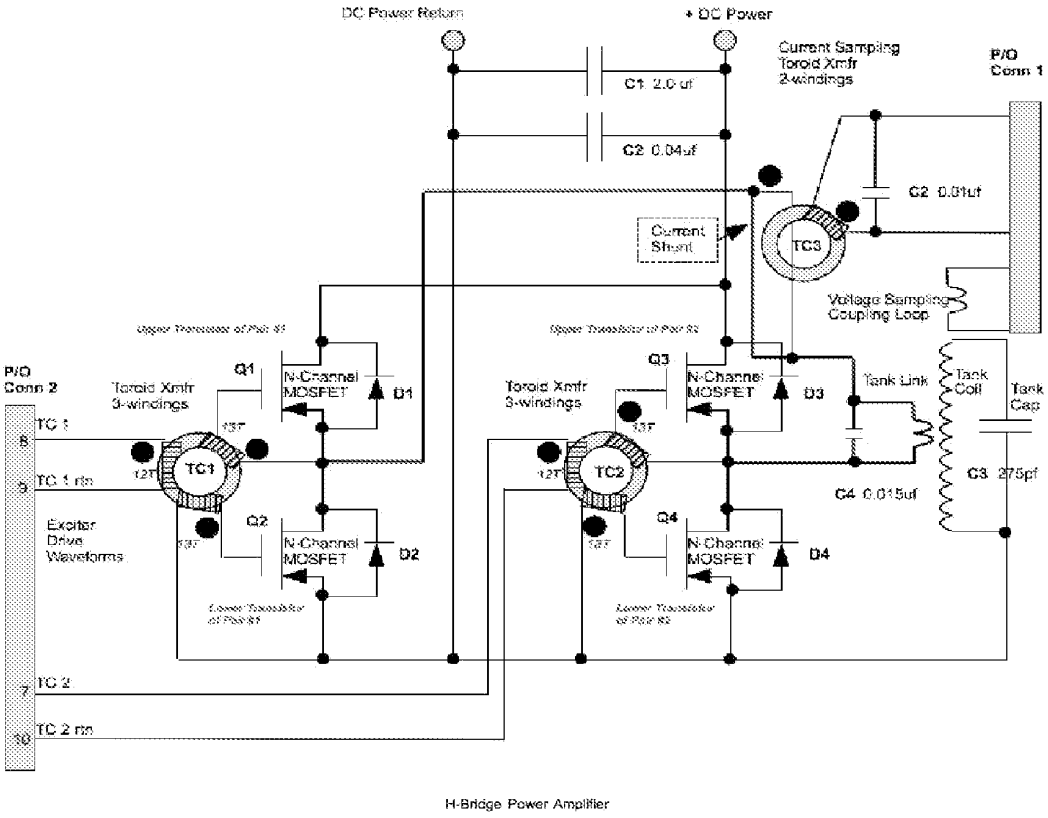

DC Power Return
+ DC Power
C1 2.0 uf
C2 0.04uf
Current Sampling Toroid Xmfr 2-windings
P/O Conn 1
C2 0.01uf
Current Shunt
TC3
Voltage Sampling Coupling Loop
P/O Conn 2
Toroid Xmfr 3-windings
Q1
N-Channel MOSFET
D1
TC 1
TC 1 rtn
TC1
12T
13T
Exciter Drive Waveforms
Q2
N-Channel MOSFET
D2
Toroid Xmfr 3-windings
Q3
N-Channel MOSFET
D3
Tank Link
Tank Coil
Tank Cap
TC2
C3 275pf
C4 0.015uf
Q4
N-Channel MOSFET
D4
TC 2
TC 2 rtn
H-Bridge Power Amplifier

FIGURE 40

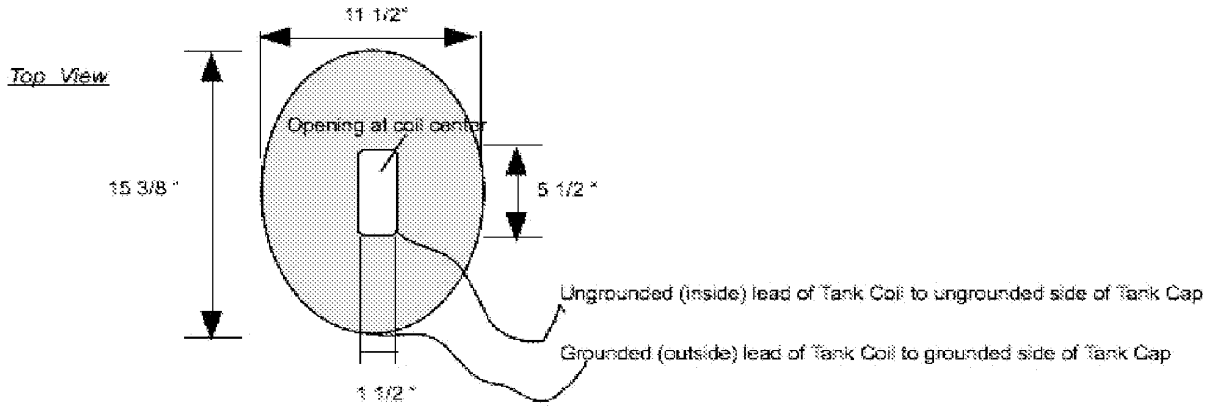

11 1/2"
Top View
Opening at coil center
15 3/8 "
5 1/2 "
Ungrounded (inside) lead of Tank Coil to ungrounded side of Tank Cap
Grounded (outside) lead of Tank Coil to grounded side of Tank Cap
1 1/2 "

FIGURE 41

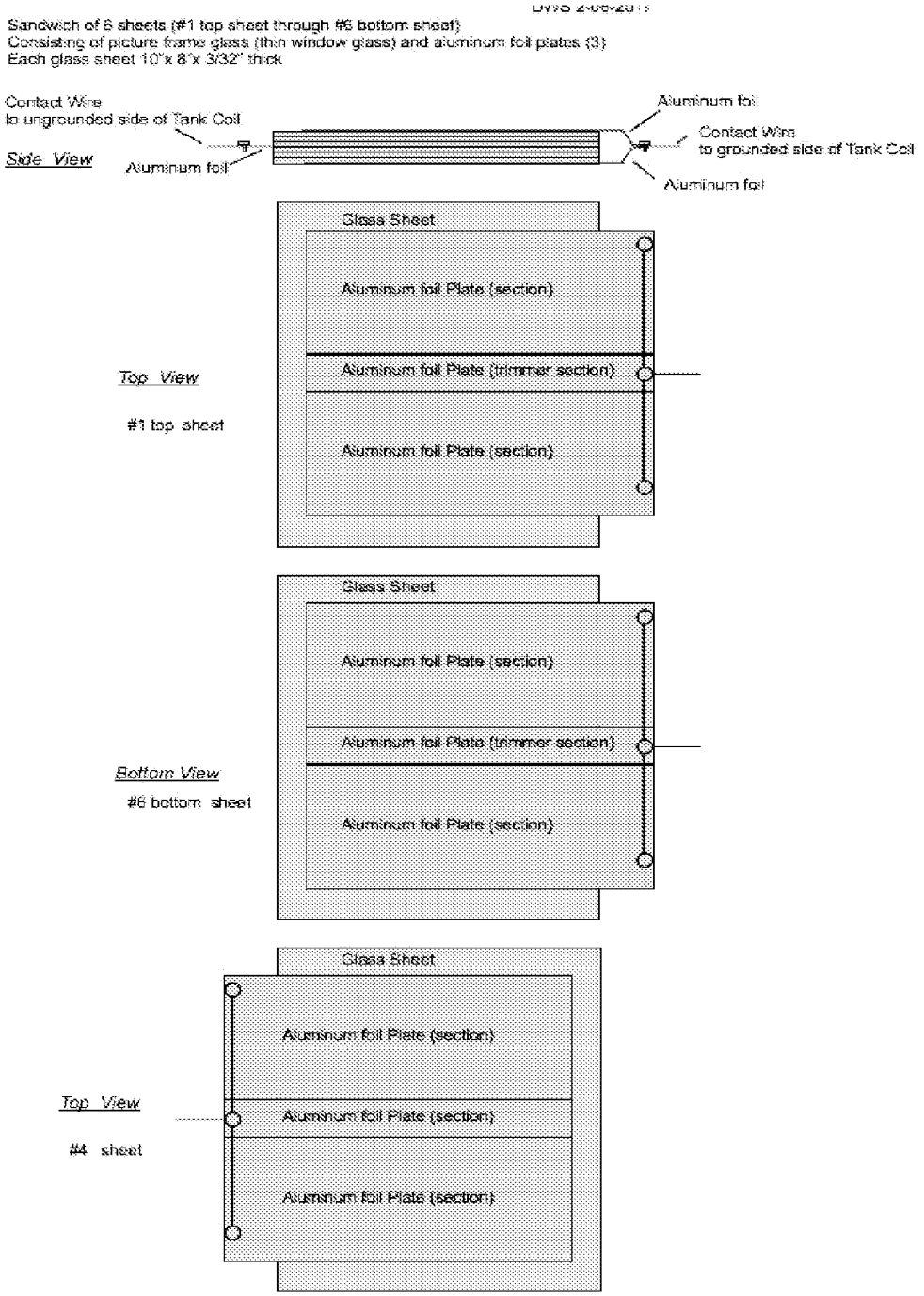

Sandwich of 6 sheets (#1 top sheet through #6 bottom sheet)
Consisting of picture frame glass (thin window glass) and aluminum foil plates (3)
Each glass sheet 10"x 8"x 3/32" thick
Contact Wire
to ungrounded side of Tank Coil
Side View
Aluminum foil
Aluminum foil
Contact Wire
to grounded side of Tank Coil
Aluminum foil
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (trimmer section)
Aluminum foil Plate (section)
Top View
#1 top sheet
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (trimmer section)
Aluminum foil Plate (section)
Bottom View
#6 bottom sheet
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (section)
Aluminum foil Plate (section)
Top View
#4 sheet

FIGURE 42

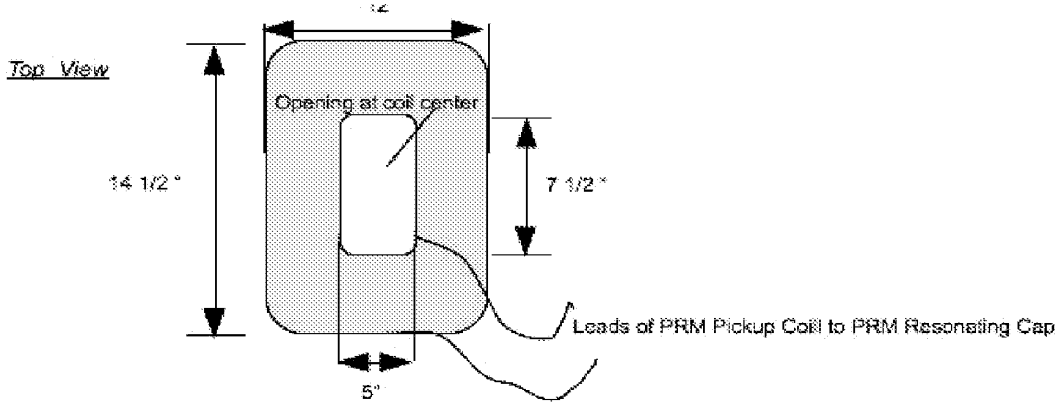

Top View
Opening at coil center
14 1/2 "
7 1/2 "
Leads of PRM Pickup Coil to PRM Resonating Cap
5"

FIGURE 43

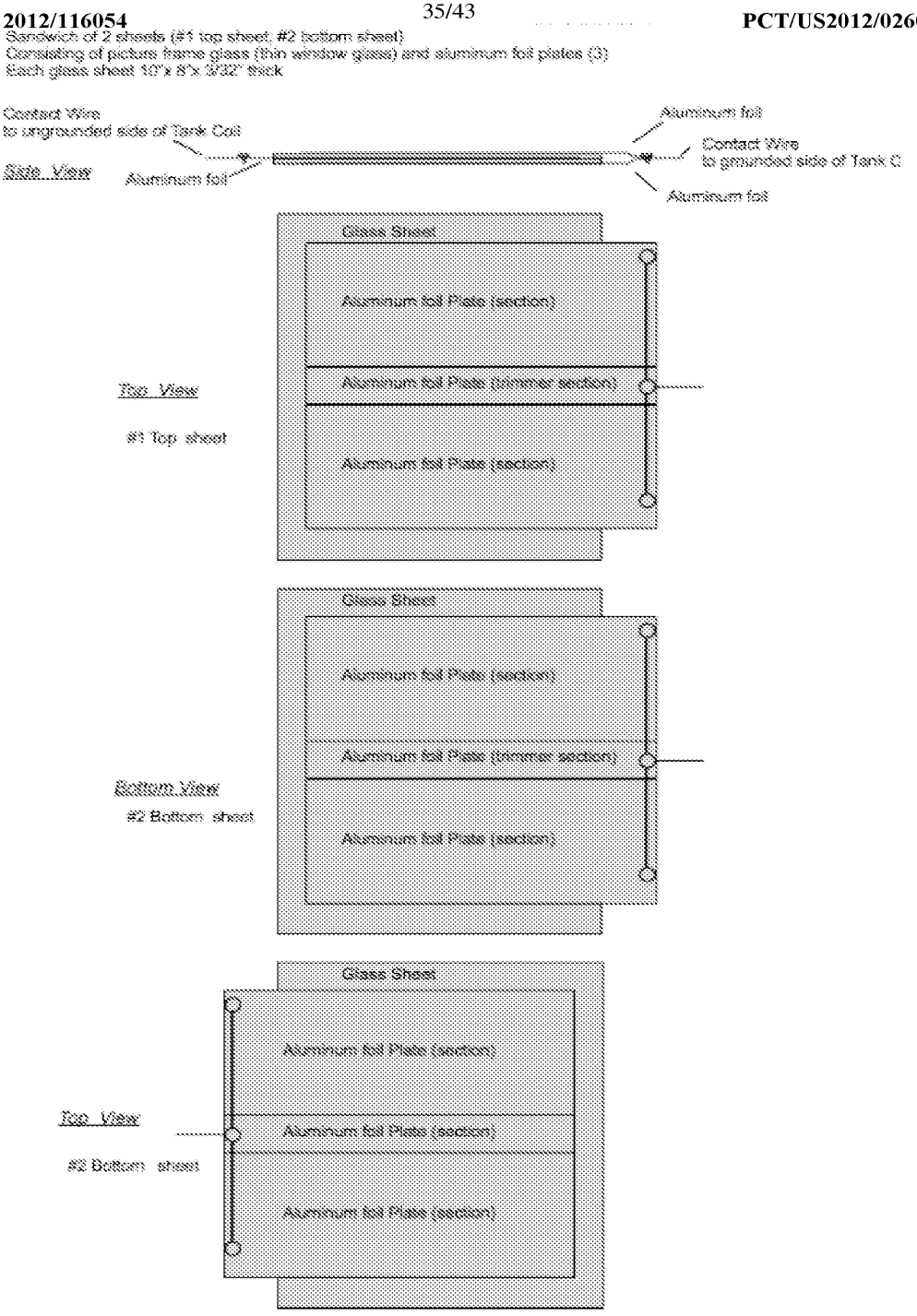

Sandwich of 2 sheets (#1 top sheet, #2 bottom sheet)
Consisting of picture frame glass (thin window glass) and aluminum foil plates (3)
Each glass sheet 10"x 8"x 3/32" thick
Contact Wire
to ungrounded side of Tank Coil
Aluminum foil
Side View
Aluminum foil
Contact Wire
to grounded side of Tank C
Aluminum foil
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (trimmer section)
Aluminum foil Plate (section)
Top View
#1 Top sheet
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (trimmer section)
Aluminum foil Plate (section)
Bottom View
#2 Bottom sheet
Glass Sheet
Aluminum foil Plate (section)
Aluminum foil Plate (section)
Aluminum foil Plate (section)
Top View
#2 Bottom sheet

FIGURE 44

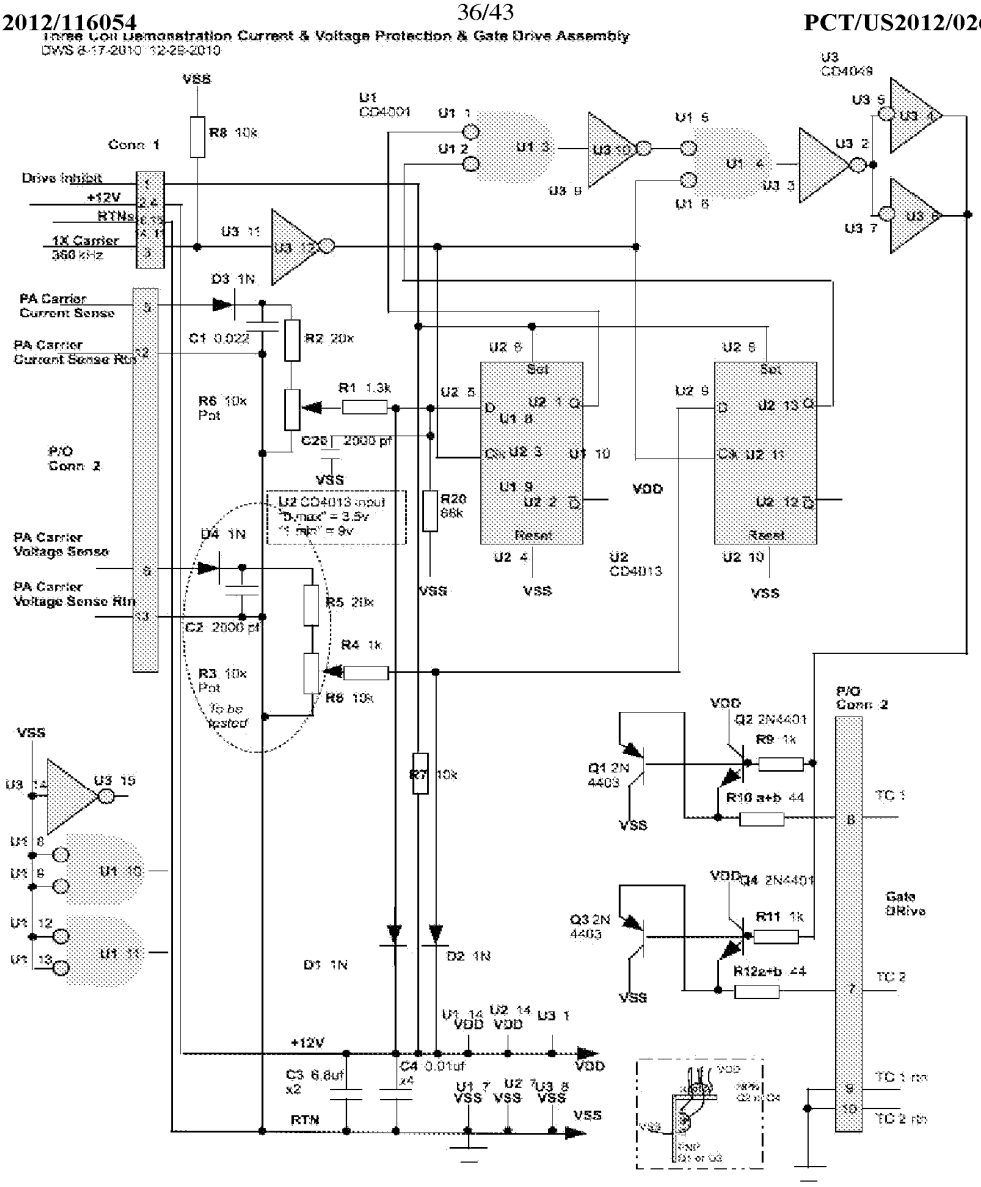

Three Coil Demonstration Current & Voltage Protection & Gate Drive Assembly
DWS 8-17-2010 12-28-2010
VSS
R8 10k
Conn 1
Drive Inhibit
+12V
RTNs
1X Carrier
360 kHz
U1
CD4001
U3
CD4049
U3 11
D3 1N
PA Carrier
Current Sense
PA Carrier
Current Sense Rtn
C1 0.022
R2 20k
R1 1.3k
R6 10k
Pot
C25 2000 pf
P/O
Conn 2
U2 CD4013 input
"0 max" = 3.5v
"1 min" = 9v
R20
66k
U2
CD4013
D4 1N
PA Carrier
Voltage Sense
PA Carrier
Voltage Sense Rtn
C2 2000 pf
R5 2k
R4 1k
R3 10k
Pot
To be
tested
R6 10k
R7 10k
D1 1N
D2 1N
+12V
C3 6.8uf
x2
C4 0.01uf
x4
RTN
VDD
Q2 2N4401
R9 1k
Q1 2N
4403
R10 a+b 44
TC 1
Q4 2N4401
R11 1k
Q3 2N
4403
R12a+b 44
TC 2
Gate
DRive
P/O
Conn 2
TC 1 rtn
TC 2 rtn

FIGURE 45

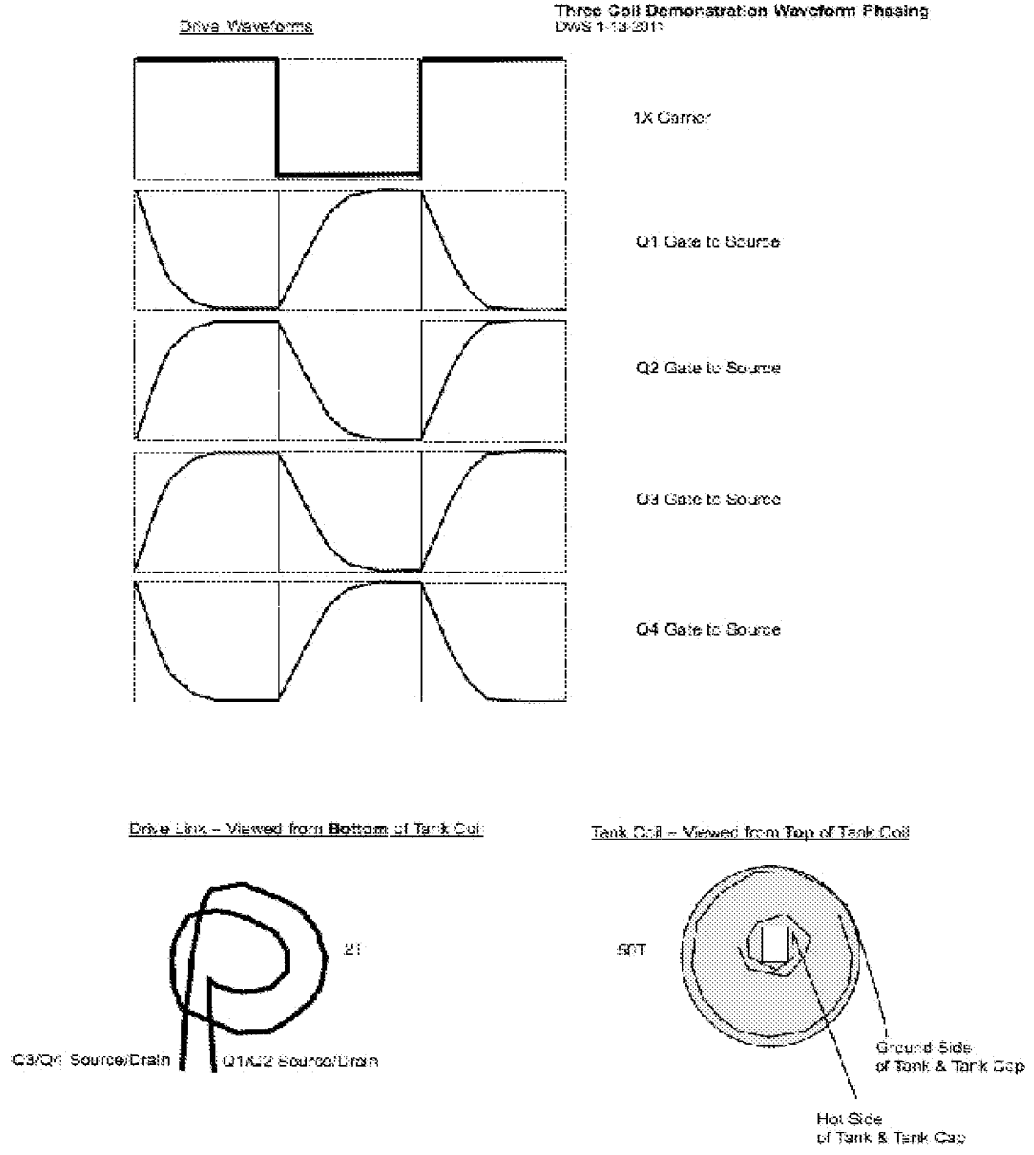

Drive Waveforms
Three Coil Demonstration Waveform Phasing
1X Carrier
Q1 Gate to Source
Q2 Gate to Source
Q3 Gate to Source
Q4 Gate to Source
Drive Link – Viewed from Bottom of Tank Coil
Q3/Q4 Source/Drain
Q1/Q2 Source/Drain
Tank Coil – Viewed from Top of Tank Coil
SRT
Ground Side
of Tank & Tank Cap
Hot Side
of Tank & Tank Cap

FIGURE 46

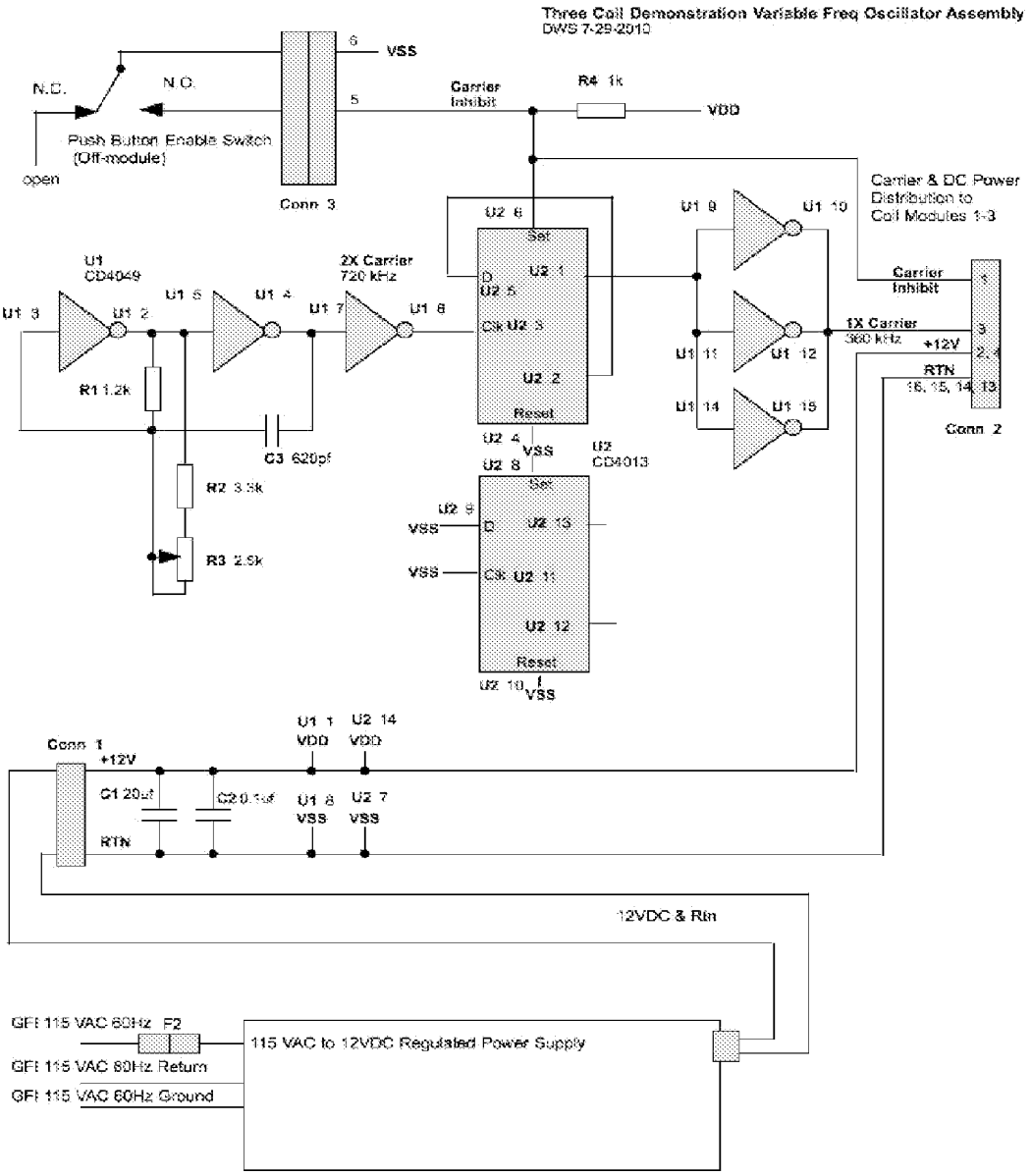

Three Coil Demonstration Variable Freq Oscillator Assembly
DWS 7-29-2010
N.C.
N.O.
Push Button Enable Switch
(Off-module)
open
Conn 3
VSS
Carrier
Inhibit
R4 1k
VDD
Carrier & DC Power
Distribution to
Coil Modules 1-3
U1
CD4049
2X Carrier
720 kHz
R1 1.2k
C3 620pf
R2 3.3k
R3 2.5k
U2
CD4013
Set
Reset
Clk
D
1X Carrier
360 kHz
+12V
RTN
Conn 2
Conn 1
C1 20uf
C2 0.1uf
12VDC & Rtn
GFI 115 VAC 60Hz F2
GFI 115 VAC 60Hz Return
GFI 115 VAC 60Hz Ground
115 VAC to 12VDC Regulated Power Supply

FIGURE 47

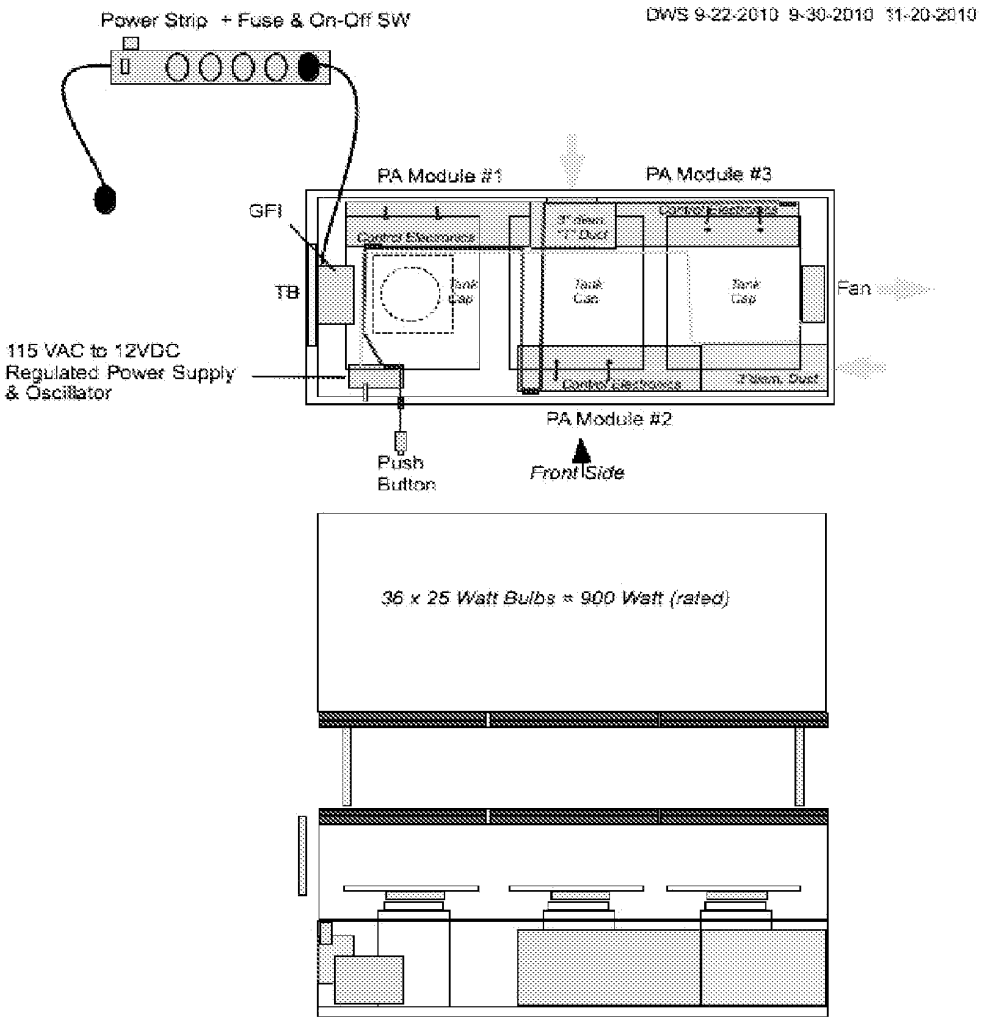

Power Strip + Fuse & On-Off SW
DWS 9-22-2010 9-30-2010 11-20-2010
PA Module #1
PA Module #3
GFI
TB
Fan
115 VAC to 12VDC
Regulated Power Supply
& Oscillator
PA Module #2
Push
Button
Front Side
36 x 25 Watt Bulbs = 900 Watt (rated)

FIGURE 48

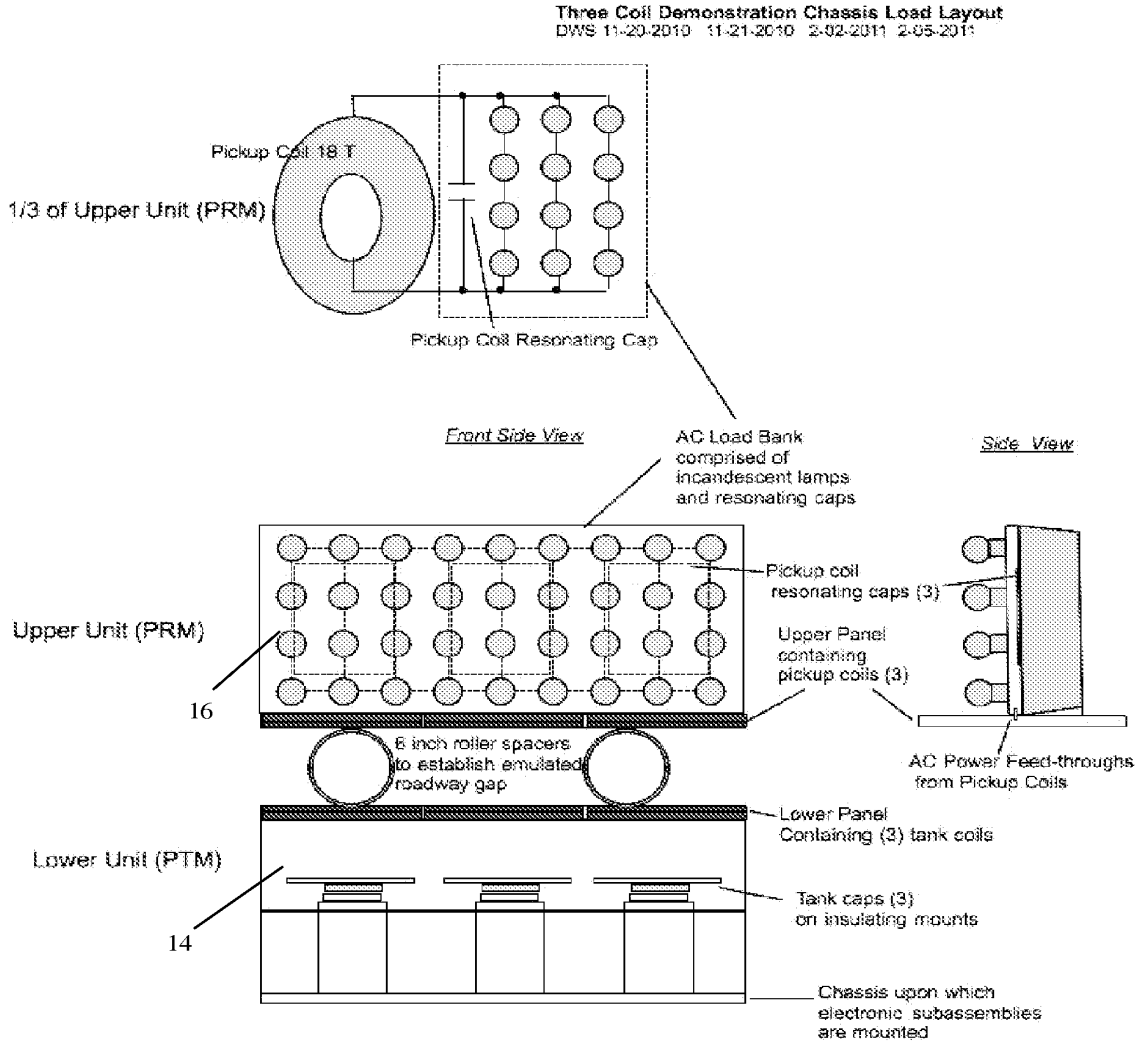

Three Coil Demonstration Chassis Load Layout
DWS 11-20-2010 11-21-2010 2-02-2011 2-05-2011
Pickup Coil 18 T
1/3 of Upper Unit (PRM)
Pickup Coil Resonating Cap
Front Side View
AC Load Bank comprised of incandescent lamps and resonating caps
Side View
Pickup coil resonating caps (3)
Upper Unit (PRM)
16
Upper Panel containing pickup coils (3)
6 inch roller spacers to establish emulated roadway gap
AC Power Feed-throughs from Pickup Coils
Lower Panel Containing (3) tank coils
Lower Unit (PTM)
Tank caps (3) on insulating mounts
14
Chassis upon which electronic subassemblies are mounted

FIGURE 49

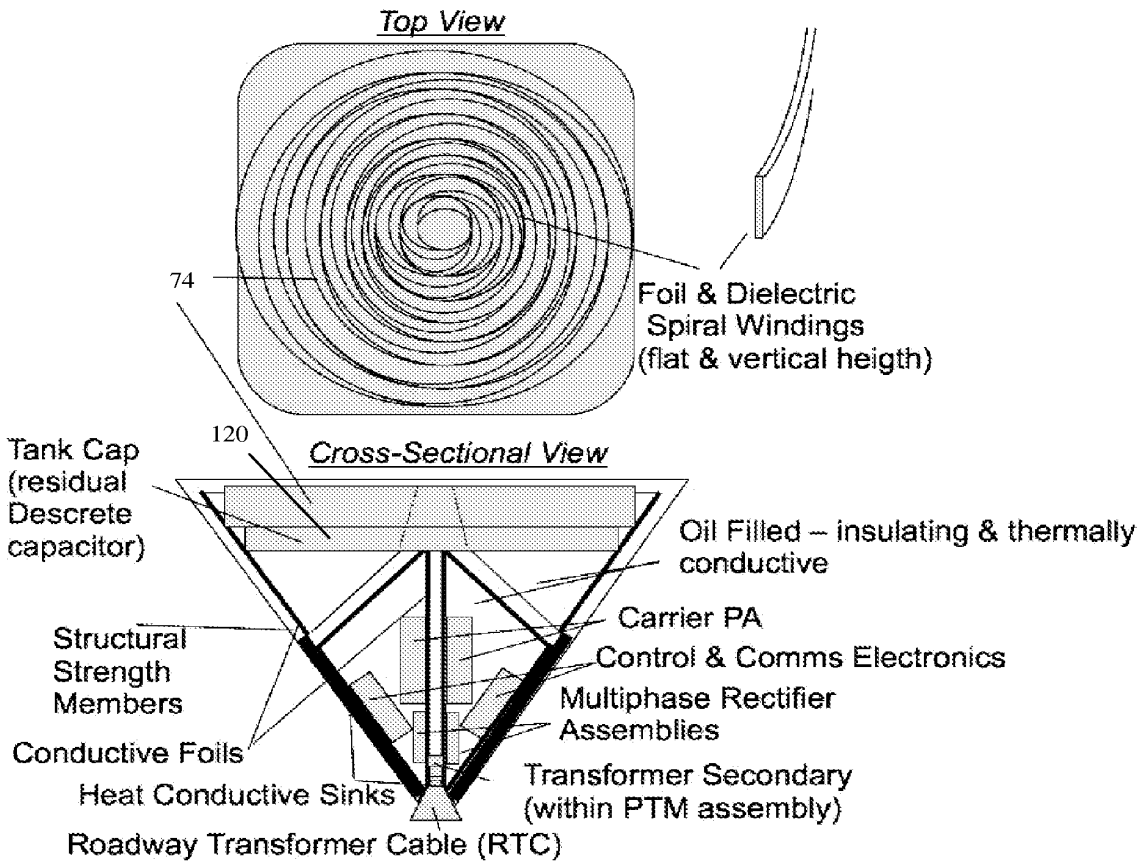

Top View
74
Foil & Dielectric
Spiral Windings
(flat & vertical heigth)
120
Cross-Sectional View
Tank Cap
(residual
Descrete
capacitor)
Oil Filled – insulating & thermally
conductive
Carrier PA
Structural
Strength
Members
Control & Comms Electronics
Multiphase Rectifier
Assemblies
Conductive Foils
Heat Conductive Sinks
Transformer Secondary
(within PTM assembly)
Roadway Transformer Cable (RTC)

FIGURE 50

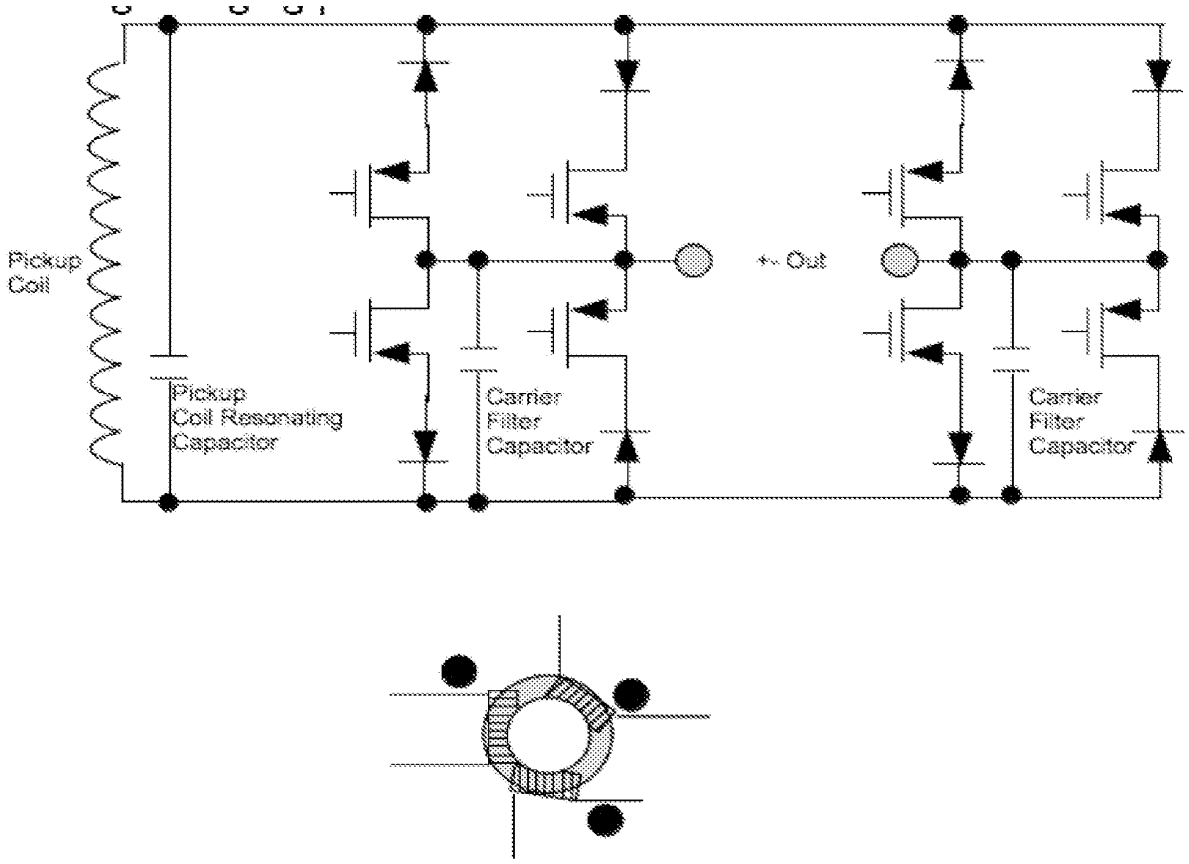

Pickup
Coil
Pickup
Coil Resonating
Capacitor
Carrier
Filter
Capacitor
+- Out
Carrier
Filter
Capacitor

FIGURE 51

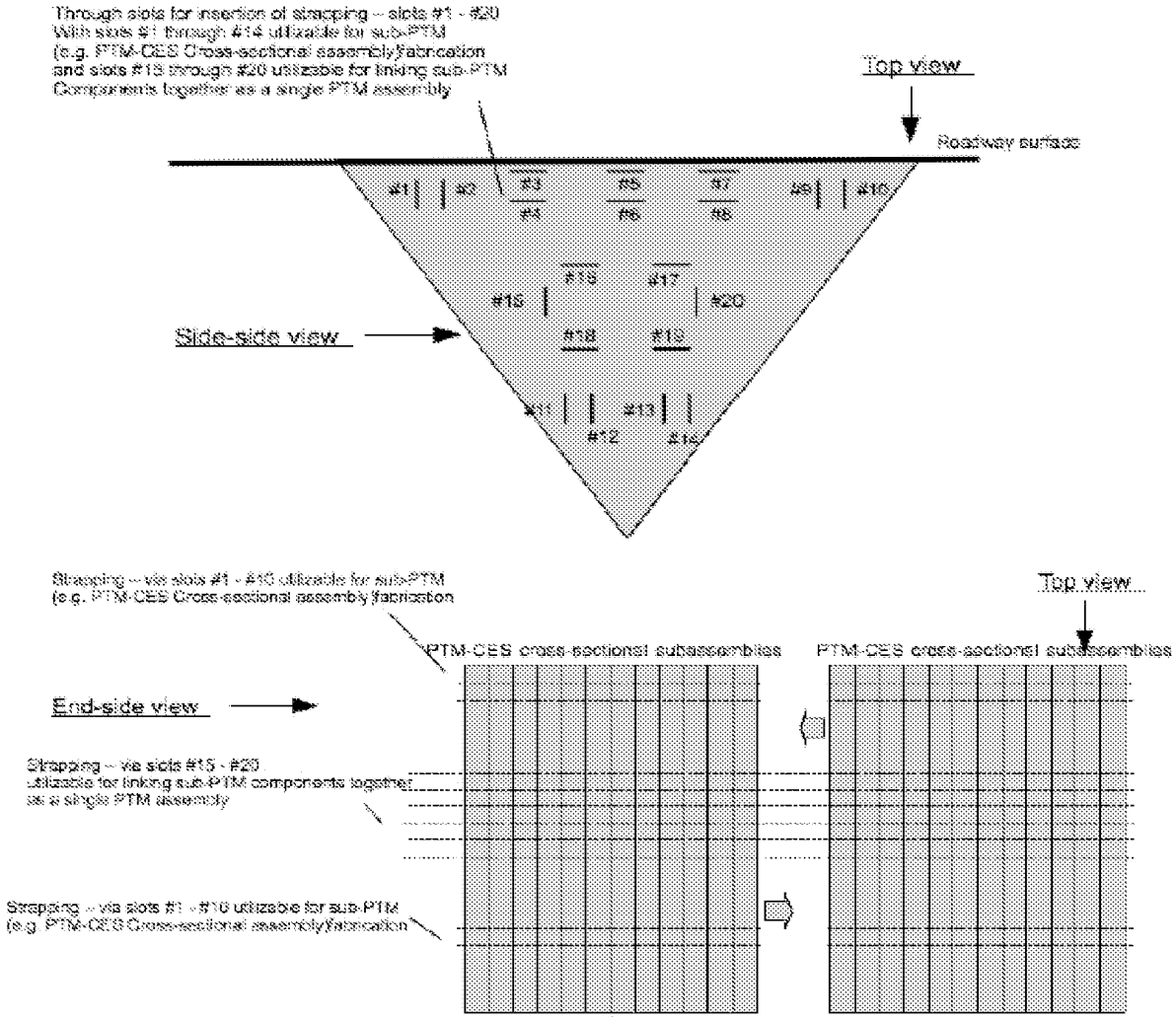

Through slots for insertion of strapping – slots #1 - #20
With slots #1 through #14 utilizable for sub-PTM
(e.g. PTM-CES Cross-sectional assembly/fabrication
and slots #15 through #20 utilizable for linking sub-PTM
Components together as a single PTM assembly
Top view
Roadway surface
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
#19
#20
Side-side view
Strapping – via slots #1 - #10 utilizable for sub-PTM
(e.g. PTM-CES Cross-sectional assembly/fabrication
Top view
PTM-CES cross-sectional subassemblies
PTM-CES cross-sectional subassemblies
End-side view
Strapping – via slots #15 - #20
utilizable for linking sub-PTM components together
as a single PTM assembly
Strapping – via slots #1 - #10 utilizable for sub-PTM
(e.g. PTM-CES Cross-sectional assembly/fabrication

FIGURE 52

PTO/AIA/22 (03-13)
Approved for use through 7/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) AFPA-01032US0
Application Number 13/352,096	Filed 1/17/2012
For SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	
Art Unit 2859	Examiner Fantu, Yalkew

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☑ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 200
☐ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 061325.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 45445.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Karl F. Kenna/ — Signature

June 27, 2014 — Date

Karl F. Kenna — Typed or printed name

415-362-3800 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☐ * Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION	
Inventor(s):	Partovi, Afshin		
Appln. No.:	13/352,096	Art Unit:	2859
Confirm. No.:	4453	Examiner:	Fantu, Yalkew
Filed:	January 17, 2012		
Title:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**	

REQUEST FOR CONTINUED EXAMINATION UNDER 37 C.F.R. §1.114

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This REQUEST FOR CONTINUED EXAMINATION and REPLY is in response to the Office Action mailed March 12, 2014.

Amendments

Please amend the above-identified application as follows:

Amendments to the Claims begin on Page 2.

Remarks begin on Page 10.

In the Claims:

Please amend Claims 1-9 and 29-36; and cancel Claims 38 and 39, as shown below. Applicant respectfully reserves the right to prosecute any originally presented claims in a continuing or future application.

1. (Currently Amended) A system for use in charging or powering one or more devices or batteries by wireless power, comprising:

one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from ~~another~~ a charger coil placed close to the receiver coil and configured to provide power thereto, ~~or~~ and

a charger coil, provided within a charger, which transmits inductive power to ~~another~~ a receiver coil placed close to the charger coil and configured to receive power therefrom~~,~~;

a ~~one or more components including a ferromagnetic, ferrite, or other magnetic material or~~ switching layer having magnetic properties and covering the one or more receiver coil or charger ~~coils~~ coil, so that, during charging or powering of ~~one or more devices or batteries~~ a device or battery, the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer is layered either

between the ~~one or more~~ receiver coil and a surface of the receiver, or

between the charger ~~coils~~ coil and a surface of the ~~other coil,~~ charger; and

wherein ~~the~~ one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the ~~other~~ receiver coil is placed close to the ~~one or more receiver or~~ charger ~~coils~~ coil, the ~~ferromagnetic, ferrite, or other magnetic material's~~ switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to affect passage of ~~a~~ magnetic flux within a particular region ~~thereof~~ of the switching layer, including

~~to allow~~ guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil ~~in~~ within a particular region of the switching layer generally aligned both with the ~~other coil and the one or more~~ receiver coil and the ~~or~~ charger ~~coils~~ coil, while

providing ~~an amount of~~ electromagnetic shielding in regions of the switching layer other than the particular region.

2. (Currently Amended) The system of claim 1, wherein the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer is provided within

one or more wireless chargers or power supplies or the electronics, coils, magnetic material, or magnets therein, or

one or more wireless power receivers or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices or batteries.

3. (Currently Amended) The system of claim 1, wherein the one or more components ~~including the ferromagnetic, ferrite, or other magnetic material or~~ and the switching layer is used to provide a degree of position independence in charging or powering the one or more devices or batteries.

4. (Currently Amended) The system of claim 1, wherein the modifying the magnitude or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer so that it ~~acts as a switching layer, allowing~~ allows a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

5. (Currently Amended) The system of claim 1, wherein the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron, carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof.

6. (Currently Amended) The system of claim 4, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of ~~ferromagnetic, ferrite, or other magnetic material or~~ the switching layer locally on or near where the receiver coil is placed.

7. (Currently Amended) The system of claim 6, wherein the saturating or altering the magnetization curve of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer locally is provided by saturating or modifying the permeability of the layer through application of

one or more DC or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

8. (Currently Amended) The system of claim 7, wherein the permanent magnet or electromagnet is incorporated behind, in front, around or at the center of the receiver or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer locally on or near where the receiver coil is placed.

9. (Currently Amended) The system of claim 7, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ~~ferrite or ferromagnetic or magnetic material or~~ switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

10. (Previously Presented) The system of claim 1, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices or batteries by wireless power.

11. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices or the batteries.

12. (Original) The system of claim 11, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof.

13. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

14. (Previously Presented) The system of claim 1, wherein the power at the devices or batteries charged or powered by wireless power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

15. (Previously Presented) The system of claim 1, wherein the wireless power transmitted to the devices or batteries charged or powered wirelessly is transmitted at substantially the same or similar frequencies.

16. (Previously Presented) The system of claim 1, wherein the wireless power transmitted to the devices or batteries charged or powered wirelessly is transmitted at different frequencies.

17. (Previously Presented) The system of claim 2, wherein the chargers or receivers include one or more microcontrollers or programmable parts or memory.

18. (Previously Presented) The system of claim 2, wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil or load modulation or through an RF or optical link or through one or more RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof.

19. (Previously Presented) The system of claim 2, wherein the presence of the one or more receivers is detected by the one or more chargers or power supplies or causes a change in the operating behavior or characteristics of the chargers or power supplies.

20. (Previously Presented) The system of claim 2, wherein the chargers or receivers may consist of one set of electronics or coils or several sets of similar or dissimilar electronics or coils to provide flexibility in wirelessly charging devices or batteries at different voltages, powers, current levels, geometries or functions or communication and regulation or detection protocols.

21. (Previously Presented) The system of claim 2, wherein the chargers or receivers may include shielding materials such as ferromagnetic or other magnetic materials or metal or other

conductive layers, or thin metal layers covering a portion or all of the charger or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system.

22. (Original) The system of claim 2, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system.

23. (Previously Presented) The system of claim 1, wherein one or more repeater antennas or coils or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

24. (Previously Presented) The system of claim 1, wherein the system includes one or more metal layers included on the top of the receiver shield or the bottom of the charger / transmitter shield to provide further shielding from the magnetic field.

25. (Previously Presented) The system of claim 1, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system.

26. (Previously Presented) The system of claim 1, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary or rechargeable battery, solar cell, fuel cell, mechanical, nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities / functions can be added as needed.

27. (Original) The system of claim 1, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products.

28. (Previously Presented) The system of claim 1, wherein the receiver or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate.

29. (Currently Amended) A method of charging or powering one or more devices or batteries by wireless power, comprising the steps of:

providing one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from ~~another~~ a charger coil placed close to the receiver coil and configured to provide power thereto, ~~or~~ and

a charger coil, provided within a charger, which transmits inductive power to ~~another~~ a receiver coil placed close to the charger coil and configured to receive power therefrom;

using a ~~one or more components including a ferromagnetic, ferrite, or other magnetic material or~~ switching layer having magnetic properties and covering the one or more receiver

coil or charger ~~coils~~ coil, so that, during charging or powering of ~~one or more devices or batteries~~ a device or battery, the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer is layered either

between the ~~one or more~~ receiver coil and a surface of the receiver, or

between the charger ~~coils~~ coil and a surface of the ~~other coil~~ charger,

to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including

wherein, when the ~~other~~ receiver coil is placed close to the ~~one or more receiver or~~ charger ~~coils~~ coil, the ~~ferromagnetic, ferrite, or other magnetic material's~~ switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to affect passage of a magnetic flux within a particular region ~~thereof~~ of the switching layer, including

~~to allow~~ guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil ~~in~~ within a particular region of the switching layer generally aligned both with the ~~other coil and the one or more~~ receiver coil and the ~~or~~ charger ~~coils~~ coil, while

providing ~~an amount of~~ electromagnetic shielding in regions of the switching layer other than the particular region.

30. (Currently Amended) The method of claim 29, wherein the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer is provided within

one or more wireless chargers or power supplies or the electronics, coils, magnetic material, or magnets therein, or

one or more wireless power receivers or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices or batteries.

31. (Currently Amended) The method of claim 29, wherein the one or more components ~~including the ferromagnetic, ferrite, or other magnetic material or~~ and the witching layer is used to provide a degree of position independence in charging or powering the one or more devices or batteries.

32. (Currently Amended) The method of claim 29, wherein the modifying the magnitude or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the

properties of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer so that it ~~acts as a switching layer, allowing~~ allows a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

33. (Currently Amended) The method of claim 32, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer locally on or near where the receiver coil is placed.

34. (Currently Amended) The method of claim 33, wherein the saturating or altering the magnetization curve of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

35. (Currently Amended) The method of claim 34, wherein the permanent magnet or electromagnet is incorporated behind, in front, around or at the center of the receiver or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ~~ferromagnetic, ferrite, or other magnetic material or~~ switching layer locally on or near where the receiver coil is placed.

36. (Currently Amended) The method of claim 34, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ~~ferrite or ferromagnetic or magnetic material or~~ switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

37. (Previously Presented) The method of claim 29, further comprising using one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices or batteries by wireless power.

38-39. (Canceled).

Remarks

This REQUEST FOR CONTINUED EXAMINATION and REPLY is in response to the Office Action mailed March 12, 2014.

I. Applicant's Interview Summary

Applicant would like to thank Examiner Yalkew Fantu for the courtesy of an interview with Karl Kenna on April 3, 2014, during the course of which interview the participants generally discussed the pending application. No agreement was reached between the parties. Applicant indicated they would file the present Reply in due course.

II. Summary of Examiner's Rejections

Prior to the Office Action mailed March 12, 2014, Claims 1-39 were pending in the application. In the Office Action, Claim 1 was rejected under the doctrine of nonstatutory obviousness-type double patenting as being unpatentable over Claim 1 of co-pending Application No. 13/709,937. Claims 1-39 were rejected under 35 U.S.C. 102(b) as being anticipated by Partovi et al (U.S. Publication No. 2007/0182367, hereinafter Partovi).

III. Summary of Applicant's Amendment

The present Reply amends Claims 1-9 and 29-36; and cancels Claims 38 and 39, leaving for the Examiner's present consideration Claims 1-37.

IV. Claim Rejections under Double Patenting

In the Office Action, Claim 1 was rejected under the doctrine of nonstatutory obviousness-type double patenting as being unpatentable over Claim 1 of co-pending Application No. 13/709,937.

Co-pending Application No. 13/709,937 is currently pending. As such, Applicant respectfully requests that the rejection of Claim 1 on the grounds of nonstatutory obviousness-type double patenting be held in abeyance, pending allowance of one or other application, at which point this rejection can be further addressed, including if necessary the filing of an appropriate Terminal Disclaimer.

V. Claim Rejections under 35 U.S.C. §102(b)

In the Office Action, Claims 1-39 were rejected under 35 U.S.C. 102(b) as being anticipated by Partovi (U.S. Publication No. 2007/0182367).

Claim 1

Claim 1 has been amended to recite:

1. (Currently Amended) A system for use in charging or powering one or more devices or batteries by wireless power, comprising:

one or more of

a receiver coil, associated with a receiver for use with a device or battery, which receives inductive power from a charger coil placed close to the receiver coil and configured to provide power thereto, and

a charger coil, provided within a charger, which transmits inductive power to a receiver coil placed close to the charger coil and configured to receive power therefrom;

a switching layer having magnetic properties and covering the one or more receiver coil or charger coil, so that, during charging or powering of a device or battery, the switching layer is layered either

between the receiver coil and a surface of the receiver, or

between the charger coil and a surface of the charger; and

wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to affect passage of ~~a~~ magnetic flux within a particular region of the switching layer, including

guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within a particular region of the switching layer generally aligned both with the receiver coil and the charger coil, while

providing electromagnetic shielding in regions of the switching layer other than the particular region.

Partovi describes a portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices is disclosed herein. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device. In some embodiments the receiver can also

comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device, or to communicate information or data to and from the pad. (Abstract).

In the Office Action, it was asserted that Partovi discloses a system for use in charging or powering one or more devices or batteries by wireless power, comprising one or more of a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom, one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while providing an amount of electromagnetic shielding in regions other than the particular region.

However, Applicant respectfully submits that Partovi does not disclose use of a switching layer having magnetic properties and covering the one or more receiver coil or charger coil, wherein one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil.

To more clearly recite the embodiment therein, Claim 1 has been amended to recite that, in accordance with an embodiment, one or more components are used to modify one or both the magnitude or phase of an electromagnetic field, provided by the charger coil, in one or multiple dimensions, including wherein, when the receiver coil is placed close to the charger coil, the switching layer's magnetic properties are locally modified, by one or more of a magnetic field of the receiver coil or charger coil, or by another magnetic component, to affect passage of magnetic flux within a particular region of the switching layer, including guiding the magnetic flux to provide localized power transfer from the charger coil to the receiver coil within a particular region of the switching layer generally aligned both with the receiver coil and the charger coil,

while providing electromagnetic shielding in regions of the switching layer other than the particular region.

Applicant respectfully submits that support for the proposed amendment is provided by Applicant's Specification, including, for example, at Figures 20, 21, 23 and 31, and the accompanying text of the application as originally filed.

In view of the above remarks, Applicant respectfully submits that Claim 1, as currently amended, is neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claim 29

The remarks provided above with regard to Claim 1 are herein incorporated by reference. Claim 29 has been amended similarly to Claim 1 to more clearly recite the embodiment therein. For similar reasons as provided above, Applicant respectfully submits that Claim 29, as currently amended, is likewise neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claims 2-28 and 30-39

Claims 38 and 39 have been canceled, rendering moot the rejection of these claims. Claims 2-28 and 30-37 depend from and include all of the features of one of Claims 1 or 29. Claims 2-28 and 30-37 are not addressed separately herein. However, Applicant respectfully submits that these claims are allowable at least as depending from an allowable independent claim, and further in view of the amendments to the independent claims, and the remarks provided above. Reconsideration thereof is respectfully requested.

VI. Conclusion

In view of the above amendments and remarks, it is respectfully submitted that all of the claims now pending in the subject patent application should be allowable, and reconsideration thereof is respectfully requested. The Examiner is respectfully requested to telephone the undersigned if he can assist in any way in expediting issuance of a patent.

The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 06-1325 for any matter in connection with this response, including any fee for extension of time, which may be required.

Respectfully submitted,

Date: June 27, 2014

By: /Karl F. Kenna /
Karl F. Kenna
Reg. No. 45445

Customer No.: 23910
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/352,096	Filing Date 01/17/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	06/27/2014	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 37	Minus	** 39	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/AJAY R. DAVID/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

23910 7590 03/12/2014

MEYER IP LAW GROUP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

EXAMINER	
FANTU, YALKEW	
ART UNIT	**PAPER NUMBER**
2859	

NOTIFICATION DATE	DELIVERY MODE
03/12/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

officeactions@meyerip.com
pctoa@meyerip.com

Office Action Summary	Application No. 13/352,096	Applicant(s) PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	Art Unit 2859	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11/15/2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-39* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-39* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *10/30/2013 and 11/26/2013*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

As per applicant's remarks of 11/12/2013, claims 1-39 are pending.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of

activities undertaken within the scope of a joint research agreement. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO internet Web site contains terminal disclaimer forms which may be used. Please visit http://www.uspto.gov/forms/. The filing date of the application will determine what form should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission.

Claim 1 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the co-pending application number 13/709,937. Although the claims at issue are not identical, they are not patentably distinct from each other because they both deal with powering and charging a mobile device or battery wirelessly or in a non-conductive way.

1. The examined claim 1 of the instant application is anticipated by the co-pending application of 13/709,937.

Claim 1 of the co-pending application No. **13/709,937**	Claim 1 of the instant application **13/352,096**
1. A system for providing positioning freedom, and support of different voltages, protocols, and power levels in a wireless power system, comprising: a base unit having one or more transmitter coils which transmit inductive power to a receiver coil placed close to the one or more transmitter coils and configured to receive power therefrom; one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more transmitter coils, so that, during charging or powering of a device or battery having the receiver coil, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more transmitter coils and the receiver	**1.** A system for use in charging or powering one or more devices or batteries by wireless power, comprising: one or more of a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom, one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic

coil, that modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the device or battery having the receiver coil is placed close to the base unit having the one or more transmitter coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux and allow power transfer within a particular region, generally aligned with the one or more transmitter coils and the receiver coil; and one or more components within the base unit or a mobile device for positioning freedom, and support of different voltages, protocols, and power levels including determining by the base unit, for the mobile device to be powered, a power protocol to be used and one or more voltage and power level requirements for the mobile device, and regulating, by the mobile device, power received at the receiver coil; wherein multiple mobile devices, batteries or receivers with different voltage or power level requirements can be simultaneously powered by the base unit.	material or layer is layered between the one or more receiver or charger coils and the other coil, which wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including to allow power transfer in a particular region, generally aligned both with the other coil and the one or more receiver or charger coils, while providing an amount of electromagnetic shielding in regions other than the particular region.

Claim 29 of the instant application is also similar to claim 1 of the co-pending application.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-39 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Partovi (US 2007/0182367).

2. **With respect to claims 1, 29 and 38**, Partovi discloses a system for use in charging or powering one or more devices or batteries by wireless power **(Figs. 1-26)**, comprising: one or more of

3. a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto **(Fig. 2, 114 and 160; figs. 1-4 and 15)**, or a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom **(Fig. 2, 112)**, one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, which wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions **(Para. # 0074)**, wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including **(Para. # 0051 and 0073)** to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while providing an amount of electromagnetic shielding in regions other than the particular region **(Para. # 0040-0041)**

4.

5. **With respect to claims 2 and 30,** Partovi discloses wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within one or more wireless chargers or power supplies and/or the electronics, coils, magnetic material, or magnets therein **(Figs. 2, 112)**, and/or one or more wireless power receivers and/or the electronics, coils, magnetic materials, or magnets therein **(Fig. 2, 114)**; and used in charging or powering the one or more devices and/or batteries **(Para. # 0050 and 0051)**.

6. **With respect to claims 3 and 31,** Partovi discloses wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is used to provide a degree of position independence in charging or powering the one or more devices and/or batteries **(Para. # 0060)**.

7. **With respect to claims 4 and 32,** Partovi discloses wherein the modifying the magnitude and/or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area **(Para. # 0058 and 0059)**.

8. **With respect to claim 5,** Partovi discloses wherein the ferromagnetic, ferrite, or other magnetic material or layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron), carbonyl iron, ferrites, vitreous metals, alloys of

Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof **(Para. # 0013)**.

9. **With respect to claims 6 and 33,** Partovi discloses , wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed **(Fig. 10, SW 268; Para. # 0110-0117)**.

10. **With respect to claims 7 and 34,** Partovi discloses wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC and/or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof **(Para. # 0096)**.

11. **With respect to claims 8 and 35,** Partovi discloses wherein the permanent magnet and/or electromagnet is incorporated behind, in front, around or at the center of the receiver and/or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed **(See Figs, 1, and 3-4)**.

12. **With respect to claims 9 and 36,** Partovi discloses, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with

appropriate magnetization orientation and strength that can provide sufficient DC and/or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer **(Para. # 0013; Figs. 11 and 17)**.

13. **With respect to claims 10, 11 and 37,** Partovi discloses, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices and/or batteries by wireless power **(Para. # 0096);** the power at the devices and/or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices and/or the batteries **(Para. # 0081 and 0082)**.

14. **With respect to claim 12,** Partovi discloses, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof **(Para. # 0081; see also Fig. 11)**.

15. **With respect to claims 13 -16** Partovi discloses, wherein the power at the devices and/or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, and power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters **(Para. # 0070)**.

16. **With respect to claim 17** Partovi discloses, wherein the chargers and/or receivers include one or more microcontrollers or programmable parts and/or memory **(Fig. 11, 204 (MCU2); Para. # 0125)**.

17. **With respect to claim 18,** Partovi discloses wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil and/or load modulation or through an RF or optical link or through RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), etc. or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof **(Para. # 0125)**.

18. **With respect to claim 19,** Partovi discloses wherein the presence of the one or more receivers is detected by the one or more chargers and/or power supplies and/or causes a change in the operating behavior or characteristics of the chargers and/or power supplies **(Para. # 0049)**.

19. **With respect to claim 20,** Partovi discloses wherein, the chargers and/or receivers may consist of one set of electronics and/or coils or several sets of similar or dissimilar electronics and/or coils to provide flexibility in wirelessly charging devices and/or batteries at different voltages, powers, current levels, geometries or functions and/or communication and regulation or detection protocols **(See Figs. 2-5; Para. # 0060)**.

20. **With respect to claim 21,** Partovi discloses wherein, the chargers and/or receivers may include shielding materials such as ferromagnetic or other magnetic

materials and/or metal or other conductive layers, and/or thin metal layers covering a portion or all of the charger and/or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system **(Para. # 0040 and 0086)**.

21. **With respect to claims 22-24 and 39,** Partovi discloses, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system and wherein one or more repeater antennas or coils and/or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets and/or electromagnets are used to extend the range between the charger and receiver while controlling the emissions **(Para. # 0080)**.

22. **With respect to claim 25,** Partovi discloses, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, etc., airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, etc., cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, etc., industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system **(Para. # 0096)**.

23. **With respect to claim 26,** Partovi discloses, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary (non-rechargeable) or rechargeable battery, solar cell, fuel cell, mechanical (hand crank, wind source, etc.), nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities/functions can be added as needed **(Para. # 0014; Fig. 18, 356)**.

24. **With respect to claim 27,** Partovi discloses, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or

advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products **(Para. # 0096)**.

25. **With respect to claim 28,** Partovi discloses, wherein the receiver and/or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device etc. to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate **(Para. # 0061)**.

RESPONSE TO ARGUMENTS

26. Applicant's arguments filed on 11/15/2013 have been considered but are ineffective to overcome the reference mentioned in the office action (See rejection above).

27. Applicant generally describes or argues that Partovi "…as currently amended, is neither anticipated nor obvious in view of the cited references … "

28. As disclosed in Partovi's reference, the newly amended limitation is also disclosed as indicated in the office action above. The newly amended claims, such as claim 1 limitations, as shown in each paragraph, connected or used an "or" option, and the reference is only addressed one of the element in the list of elements indicated to multiple use of "or" gives an alternative options to claiming language. There is no particular argument specific to the reference used in the rejection. As for the general

statement described above, the Partovi reference discloses the limitations as indicated in the office action.

29. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

30. A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to YALKEW FANTU whose telephone number is (571)272-8928. The examiner can normally be reached on M-F: 7 - 4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, DREW A. DUNN can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US0

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7952322		2011-05-31	Partovi et al.	
	2	7948208		2011-05-24	Partovi et al.	
	3	7443135		2008-10-28	Cho	
	4	5367242		1994-11-22	Hulman	
	5	7915858		2011-03-29	Liu et al.	
	6	4311953		1982-01-19	Fukuda et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Y.F./

Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	1	20060202665		2011-03-10	Hsu		
	2	20060108977		2006-05-25	Kagermeier et al.		
	3	20100081473		2010-04-01	Chatterjee et al.		

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Receipt date: 10/30/2013	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

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	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320	108,139,150	9/5/2013	YF
455	all	9/5/2013	

SEARCH NOTES		
Search Notes	Date	Examiner
320/109,139,150;455/all with text search was conducted	9/5/2013	YF
Inventor's search in PALM and eDAN was conducted	9/5/2013	YF
EAST Search (See Printout)	9/5/2013	YF
Related applications search was conducted	9/5/2013	YF
an updsated search was conducted	3/03/2014	YF

INTERFERENCE SEARCH			
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	Attorney Docket Number	AFPA-01032US0	

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	Examiner Name	Fantu, Yalkew	
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	Examiner Name	Fantu, Yalkew	
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	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

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	1	WO03096512A2	WO		2003-11-20	Splashpower Limited		☐
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	1	2004030176	WO		2004-04-08	Splashpower Limited		☐

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	Attorney Docket Number	AFPA-01032US0

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Name/Print	Karl F. Kenna	Registration Number	45,445

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	Examiner	Art Unit
	YALKEW FANTU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
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☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/05/2013								
	1	✓								
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	39	✓								

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	7	5434493		1995-07-18	Woody et al.	
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Receipt date: 10/30/2013	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20100007307		2010-01-14	Barrman et al.	
	2	20080272889		2008-11-06	Symons et al.	
	3	20100277121		2010-11-04	Hall et al.	
	4	20110012556		2011-01-20	Lai	
	5	20020093309		2002-07-18	Peele et al.	
	6	20100201313		2010-08-12	Vorenkamp et al.	
	7	20100213895		2010-08-26	Keating et al.	
	8	20100327804		2010-12-30	Takahashi et al.	
	9	20110057606		2011-03-10	Saunamaki et al.	
	10	20070139000		2007-06-21	Kozuma	

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Receipt date: 10/30/2013	Application Number	13352096	13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2012-01-17	
(Not for submission under 37 CFR 1.99)	First Named Inventor	Partovi, Afshin	
	Art Unit	2859	
	Examiner Name	Fantu, Yalkew	
	Attorney Docket Number	AFPA-01032US0	

	11	20110050164		2011-03-03	Partovi et al.		

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	JP/2006-246633A	JP		2006-09-14	Kamitsuma Yosuke et al.		☐
	2	JP/2006-500894A	JP		2006-01-05	Beart et al.		☐
	3	2011/156768 A2	WO		2011-12-15	Partovi		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report dated June 14, 2013, International Application No. PCT/US2013/033352 filed March 21, 2013, 3 pages	☐

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Examiner Signature	/Yalkew Fantu/	Date Considered	03/05/2014

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Receipt date: 10/30/2013	Application Number	13352096 13352096 - GAU: 2859
INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Not for submission under 37 CFR 1.99)**	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13709937
Filing Date	2012-12-10
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US1

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7915858		2011-03-29	Liu	
	2	8169185		2012-05-01	Partovi	
	3	4800328		1989-01-24	Bolger	
	4	5367242		1994-11-22	Hulman	
	5	7554316		2009-06-30	Stevens	
	6	7151357		2006-12-19	Xian	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13709937
	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	1	20070178945		2007-08-02	Cook	
	2	20050007067		2007-02-08	Baarman	
	3	20100007307		2010-01-14	Baarman	
	4	20080272889		2008-11-06	Symons	
	5	20100277121		2010-11-04	Hall	
	6	20100127660		2010-05-27	Cook	
	7	20110012556		2011-01-20	Lai	
	8	20100081473		2010-04-01	Chatterjee	
	9	20090284227		2009-11-19	Mohammadian	
	10	20090049554		2009-02-19	Vuong	
	11	20060106965		2006-05-18	Falcon	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13709937
	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	12	20100081473		2010-04-01	Chatterjee		

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,548, November 20, 2013, 5 pages.	☐
	2	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/115,811, September 23, 2013, 17 pages.	☐
	3	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,584, September 13, 2013, 16 pages.	☐
	4	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/158,134 January 22, 2014, 43 pages.	☐
	5	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,827 February 5, 2014, 28 pages.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13709937
	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

	6	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/708,520 February 5, 2014, 8 pages.	☐
	7	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/710,062, February 27, 2014, 9 pages.	☐
	8	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/710,017, February 27, 2014, 11 pages.	☐
	9	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/709,983, February 27, 2014, 10 pages.	☐
	10	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U. S. Patent Application No. 13/115,811, March 4, 2014, 15 pages.	☐
	11	UNKNOWN AUTHOR, System Description Wireless Power Transfer, Volume 1: Low Power Part 1: Interface Definition, Version 1.0, July 2010, 83 pages.	☐
	12	THE PATENT OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA, 2nd Office Action for Chinese Patent Application No. 200880023854.4, April 15, 2013, 4 pages.	☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13709937
	Filing Date	2012-12-10
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl F. Kenna/	Date (YYYY-MM-DD)	2014-03-06
Name/Print	Karl F. Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	18395759
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	06-MAR-2014
Filing Date:	17-JAN-2012
Time Stamp:	19:09:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	6167
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Other Reference-Patent/App/Search documents	Office_Action_13115811_030414.pdf	530236 8dd7840345b1969ad12962b15f57e7a22283c4f0	no	15
Warnings:					
Information:					
2	Other Reference-Patent/App/Search documents	Office_Action_13709983_022714.pdf	398154 20b6f93510f4d9f10ce7c7f74c351b2bd1de68b2	no	10
Warnings:					
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3	Other Reference-Patent/App/Search documents	Office_Action_13710017_022714.pdf	403368 bdac8eda9a1e46c7b797c4190c5a712ce75f382b	no	11
Warnings:					
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4	Other Reference-Patent/App/Search documents	Office_Action_13710062_022714.pdf	374451 3d6302cadc33628ea7fd2e4527b6deee4c732081	no	9
Warnings:					
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5	Other Reference-Patent/App/Search documents	33_Office_Action_13708548_112013.pdf	166335 25ff229bc3e22aff05c3aade198200b54f67872f	no	5
Warnings:					
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6	Other Reference-Patent/App/Search documents	34_Office_Action_13115811_092313.pdf	636644 35296e72678a5b0255672996fa32515dcea116a4	no	17
Warnings:					
Information:					
7	Other Reference-Patent/App/Search documents	35_Office_Action_13708584_091313.pdf	536292 6a1c98a0c706b4d2003f4eaefe109d1b679ccac0	no	16
Warnings:					
Information:					
8	Other Reference-Patent/App/Search documents	Office_Action_13158134_012214.pdf	1746422 959da351a32eb8b5d8e46eb86c092e0d23adb001	no	43

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9	Other Reference-Patent/App/Search documents	Office_Action_13708827_020514.pdf	1143153 fdc54c1be2791f718e7216323de8d7cbd1d254c4	no	28
Warnings:					
Information:					
10	Other Reference-Patent/App/Search documents	Office_Action_13708520_020514.pdf	297034 ae82aed12a88ab6f9cb60ba83c470601a3819a9e	no	8
Warnings:					
Information:					
11	Transmittal Letter	afpa_1032us0_IDS_Trans_030614.pdf	121483 076293e3fc0741e37c7e520f278d7712279ae5dc	no	2
Warnings:					
Information:					
12	Other Reference-Patent/App/Search documents	afpa_1013cn0_2nd_OA.pdf	262095 f673dbfef695a8f5e6fc70ec6968a01b36692ba7	no	4
Warnings:					
Information:					
13	Non Patent Literature	41_UnknownAuthor_WirelessPowerSpecificationPart1.pdf	2657502 78189ec3c3b07cf8e3fdba60b0fc9045f161d59e	no	83
Warnings:					
Information:					
14	Information Disclosure Statement (IDS) Form (SB08)	afpa_1032us1_030614_IDS.pdf	968528 d21d9596000730bae0a79f2bc63f6c1df83df9a3	no	6
Warnings:					
Information:					
15	Fee Worksheet (SB06)	fee-info.pdf	30615 3ad9cbcfdd5b556143eba152490e52b009cd0e8d	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	10272312	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	PATENT APPLICATION
Inventor(s): Partovi, Afshin et al.	
Appl. No.: 13/352,096	Art Unit: 2859
Confirm. No.: 4453	Examiner: Fantu, Yalkew
Filed: January 17, 2012	
Title: SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

This statement should be considered because:

__ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.

-- AND *(check at least one of the following)* --

__ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

MEYER IP LAW GROUP

Date: March 6, 2014

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

Customer No. 23910
MEYER IP LAW GROUP
410 Pacific Avenue
San Francisco, California 94133
Telephone: (415) 362-3800

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

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	1	2004030176	WO		2004-04-08	Splashpower Limited		☐

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	Attorney Docket Number	AFPA-01032US0

	1	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/708, 548, November 20, 2013, 5 pages.	☐
	2	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/115, 811, September 23, 2013, 17 pages.	☐
	3	UNITED STATES PATENT AND TRADEMARK OFFICE, Office Action for U.S. Patent Application No. 13/708,584, September 13, 2013, 16 pages.	☐
	4	THE PATENT OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA, 2nd Office Action for Chinese Patent Application No. 200880023854.4, April 15, 2013, 4 pages.	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl F. Kenna/	Date (YYYY-MM-DD)	2013-11-26
Name/Print	Karl F. Kenna	Registration Number	45,445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Inventor(s): Partovi, Afshin et al. Appl. No.: 13/352,096 Confirm. No.: 4453 Filed: January 17, 2012 Title: SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	PATENT APPLICATION Art Unit: 2859 Examiner: Fantu, Yalkew **Customer No. 23910**

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

___ As allowed under 37 CFR §1.98(d), copies of cited documents noted with an asterisk are not enclosed because they were previously submitted in U.S. Patent Application No. , which is relied on for an earlier effective filing date under 35 USC §120, and which included an Information Disclosure Statement that complies with 37 CFR §1.98(a) through (c).

This statement should be considered because:

_ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

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-- AND *(check at least one of the following)* --

__ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

FLIESLER MEYER LLP

Date: November 26, 2013

By: /Karl Kenna/
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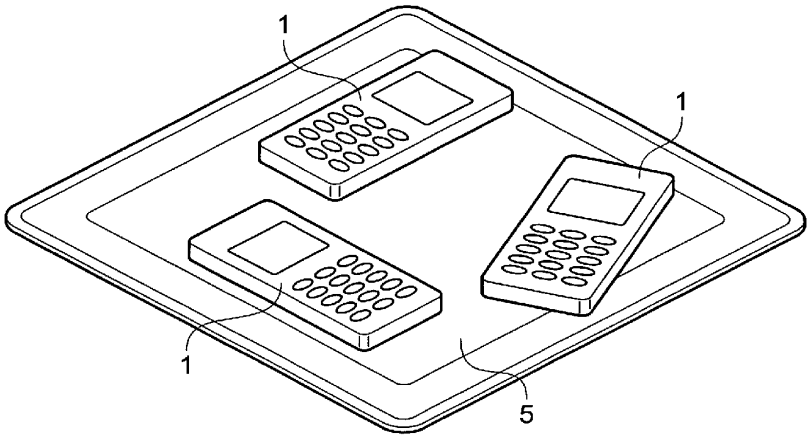
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Declaration under Rule 4.17:
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— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: IMPROVEMENTS RELATING TO RETENTION OF RECHARGEABLE DEVICES



(57) Abstract: There is disclosed a system and method for retaining portable rechargeable devices to recharging stations wherein one or other or both of the recharging station and the portable device are provided with connecting means adapted for temporary releasable connection of the two. This is particularly advantageous when used with recharging stations, which permit the device to be recharged in multiple places on the recharging station, providing a positive means of retaining the device. This is particularly advantageous if the recharging station is to be used in a mobile environment such as a car, or on a wall or ceiling.

WO 2004/030176 A2

IMPROVEMENTS RELATING TO RETENTION OF RECHARGEABLE DEVICES

This invention relates to a new system for temporary attachment of portable rechargeable devices to recharging stations, and a method of temporarily attaching portable rechargeable devices to their charging units.

Today's portable rechargeable devices are typically recharged by temporarily connecting them to a recharger via a mating plug-in or clip-on connection. An example is the typical "floating wire" connection between a mains charger and a mobile phone (see Figure 1).

The connection serves two purposes:

1) It electrically connects the device to its recharger, allowing transfer of power.
2) It mechanically connects the device to its recharger, in a way which retains it securely against forces from accidental knocks and the like, but is easily removable by the user. This mechanical connection thus allows recharging to continue reliably until the user physically breaks the connection, and in some cases may also keep the device conveniently available to the user. Examples of the latter include the recharging "cradle" for the Palm Pilot® and the drop-in "hands-free" car socket for a mobile phone.

Some of today's portable rechargeable devices are charged by a non-contact means, for example by inductive power transfer. An example is the Braun® electric toothbrush, where the toothbrush must be accurately located onto a spigot on the recharger, which retains it. However, the spigot serves only as a positioning means and no additional force is required to separate the toothbrush from the charger other than that required to lift the toothbrush against gravity.

But some of these non-contact charging means do not require the device and the recharger to be so precisely aligned. Such solutions may offer significant freedoms for the designer and for the user. For example the recharging means may be a

laminar surface upon which a device can conveniently be placed, in any position and any orientation, as disclosed, for example, in the present applicant's UK patent application no. 01283175 of 27 November 2001. This avoids the limitations of the positive mechanical connection (e.g. cradles, connectors, clips) required by other charging solutions, and so is more convenient to the user because it is easier to place a device casually anywhere on a surface than precisely to align it with a mechanical socket. Dispensing with the need for mechanical location may also allow other benefits, such as the ability simultaneously to recharge multiple units, and/or to recharge devices of different types on the same recharger.

However in some situations, the lack of positive mechanical retention of such a surface may be a disadvantage for users. For example:

- A flat recharging surface must be kept substantially horizontal to prevent devices from sliding off the surface. But this requirement may be inconvenient to the user – for example putting the surface on a desk may occupy otherwise-useful space. Freeing-up the surface so that it can be placed in any orientation would give the user much more flexibility to use otherwise-useless space – for example to mount the surface vertically on a wall, or even on the inside of a car roof.
- If a mobile recharging surface is likely to be subject to movement (e.g. a tabletop that may get knocked, or in a car, aeroplane or spacecraft), the devices may fall off.

Clearly, it would be convenient to remove these potential disadvantages whilst preserving the benefits of freedom of design and use of such surface-based charging systems.

According to a first aspect of the present invention there is provided a system for wireless powering or recharging of rechargeable devices, the system comprising a charging unit and a power receiving device, wherein one or other or both of the charging unit and the power receiving device is provided with connecting means

adapted for temporary releasable connection of the power receiving device to the charging unit, the connecting means not being an electrical connection.

According to a second aspect of the invention, there is provided a system for wireless powering or recharging of rechargeable devices, the system comprising a charging unit and a power receiving device, wherein one or other or both of the charging unit and the power receiving device is provided with connecting means adapted for temporary releasable connection of the power receiving device to the charging unit in at least two positions and/or rotations of the device relative to the charging unit.

According to a third aspect of the invention, there is provided a charging unit adapted for wireless powering or recharging of a power receiving device, wherein the charging unit is provided with connecting means for temporary releasable connection of a power receiving device thereto, the connecting means not being an electrical connection.

According to a fourth aspect of the present invention, there is provided a power receiving device adapted for wireless powering or recharging by a charging unit, wherein the power receiving device is provided with connecting means for temporary releasable connection of a charging unit thereto, the connecting means not being an electrical connection.

According to a fifth aspect of the present invention, there is provided a method of wireless powering or recharging of a power-receiving device which comprises temporarily attaching the device to a charging unit, said method further comprising utilising a releasable temporary connecting means attached to the charging unit and/or the device, wherein said connecting means is adapted to enable the charging unit and the device to be attached in one or more positions and/or orientations relative to each other, the connecting means not being an electrical connection.

Accordingly, embodiments of the present invention provides a system for powering or recharging rechargeable devices which has several advantages over the prior art.

Such a system is advantageous because it provides convenient retention of the device to the charging unit while still preserving the convenience of being able to simple drop or press the device against the charging unit, thus greatly expanding the number of usable places for the user to locate the charging unit.

It is to be appreciated that embodiments of the present invention are distinguished over existing systems and methods in that there is provided a combination of wireless power transfer and a temporary releasable connection. Ordinary wired power transfer systems generally incorporate a releasable physical connection such as a plug and socket with physical mating means, but these are provided in order to secure a good electrical connection. Ordinary wireless power transfer systems, on the other hand, do not incorporate physical, temporary releasable physical connections, since these have hitherto been seen as disadvantageous in a wireless system. For the avoidance of doubt, it is hereby stated that the expression "temporary releasable connection" is intended to cover connections that require a predetermined degree of force for separation. In other words, a simple location spigot such as found in wireless electric toothbrush chargers is not intended to be covered by the term "temporary releasable connection", since no particular force is required to separate the toothbrush from the charger. Embodiments of the present invention therefore combine a releasable physical connection with a wireless power transfer system in a counterintuitive way that is not suggested by the prior art.

Preferably, the power receiving device is portable. Examples of portable power receiving devices include mobile telephones, lap-top computers, and personal digital assistants (PDA).

Examples of relative positions and/or orientations in which the charging unit and device may be attached include:

- Any position in one translational dimension.
- Any position in an orthogonal translational dimension.
- Any rotation about one plane.
- Any rotation about a plane orthogonal to the first.

- Any combination of the above.

It will be understood that the term "recharging" may also be taken to mean "powering" for devices which do not have substantial rechargeable batteries, and therefore can only operate while in proximity to the recharger, for example lightbulbs, fans etc.

Preferably, the charging unit is capable of charging multiple types of device.

Preferably, the charging unit is capable of charging multiple devices simultaneously.

Preferably, the device is capable of being charged by multiple types of charging unit.

Advantageously, the connecting means comprises a means added to the surface of the device and/or the charging unit. Examples of this type of connecting means include hook-and-eye fasteners (such as Velcro™), suckers, reusable, self-adhesive glue (as used in, for example, Post-It™ notes) or high stiction/friction surfaces such as a rubbery or rough surface. The means may cover only a small portion of the surface, or for example a complete face, or the entire device and/or charging unit.

Alternatively or in addition, the connecting means may comprise a shaping of the surface of the device and/or the charging unit. Examples of the connecting means used in this embodiment of the invention include bumps, ridges or grooves on the surface of either the charging unit or the device. For example, the connecting means may comprise a plurality of projections on one surface and a plurality of corresponding holes on another surface, for example as used in Lego® building blocks. Alternatively, spiked systems such as those exemplified by Stickle-Bricks(R) or spikes with corresponding holes can be used as connecting means. Hook-and-eye shapings may also be used as connecting means.

Alternatively or in addition, the connecting means may comprise means added beneath the surface of the device and/or the charging unit, said means being capable

of acting at a distance. Examples of the connecting means in this embodiment of the invention may include permanent magnets, and arrays of such, electromagnets, and arrays of such or possibly electrostatically-charged terminals.

Alternatively or in addition, only the charging unit, and not the device comprises a connecting means. In this embodiment, examples of the connecting means include pockets. For example, the charging unit may be positioned so that it hangs vertically on a wall and the connecting means of the charging unit may be multiple pockets to receive one or more devices. Further examples of the connecting means of the charging unit may include elastic bands to strap down the device(s), or indentations or contours on the charging unit. Examples of such indentations or contours on the charging unit include a ridge designed to hold standard AA cells for example or a bowl shape indentation to retain a variety of differently-shaped devices.

In one embodiment, the connecting means may be adapted to enable the charging unit and the device to be mated in a large number of different relative orientations, for example, such that the possible relative location and rotation of the device and charging unit are quantised into so many possibilities that there is no limitation visible to the user. For example, the connecting means could be Velcro®, which would enable mating between the charging unit and the device to occur in almost any position and rotation relative to each another. Alternatively, the connecting means may be adapted to enable the charging unit and the device to be mated in a limited number of relative orientations only. For example, the connecting means may comprise a plurality of projections on one surface and a plurality of corresponding holes on another surface, such as Lego® building blocks, which may only allow mating between the charging unit and the device in a maximum of four possible rotations and at a finite number of discrete locations).

In particular, there may only be one possible relative orientation in which the device and charging unit may be mated together. For example, a manufacturer selling a device capable of being recharged by relatively large recharging surfaces may nevertheless choose to include with the device a small, low-cost recharging surface

which precisely fits the device, and is retained to it, for example by 4 holes in the device and 4 corresponding bumps in the surface. Thus the user can "clip" the surface of the charging unit to the device in a manner similar to today's wired charging connections, but the device is capable of being used more flexibly with larger charging unit surfaces. In this case, the surface may be incorporated directly into a mains-powered charging unit, providing a low-cost "no wires" easy-travel solution onto which a device can be conveniently pressed.

The connecting means of the device may correspond to the connecting means of the charging unit, such that devices will attach to charging units, but not devices to devices nor charging units to charging units. An example of a connecting means of this embodiment is Velcro® which comes in "male" and "female" types which stick to each other but not to themselves. Thus, the connecting means of the device may be Velcro® of the male type, and the connecting means of the charging unit may be Velcro® of the female type.

Alternatively, the connecting means of the charging unit may be identical to the connecting means of the device. This embodiment will be capable of attaching to itself and may be used on all devices and charging units. An example is a reusable tacky adhesive such as the glue used in Post-It® notes. A potential advantage of this is in the case where a device is capable of performing the function of a charging unit to another device.

In a yet further embodiment, there may be several different classes of pairs of types of connecting means, with each pair class attaching only to the other of the pair. A potential advantage of this is in the case that not all charging units are capable of recharging all devices – a user can then immediately feel that a device is not "sticking" to a (or part of a) charging unit and will not be recharged by it.

In addition to the embodiments described above, the connecting means may in addition possess aesthetic or visual qualities to conveniently inform users that a device is capable of being recharged, or a charging unit is available to recharge, or if

a certain (part of the) charging unit is more appropriate for charging a particular class of device in the manner described above.

Examples of these qualities include giving the connecting means:

- A specific reflective colour (e.g. Pantone® 123)
- A specific emissive colour (e.g. a bright red light)
- A fluorescent or luminous colour
- A specific "sheen" (e.g. glittering metallic silver)
- A specific repeated pattern (e.g. triangles)
- A specific logo design or text (e.g. "Zap™")
- An outline of the area in which a device may receive power
- A texture, which may optionally be recognisable by touch alone (e.g. fuzzy)
- A material

or combinations of the above.

These aesthetic qualities may even by used to inform users of the presence of devices or charging units in places where they would not otherwise suspect them, for example a charging unit embedded within part of a tabletop.

The aesthetic qualities may change their appearance or touch depending on the state of the device and/or the charging unit. For example the surface of a device and/or charging unit may change colour when it is powered-on, or the device is in need of recharging, or is recharging, or is recharged, or is in need of attention (for example a mobile phone device receiving an incoming call).

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

For a better understanding of the present invention and to show it may be carried into effect, reference shall now be made, by way of example, to the accompanying drawings, in which:

FIGURE 1 shows an example of a prior art recharging connection;

FIGURE 2 shows an embodiment of the present invention; and

FIGURE 3 shows an alternative embodiment of the present invention.

Referring to Figure 3, there is shown a power receiving device 1, in this embodiment the device is a mobile phone. The mobile phone 1 has a connecting means 3 attached to the back of the phone. In this embodiment the connecting means 3 of the device 1 is a patch of self-adhesive Velcro® of the "male" type. This is black and slightly prickly, informing the user that the phone may be charged on a charging surface. Figure 3 also shows a charging unit 5. In this embodiment the charging unit 5 is an inductive recharging pad. On the surface 7 of the pad 5 is attached a patch of self-adhesive Velcro® of the "female" type 9, which acts as the connecting means of the charging unit. This is black and slightly fuzzy, informing the user that the pad may charge devices.

To mate the phone 1 and the pad 5 temporarily, the user simply presses the phone 1 onto the pad 5 (or drops it, if the pad is below the phone) and the Velcro® 3, 9 holds the phone in place on the pad . The phone can be placed onto the pad in any orientation and in any position, and is held securely by the Velcro®. Once the phone and the pad are attached in this way, the phone can receive power from the pad and so can be recharged. When the phone 1 has been recharged fully, or before if desired, it can be removed from the pad 5 easily by the user at any time, simply by pulling it away. This disengages the Velcro® 3 from the Velcro® 9.

Figure 2 shows an alternative embodiment wherein a plurality of devices 1, (in this

embodiment, mobile phones) are attached to a charging unit 5 (in this embodiment, a pad). Figure 2 shows that, in this embodiment, the mobile phone 1 and the pad 5 can be mated at various different orientations to the each other and also the mobile phones can be positioned at different orientations relative to the other mobile phones 1.

CLAIMS:

1. A system for wireless powering or recharging of rechargeable devices, the system comprising a charging unit and a power receiving device, wherein one or other or both of the charging unit and the power receiving device is provided with connecting means adapted for temporary releasable connection of the power receiving device to the charging unit, the connecting means not being an electrical connection.

2. A system as claimed in claim 1, wherein the connecting means is adapted for temporary releasable connection of the power receiving device to the charging unit in at least two positions and/or rotations of the device relative to the charging unit.

3. A system as claimed in claim 1 or 2, wherein the connecting means is selected from a group comprising: hook-and-eye fasteners, suckers, reusable self-adhesive glue, high stiction/friction surfaces, a shaped recess or projection or plurality thereof, a permanent magnet or array of permanent magnets, an electromagnet or array of electromagnets, and electrostatically-charged terminals.

4. A charging unit adapted for wireless powering or recharging of a power receiving device, wherein the charging unit is provided with connecting means for temporary releasable connection of a power receiving device thereto, the connecting means not being an electrical connection.

5. A charging unit as claimed in claim 4, wherein the connecting means is adapted for temporary releasable connection of the power receiving device to the charging unit in at least two positions and/or rotations of the device relative to the charging unit.

6. A charging unit as claimed in claim 4 or 5, wherein the connecting means is selected from a group comprising: hook-and-eye fasteners, suckers, reusable self-adhesive glue, high stiction/friction surfaces, a shaped recess or projection or

plurality thereof, a permanent magnet or array of permanent magnets, an electromagnet or array of electromagnets, and electrostatically-charged terminals.

7. A power receiving device adapted for wireless powering or recharging by a charging unit, wherein the power receiving device is provided with connecting means for temporary releasable connection of a charging unit thereto, the connecting means not being an electrical connection.

8. A power receiving device as claimed in claim 7, wherein the connecting means is adapted for temporary releasable connection of the power receiving device to the charging unit in at least two positions and/or rotations of the device relative to the charging unit.

9. A power receiving device as claimed in claim 7 or 8, wherein the connecting means is selected from a group comprising: hook-and-eye fasteners, suckers, reusable self-adhesive glue, high stiction/friction surfaces, a shaped recess or projection or plurality thereof, a permanent magnet or array of permanent magnets, an electromagnet or array of electromagnets, and electrostatically-charged terminals.

10. A method of wireless powering or recharging of a power-receiving device which comprises temporarily attaching the device to a charging unit, said method further comprising utilising a releasable temporary connecting means attached to the charging unit and/or the device, wherein said connecting means is adapted to enable the charging unit and the device to be attached in one or more positions and/or orientations relative to each other, the connecting means not being an electrical connection.

11. A method according to claim 10, wherein the connecting means is adapted for temporary releasable connection of the power receiving device to the charging unit in at least two positions and/or rotations of the device relative to the charging unit.

12. A method according to claim 10 or 11, wherein the connecting means is selected from a group comprising: hook-and-eye fasteners, suckers, reusable self-adhesive glue, high stiction/friction surfaces, a shaped recess or projection or plurality thereof, a permanent magnet or array of permanent magnets, an electromagnet or array of electromagnets, and electrostatically-charged terminals.

13. A system for wireless powering or recharging of rechargeable devices, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

14. A charging unit adapted for wireless powering or recharging of a power receiving device, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

15. A power receiving device adapted for wireless powering or recharging by a charging unit, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

16. A method of wireless powering or recharging of a power-receiving device, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

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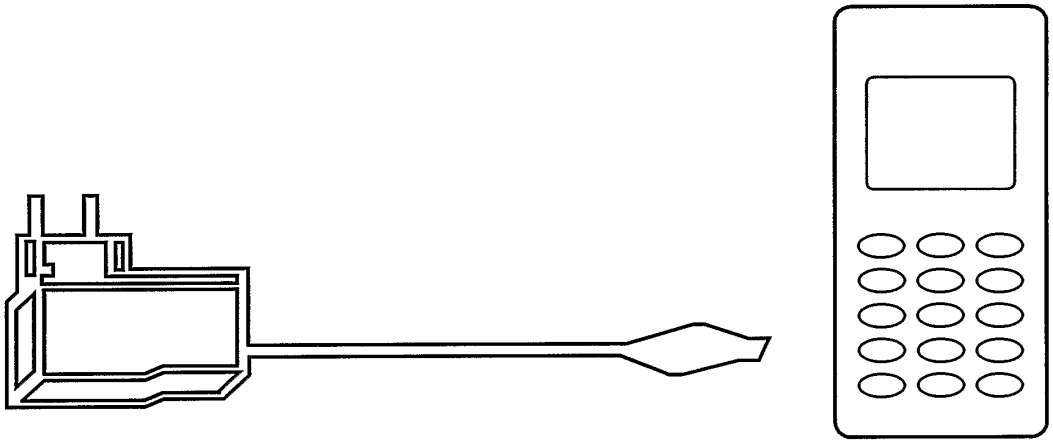


Fig. 1

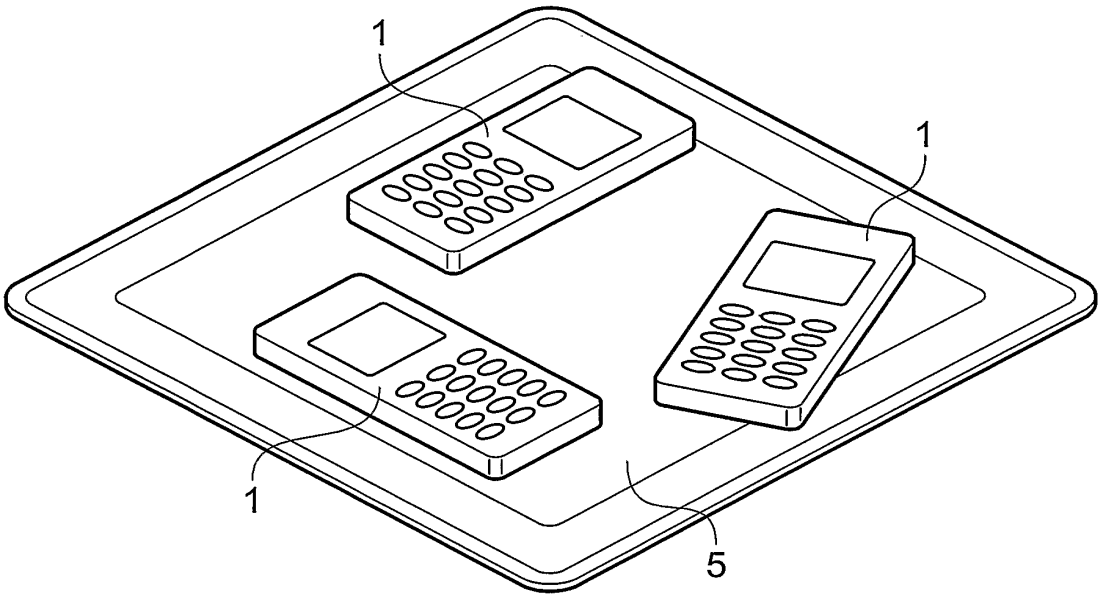


Fig. 2

3/3

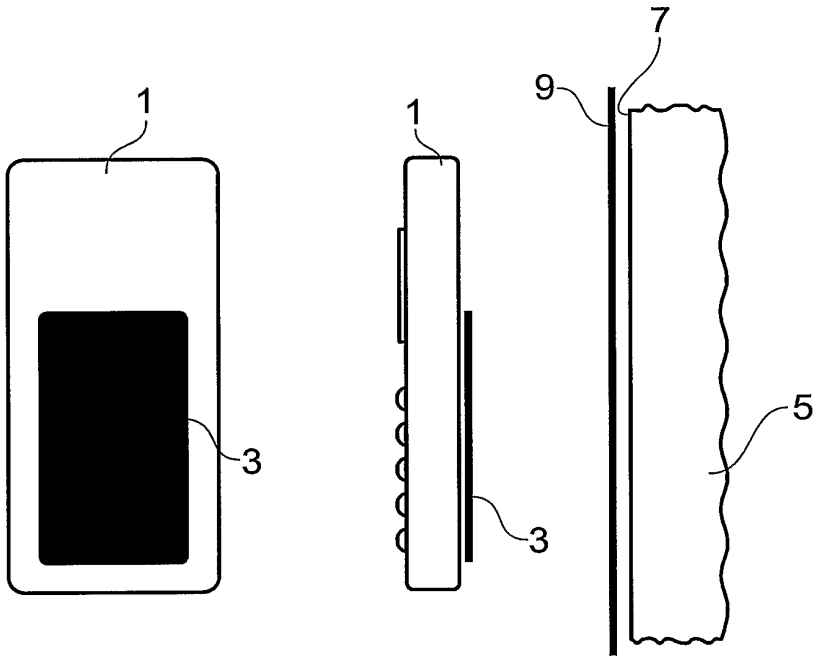


Fig. 3

Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	17500663
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	26-NOV-2013
Filing Date:	17-JAN-2012
Time Stamp:	18:25:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	6831
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	afpa_1032us0_IDS_1113.pdf	796636 5eb422ad524335b209766ab5467d4c0aa42325b1	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
2	Transmittal Letter	afpa_1032us0_IDS_Trans_112613.pdf	121794 d785364adea640a1422afd845d715253d11b9066	no	2
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Information:					
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5	Other Reference-Patent/App/Search documents	34_Office_Action_13115811_092313.pdf	636644 35296e72678a5b0255672996fa32515dcea116a4	no	17
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7	Other Reference-Patent/App/Search documents	afpa_1013cn0_2nd_OA.pdf	262095 f673dbfef695a8f5e6fc70ec6968a01b36692ba7	no	4
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Warnings:					
Information:					
		Total Files Size (in bytes):	5906026		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION	
Inventor(s):	Partovi, Afshin		
Appln. No.:	13/352,096	Art Unit:	2859
Confirm. No.:	4453	Examiner:	Fantu, Yalkew
Filed:	January 17, 2012		
Title:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	**Customer No. 23910**	

REPLY TO OFFICE ACTION UNDER 37 C.F.R. §1.111

Mail Stop AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This REPLY is in response to the Office Action mailed September 11, 2013.

Amendments

Please amend the above-identified application as follows:

Amendments to the Claims begin on Page 2.

Remarks begin on Page 10.

In the Claims:

Please amend Claims 1-5, 7-11, 13-21, 23-26, 28-32 and 34-39, as shown below. Applicant respectfully reserves the right to prosecute any originally presented or canceled claims in a continuing or future application.

1. (Currently Amended) A system for use in charging [[and/or]] or powering one or more devices [[and/or]] or batteries by wireless power, comprising:

one or more of

a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or

a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom,

one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, ~~which~~ wherein the one or more components are used to modify one or both the magnitude [[and/or]] or phase of an electromagnetic field in one or multiple dimensions,

wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including

to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while

providing an amount of electromagnetic shielding in regions other than the particular region.

2. (Currently Amended) The system of claim 1, wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within

one or more wireless chargers or power supplies [[and/or]] or the electronics, coils, magnetic material, or magnets therein, [[and/or]] or

one or more wireless power receivers [[and/or]] or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices [[and/or]] or batteries.

3. (Currently Amended) The system of claim 1, wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is used to provide a degree of position independence in charging or powering the one or more devices [[and/or]] or batteries.

4. (Currently Amended) The system of claim 1, wherein the modifying the magnitude [[and/or]] or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

5. (Currently Amended) The system of claim 1, wherein the ferromagnetic, ferrite, or other magnetic material or layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron [[)]], carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof.

6. (Original) The system of claim 4, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

7. (Currently Amended) The system of claim 6, wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC [[and/or]] or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

8. (Currently Amended) The system of claim 7, wherein the permanent magnet [[and/or]] or electromagnet is incorporated behind, in front, around or at the center of the receiver [[and/or]] or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

9. (Currently Amended) The system of claim 7, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC [[and/or]] or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

10. (Currently Amended) The system of claim 1, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices [[and/or]] or batteries by wireless power.

11. (Currently Amended) The system of claim 1, wherein the power at the devices [[and/or]] or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices [[and/or]] or the batteries.

12. (Original) The system of claim 11, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof.

13. (Currently Amended) The system of claim 1, wherein the power at the devices [[and/or]] or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

14. (Currently Amended) The system of claim 1, wherein the power at the devices [[and/or]] or batteries charged or powered by wireless power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

15. (Currently Amended) The system of claim 1, wherein the wireless power transmitted to the devices [[and/or]] or batteries charged [[and/or]] or powered wirelessly is transmitted at substantially the same or similar frequencies.

16. (Currently Amended) The system of claim 1, wherein the wireless power transmitted to the devices [[and/or]] or batteries charged [[and/or]] or powered wirelessly is transmitted at different frequencies.

17. (Currently Amended) The system of claim 2, wherein the chargers [[and/or]] or receivers include one or more microcontrollers or programmable parts [[and/or]] or memory.

18. (Currently Amended) The system of claim 2, wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil [[and/or]] or load modulation or through an RF or optical link or through one or more RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), [[etc.]] or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof.

19. (Currently Amended) The system of claim 2, wherein the presence of the one or more receivers is detected by the one or more chargers [[and/or]] or power supplies [[and/or]] or causes a change in the operating behavior or characteristics of the chargers [[and/or]] or power supplies.

20. (Currently Amended) The system of claim 2, wherein the chargers [[and/or]] or receivers may consist of one set of electronics [[and/or]] or coils or several sets of similar or dissimilar electronics [[and/or]] or coils to provide flexibility in wirelessly charging devices [[and/or]] or batteries at different voltages, powers, current levels, geometries or functions [[and/or]] or communication and regulation or detection protocols.

21. (Currently Amended) The system of claim 2, wherein the chargers [[and/or]] or receivers may include shielding materials such as ferromagnetic or other magnetic materials [[and/or]] or metal or other conductive layers, [[and/or]] or thin metal layers covering a portion or all of the charger [[and/or]] or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system.

22. (Original) The system of claim 2, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger

system.

23. (Currently Amended) The system of claim 1, wherein one or more repeater antennas or coils [[and/or]] or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets [[and/or]] or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

24. (Currently Amended) The system of claim 1, wherein the system includes one or more metal layers included on the top of the receiver shield [[and/or]] or the bottom of the charger / transmitter shield to provide further shielding from the magnetic field.

25. (Currently Amended) The system of claim 1, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, [[etc.,]] airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, [[etc.,]] cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, [[etc.,]] industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system.

26. (Currently Amended) The system of claim 1, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary ~~(non-rechargeable)~~ or rechargeable battery, solar cell, fuel cell, mechanical ~~(hand-crank, wind-source, etc.)~~, nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities / functions can be added as needed.

27. (Original) The system of claim 1, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and

other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products.

28. (Currently Amended) The system of claim 1, wherein the receiver [[and/or]] or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device [[etc.]] to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate.

29. (Currently Amended) A method of charging [[and/or]] or powering one or more devices [[and/or]] or batteries by wireless power, comprising the steps of:

providing one or more of

a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or

a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom;

using one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, to modify one or both the magnitude [[and/or]] or phase of an electromagnetic field in one or multiple dimensions,

wherein, when the other coil is placed close to the one or more receiver or

charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including

to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while

providing an amount of electromagnetic shielding in regions other than the particular region.

30. (Currently Amended) The method of claim 29, wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within

one or more wireless chargers or power supplies [[and/or]] or the electronics, coils, magnetic material, or magnets therein, [[and/or]] or

one or more wireless power receivers [[and/or]] or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices [[and/or]] or batteries.

31. (Currently Amended) The method of claim 29, wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is used to provide a degree of position independence in charging or powering the one or more devices [[and/or]] or batteries.

32. (Currently Amended) The method of claim 29, wherein the modifying the magnitude [[and/or]] or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

33. (Original) The method of claim 32, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

34. (Currently Amended) The method of claim 33, wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer through application of one or

more DC [[and/or]] or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

35. (Currently Amended) The method of claim 34, wherein the permanent magnet [[and/or]] or electromagnet is incorporated behind, in front, around or at the center of the receiver [[and/or]] or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

36. (Currently Amended) The method of claim 34, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC [[and/or]] or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

37. (Currently Amended) The method of claim 29, further comprising using one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices [[and/or]] or batteries by wireless power.

38. (Currently Amended) A system for use in charging or powering one or more devices [[and/or]] or batteries by wireless power, comprising:

one or more components including a large area transmitter coil of wire, Litz wire, or PCB type, or a combination thereof, covered by a ferromagnetic, ferrite, or other magnetic material or layer and having a relatively higher permeability, that acts to guide, confine, and shield a field therein.

39. (Currently Amended) The system of claim 38, wherein one or more repeater antennas or coils [[and/or]] or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets [[and/or]] or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

Remarks

This REPLY is in response to the Office Action mailed September 11, 2013.

I. Request for Interview

In the event the amendments and remarks provided herein fail to place the application in condition for allowance, Applicant respectfully requests the opportunity to interview with the Examiner, at the Examiner's convenience, and prior to issuance of a subsequent Office Action, to assist in expediting prosecution.

II. Summary of Examiner's Rejections

Prior to the Office Action mailed September 11, 2013, Claims 1-39 were pending in the application. In the Office Action, Claims 1-5, 7-11 and 13-21 were objected to due to informalities. Claims 1-39 were rejected under 35 U.S.C. 102(b) as being anticipated by Partovi et al (U.S. Publication No. 2007/0182367, hereinafter Partovi).

III. Summary of Applicant's Amendment

The present Reply amends Claims 1-5, 7-11, 13-21, 23-26, 28-32 and 34-39, leaving for the Examiner's present consideration Claims 1-39.

IV. Objections to the Claims

In the Office Action, Claims 1-5, 7-11 and 13-21 were objected to due to informalities. Accordingly, the claims have been amended as shown above, to address the informalities. Reconsideration thereof is respectfully requested.

V. Claim Rejections under 35 U.S.C. §102(b)

In the Office Action, Claims 1-39 were rejected under 35 U.S.C. 102(b) as being anticipated by Partovi (U.S. Publication No. 2007/0182367).

Claim 1

Claim 1 has been amended to recite:

1. (Currently Amended) A system for use in charging or powering one or more devices or batteries by wireless power, comprising:

one or more of

a receiver coil which receives inductive power from another coil

placed close to the receiver coil and configured to provide power thereto, or

a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom,

one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions,

wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including

to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while

providing an amount of electromagnetic shielding in regions other than the particular region.

Partovi describes a portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices is disclosed herein. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device. In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device, or to communicate information or data to and from the pad. (Abstract).

In the Office Action, it was asserted that Partovi discloses a system for use in charging and/or powering one or more devices and/or batteries by wireless power, comprising one or more components including a ferromagnetic, ferrite, or other magnetic material or layer, which are used to modify the magnitude and/or phase of an electromagnetic field in one or multiple dimensions.

To more clearly recite the embodiment therein, Claim 1 has been amended to recite that, in accordance with an embodiment, the system comprises one or more of a receiver coil which receives inductive power from another coil placed close to the receiver coil and configured to provide power thereto, or a charger coil which transmits inductive power to another coil placed close to the charger coil and configured to receive power therefrom, one or more components including a ferromagnetic, ferrite, or other magnetic material or layer covering the one or more receiver or charger coils, so that, during charging or powering of one or more devices or batteries, the ferromagnetic, ferrite, or other magnetic material or layer is layered between the one or more receiver or charger coils and the other coil, wherein the one or more components are used to modify one or both the magnitude or phase of an electromagnetic field in one or multiple dimensions, wherein, when the other coil is placed close to the one or more receiver or charger coils, the ferromagnetic, ferrite, or other magnetic material's magnetic properties are locally modified to affect passage of a magnetic flux within a particular region thereof, including to allow power transfer in a particular region generally aligned both with the other coil and the one or more receiver or charger coils, while providing an amount of electromagnetic shielding in regions other than the particular region.

In view of the above remarks, Applicant respectfully submits that Claim 1, as currently amended, is neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claim 29

The remarks provided above with regard to Claim 1 are herein incorporated by reference. Claim 29 has been amended similarly to Claim 1 to more clearly recite the embodiment therein. For similar reasons as provided above, Applicant respectfully submits that Claim 29, as currently amended, is likewise neither anticipated by, nor obvious in view of the cited references, when considered alone or in combination. Reconsideration thereof is respectfully requested.

Claims 2-28 and 30-39

Claims 2-28 and 30-39 depend from and include all of the features of one of Claims 1 or 29. Claims 2-28 and 30-39 are not addressed separately herein. However, Applicant respectfully submits that these claims are allowable at least as depending from an allowable independent claim, and further in view of the amendments to the independent claims, and the remarks provided above. Reconsideration thereof is respectfully requested.

VI. Conclusion

In view of the above amendments and remarks, it is respectfully submitted that all of the claims now pending in the subject patent application should be allowable, and reconsideration thereof is respectfully requested. The Examiner is respectfully requested to telephone the undersigned if he can assist in any way in expediting issuance of a patent.

The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 06-1325 for any matter in connection with this response, including any fee for extension of time, which may be required.

Respectfully submitted,

Date: November 15, 2013

By: /Karl F. Kenna /
Karl F. Kenna
Reg. No. 45445

Customer No.: 23910
FLIESLER MEYER LLP
410 Pacific Avenue
San Francisco, California 94133
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Inventor(s): Partovi, Afshin et al. Appl. No.: 13/352,096 Confirm. No.: 4453 Filed: January 17, 2012 Title: SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	PATENT APPLICATION Art Unit: 2859 Examiner: Fantu, Yalkew **Customer No. 23910**

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

___ As allowed under 37 CFR §1.98(d), copies of cited documents noted with an asterisk are not enclosed because they were previously submitted in U.S. Patent Application No. , which is relied on for an earlier effective filing date under 35 USC §120, and which included an Information Disclosure Statement that complies with 37 CFR §1.98(a) through (c).

✓ A copy of an International Search Report and Written Opinion dated August 31, 2012 for Application No.PCT/US2012/021729.

This statement should be considered because:

__ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.

-- AND *(check at least one of the following)* --

__ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

✓ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

FLIESLER MEYER LLP

Date: November 15, 2013

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

Customer No. 23910
FLIESLER MEYER LLP
410 Pacific Avenue
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PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

KENNA KARL F.

FLIESLER MEYER LLP 650 CALIFORNIA STREET, FOURTEENTH FLOOR SAN FRANCISCO CA 94108 USA

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 31 AUGUST 2012 (31.08.2012)
Applicant's or agent's file reference AFPA01032WO0	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. **PCT/US2012/021729**	International filing date *(day/month/year)* **18 JANUARY 2012 (18.01.2012)**
Applicant **PARTOVI AFSHIN**	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:

   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 . 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90bis.1 and 90bis.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the PCT Applicant's Guide, National Chapters.

Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Chcongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea	Authorized officer COMMISSIONER
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8753

Form PCT/ISA/220 (July 2010)

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Services => PCT Services

ID : PCT international application number
PW : **XV5WWV8S**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com
Email: ipkc@ipkcenter.com
Phone: +1 703 388 1066
Fax: +1 703 388 1084

Notes to Form PCT/ISA/220 (July 2010)

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PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
AFPA01032WO0		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2012/021729	**18 JANUARY 2012 (18.01.2012)**	18 JANUARY 2011 (18.01.2011)

Applicant

PARTOVI AFSHIN

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of :
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   ✓ ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 23
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/021729

A. CLASSIFICATION OF SUBJECT MATTER

H02J 17/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J 17/00; H01F 38/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: wireless power, magnet, modify, magnitude, phase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2000-341885 A (MATSUSHITA ELECTRIC WORKS LTD) 08 December 2000 See the abstract; paragraph [0020]; figure 7.	1-18,20-24,26-39 19,25
Y A	US 2010-0244584 A1 (AZANCOT YOSSI et al.) 30 September 2010 See the abstract; claims 1,11; figures 11,12a,12b.	19,25 1-18,20-24,26-39
A	JP 2003-045731 A (NEC TOKIN CORP) 14 February 2003 See the abstract; paragraphs [0002]-[0010]; claim 1; figures 1,2.	1-39
A	JP 2009-200174 A (PANASONIC ELECTRIC WORKS CO LTD) 03 September 2009 See the abstract; claim 1; figure 1.	1-39

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 AUGUST 2012 (30.08.2012)	**31 AUGUST 2012 (31.08.2012)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	WEE Jae Woo Telephone No. 82-42-481-8540

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2012/021729

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2000-341885 A	08.12.2000	None	
US 2010-0244584 A1	30.09.2010	AU 2008-309154 A1	16.04.2009
		CA 2702164 A1	16.04.2009
		CN 102017031 A	13.04.2011
		EP 2206129 A2	14.07.2010
		JP 2011-030418 A	10.02.2011
		JP 2011-501633 A	06.01.2011
		KR 10-2010-0082008 A	15.07.2010
		KR 10-2010-0087712 A	05.08.2010
		US 2009-0179424 A1	16.07.2009
		US 2010-0219183 A1	02.09.2010
		US 2010-0219693 A1	02.09.2010
		US 2010-0259401 A1	14.10.2010
		WO 2009-047768 A2	16.04.2009
		WO 2009-047768 A3	16.04.2009
JP 2003-045731 A	14.02.2003	None	
JP 2009-200174 A	03.09.2009	EP 2246864 A1	03.11.2010
		KR 10-2010-0121644 A	18.11.2010
		TW 200937466 A	01.09.2009
		US 2010-0320843 A1	23.12.2010
		WO 2009-104474 A1	27.08.2009

Form PCT/ISA/210 (patent family annex) (July 2009)

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PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KENNA KARL F.

FLIESLER MEYER LLP 650 CALIFORNIA STREET,
FOURTEENTH FLOOR SAN FRANCISCO CA 94108 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**31 AUGUST 2012 (31.08.2012)**
Applicant's or agent's file reference AFPA01032WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/021729	**18 JANUARY 2012 (18.01.2012)**	18 JANUARY 2011 (18.01.2011)

International Patent Classification (IPC) or both national classification and IPC

H02J 17/00(2006.01)i

Applicant

PARTOVI AFSHIN

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	30 AUGUST 2012 (30.08.2012)	WEE Jae Woo Telephone No.82-42-481-8540

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/021729

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/021729

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	19,25	YES
	Claims	1-18,20-24,26-39	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-39	NO
Industrial applicability (IA)	Claims	1-39	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following document:

D1: JP 2000-341885 A (MATSUSHITA ELECTRIC WORKS LTD) 08 December 2000
D2: US 2010-0244584 A1 (AZANCOT YOSSI et al.) 30 September 2010

1. Novelty and Inventive step

1.1. Claims 1-28

1.1.1. Claims 1-18, 20-24, 26-28

D1, which is considered to be the closest prior art to the subject matter of claims 1-18, 20-24, 26-28, discloses a magnetic part(7) gathering magnetic flux(B) in order to increase the power transmitted from the primary coil to the secondary coil (See paragraph [0020], figure 7). As all of the features of claims 1-18, 20-24, 26-28 are disclosed in D1, claims 1-18, 20-24, 26-28 are anticipated by D1. Therefore, claims 1-18, 20-24, 26-28 lack novelty under PCT Article 33(2).

1.1.2. Claims 19, 25

Claim 19 differs from D1 in including the presence of the one or more receivers which are detected by the one or more chargers and/or power supplies and/or cause a change in the operating behavior or characteristics of the chargers and/or power supplies. Therefore, the subject matter of claim 19 is considered to be novel under PCT Article 33(2). However D2 describes the features of communicating a signal from the primary inductor to a controller and detecting a radiation emanating from the primary inductor(See claim 11). Accordingly, claim 19 would have been obvious over D2 in view of D1. Thus, the subject matter of claim 19 does not involve an inventive step under PCT Article 33(3).

(Continued on the Supplemental box.)

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Box No. V

Claim 25 differs from D1 in including the wireless charger or power supply that may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat. Therefore, the subject matter of claim 25 is considered to be novel under PCT Article 33(2). However D2 describes the wireless charger or power supply used in a standing lamp(1320a), a photocopier(1320b), a reading lamp(1340a), a laptop computer(1340b), a novelty coffee mug(1340c) (See figures 11, 12a, 12b). Accordingly, claim 25 would have been obvious over D2 in view of D1. Thus, the subject matter of claim 25 does not involve an inventive step under PCT Article 33(3).

1.2. Claims 29-37

Claims 29-37 are the same as claims 1-4, 6-10 in the aspect of a technical concept. Therefore, claims 29-37 lack novelty under PCT Article 33(2).

1.3. Claims 38-39

Claims 38-39 are the same as claims 1, 23 in the aspect of a technical concept. Therefore, claims 38-39 lack novelty under PCT Article 33(2).

2. Industrial Applicability

Claims 1-39 are considered to be industrially applicable under PCT Article 33(4).

Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna/Christopher Burnharte
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	17420878
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	15-NOV-2013
Filing Date:	17-JAN-2012
Time Stamp:	19:43:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	6690
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees) Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees) Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1		afpa_1032us0_ROA_091113.pdf	115362 a800207d18222e709a5df1545c945d35c06c62d1	yes	13
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
	Claims		2	9	
	Applicant Arguments/Remarks Made in an Amendment		10	13	
Warnings:					
Information:					
2	Transmittal Letter	afpa_1032us0_IDS_Trans_111513.pdf	122014 eeb7f490073ef8541ee840284ac5f2608cc6d36e	no	2
Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	afpa_1032wo0_ISR.pdf	486296 bdabb6c08a91d049f2fc86d8d50bc4f3f84c84fc	no	9
Warnings:					
Information:					
4	Non Patent Literature	41_UnknownAuthor_WirelessPowerSpecificationPart1.pdf	2657529 ae2b9f0e8824e8e7d8cc8a48a0aa2b7c5e4a9ca5	no	83
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	30885 63a5c83e353e77b92b05677c1cae9f5139a55c90	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	3412086		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/352,096	Filing Date 01/17/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **11/15/2013**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 39	Minus	** 39	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/NINA RATANAVONG/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13352096
Filing Date	2012-01-17
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	Fantu, Yalkew
Attorney Docket Number	AFPA-01032US0

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7952322		2011-05-31	Partovi et al.	
	2	7948208		2011-05-24	Partovi et al.	
	3	7443135		2008-10-28	Cho	
	4	5367242		1994-11-22	Hulman	
	5	7915858		2011-03-29	Liu et al.	
	6	4311953		1982-01-19	Fukuda et al.	

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U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13352096
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	1	20060202665		2011-03-10	Hsu	
	2	20060108977		2006-05-25	Kagermeier et al.	
	3	20100081473		2010-04-01	Chatterjee et al.	

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FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	European Search Report and Search Opinion in connection with Europe Application 08747863.2 (European National Stage application of PCT/US2008/063084) dated April 2, 2013, 7 pages.	☐
	2	Office Action in connection with Chinese Application 200880023854.4 (Chinese National Stage application of PCT/ US2008/063084) dated August 28, 2012, 18 pages.	☐
	3	Office Action in connection with Application No. 12/769,586 dated August 27, 2013, 15 pages.	☐

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	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	4	Office Action in connection with Application No. 13/352,096 dated September 11, 2013, 12 pages.	☐
	5	Office Action in connection with Application No. 13/709,937 dated September 12, 2013, 7 pages.	☐
	6	Office Action in connection with Application No. 12/769,586 dated December 13, 2012, 19 pages.	☐
	7	Office Action in connection with Application No. 13/708,827 dated June 26, 2013, 22 pages.	☐
	8	Office Action in connection with Application No. 13/708,838 dated June 24, 2013, 27 pages.	☐
	9	PCT International Search Report in connection with PCT Application No. PCT/US2011/040062 dated February 17, 2012, 9 pages.	☐
	10	Office Action in connection with Application No. 13/708,548 dated June 7, 2013, 5 pages.	☐
	11	Office Action in connection with Application No. 13/115,811 dated March 28, 2013, 13 pages.	☐
	12	Office Action in connection with Application No. 13/708,520 dated May 24, 2013, 7 pages.	☐
	13	Office Action in connection with Application No. 13/158,134 dated June 12, 2013, 15 pages.	☐
	14	Office Action in connection with Application No. 13/709,983 dated June 7, 2013, 7 pages.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	15	Office Action in connection with Application No. 13/710,017 dated June 11, 2013, 7 pages.	☐
	16	Office Action in connection with Application No. 13/710,062 dated June 7, 2013, 7 pages.	☐
	17	Office Action in connection with Japanese Application JP/2010-507666 (Japanese National Stage application of PCT/US2008/063084) dated December 3, 2012, 4 pages.	☐
	18	Office Action in connection with Application No. 12/769,586 dated December 13, 2012, 19 pages.	☐
	19	International Search Report and Written Opinion of the International Searching Authority, Korean Intellectual Property Office, in re International Application No. PCT/US2010/032845 dated December 13, 2010, 10 pages.	☐
	20	WildCharge Life unplugged!, http://www.wildcharg.com/4/17/2009, 2 pages	☐
	21	Powermat "the Future of Wireless Power has Arrived", http://www.pwrmat.com,4/15/2009, 2 pages	☐
	22	eCoupled Wireless Power Technology Fulton Innovation, http://www.ecoupled.com, 4/15/2009, 5 pages	☐
	23	Qualcomm Products and Services -Wirelss Airlink Technologies, http://www.qualcomm.com/products_services/airlinks, 4/15/2009, 4 pages	☐
	24	Office Action in connection with Application No. 11/757,067 dated January 26, 2009, 14 pages.	☐
	25	Office Action in connection with Application No. 11/757,067 dated October 19, 2009, 14 pages.	☐

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	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	26	Office Action in connection with Application No. 11/757,067 dated May 10, 2010, 15 pages.	☐
	27	Office Action in connection with Application No. 13/113,977 dated November 9, 2012, 9 pages	☐
	28	Office Action in connection with Application No. 11/669,113 dated October 29, 2008, 11 pages.	☐
	29	Office Action in connection with Application No. 11/669,113 dated August 25, 2009, 17 pages.	☐
	30	Office Action in connection with Application No. 11/669,113 dated May 13, 2010, 20 pages	☐
	31	Office Action in connection with Application No. 12/116,876 dated May 2, 2011, 5 pages.	☐
	32	Office Action in connection with Application No. 13/442,698 dated September 13, 2012, 6 pages.	☐
	33	PCT International Search Report in connection with PCT application No. PCT/US2008/63084, 8 pages, dated August 8, 2008.	☐
	34	PCT International Search Report in connection with PCT application No. PCT/US2007/61406, 8 pages, dated February 14, 2008.	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl Kenna/	Date (YYYY-MM-DD)	2013-10-30
Name/Print	Karl Kenna	Registration Number	45,445

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6906495		2005-06-14	Cheng	
	2	5959433		1999-09-28	Rohde	
	3	6208115		2001-03-27	Binder	
	4	5952814		1999-09-14	Van Lerbergne	
	5	6489745		2002-12-03	Koreis	
	6	6331744		2001-12-18	Chen	
	7	6040680		2000-03-21	Toya	
	8	5734254		1998-03-31	Stephens	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	9	6636017		2003-10-21	Zink et al.	
	10	6586909		2003-07-01	Trepka	
	11	6462509		2002-10-08	Abe	
	12	7042196		2006-05-09	Cheng	
	13	6184651		2001-02-06	Fernandez	
	14	6016046		2000-01-18	Kaite	
	15	7164255		2007-01-16	Hui	
	16	6756765		2004-06-29	Bruning	
	17	6917182		2005-07-12	Burton	
	18	6741064		2004-05-25	Liu	
	19	6650088		2003-11-18	Webb	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

	20	6697272		2004-02-24	Nanbu	
	21	6008622		1999-12-28	Nakawatase	
	22	6625477		2003-09-23	Wakefield	
	23	6436299		2002-08-20	Baarman	
	24	6673250		2004-01-06	Kuennen	
	25	6731071		2004-05-04	Baarman	
	26	6806649		2004-10-19	Mollema	
	27	6812645		2004-11-02	Baarman	
	28	6825620		2004-11-30	Kuennen	
	29	6831417		2004-12-14	Baarman	
	30	6917163		2005-07-12	Baarman	

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	Attorney Docket Number	AFPA-01032US0

	31	6943733		2005-09-13	Vance	
	32	6975198		2005-12-13	Baarman	
	33	7031662		2006-04-18	Suzuki	
	34	7116200		2006-10-03	Baarman	
	35	7118240		2006-10-10	Baarman	
	36	7126450		2006-10-24	Baarman	
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	Attorney Docket Number	AFPA-01032US0

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	11	20110050164		2011-03-03	Partovi et al.		

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SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl Kenna/	Date (YYYY-MM-DD)	2013-10-30
Name/Print	Karl Kenna	Registration Number	45,445

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
AFPA1030WO0		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2011/040062	**10 JUNE 2011 (10.06.2011)**	11 JUNE 2010 (11.06.2010)
Applicant		
MOJO MOBILITY, INC. et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 2
      ☐ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☒ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/040062

A. CLASSIFICATION OF SUBJECT MATTER

H02J 17/00(2006.01)i, H02J 7/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J 17/00; H01F 38/00, H01F 7/02; H02J 700; H02J 7/00; H01F 7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: "Converter", "Inverter", "Half-bridge", "Charger", "Coil", "Battery ", "Microcontroller", "Wireless power", "Magnetic", "Multi-pole"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6844702 B2 (Koninklijke Philips Electronics) 18 Jan. 2005 see the abstract, claims 1-19, column 2 line 34 - column 6 line 20, figures 1-5	1-6
X	US 2009-0243397 A1 (Nigel Power LLC) 1 Oct. 2009 see the abstract, claims 1-40, paragraph [0162]-[0268], figures 1-23	1-6
X	US 2009-0127937 A1 (Nigel Power LLC) 21 May. 2009 see the abstract, claims 1-28, paragraph [0022]-[0064], figures 1-6	1-6
A	US 2007-0182367 A1 (Afshin Partovi) 9 Aug. 2007 see the abstract, claims 1-36, figures 1-22	1-15
A	US 6094119 A (Eastman Kodak Comp) 25 Jul. 2000 see the abstract, claims 1-8, figures 1-7	1-15
A	US 6573817 B2 (STI Optronics Inc) 3 Jun. 2003 see the abstract, claims 1-55, figures 1-9	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 FEBRUARY 2012 (10.02.2012)	**17 FEBRUARY 2012 (17.02.2012)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Cheongsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer BAE, Jin Yong Telephone No. 82-42-481-8503

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2011/040062

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6844702 B2	18.01.2005	AU 2003-230103 A1	02.12.2003
		CN 1653670 A	10.08.2005
		CN 1653670 C	10.08.2005
		EP 1506606 A1	16.02.2005
		JP 2005-526474 A	02.09.2005
		KR 10-2005-0005480 A	13.01.2005
		US 2003-0214821 A1	20.11.2003
		WO 03-098773 A1	27.11.2003
US 2009-0243397 A1	01.10.2009	CN 101978746 A	16.02.2011
		EP 2269408 A2	05.01.2011
		JP 2011-514781 A	06.05.2011
		KR 10-2010-0130618 A	13.12.2010
		WO 2009-111597 A2	11.09.2009
		WO 2009-111597 A3	11.09.2009
US 2009-0127937 A1	21.05.2009	CN 101911029 A	08.12.2010
		EP 2223222 A2	01.09.2010
		JP 2011-508578 A	10.03.2011
		KR 10-2010-0083846 A	22.07.2010
		WO 2009-065099 A2	22.05.2009
		WO 2009-065099 A3	22.05.2009
US 2007-0182367 A1	09.08.2007	US 2007-0279002 A1	06.12.2007
		US 7948208 B2	24.05.2011
		US 7952322 B2	31.05.2011
		WO 2007-090168 A2	09.08.2007
		WO 2007-090168 A3	09.08.2007
US 6094119 A	25.07.2000	JP 2000-182829 A	30.06.2000
US 6573817 B2	03.06.2003	DE 60229686 D1	18.12.2008
		EP 1246513 A2	02.10.2002
		EP 1246513 A3	29.06.2005
		EP 1246513 B1	05.11.2008
		JP 2003-007500 A	10.01.2003
		US 2002-0158736 A1	31.10.2002

Form PCT/ISA/210 (patent family annex) (July 2009)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
AFPA1026WO0		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2010/032845	**28 APRIL 2010 (28.04.2010)**	28 APRIL 2009 (28.04.2009)

Applicant

MOJO MOBILITY, INC. et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/032845

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/00(2006.01)i, H02J 17/00(2006.01)i, H01F 38/14(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J 7/00; G06F 15/16; H04J 3/22; H04B 7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: wireless charging, contactless, communication, coil, magnet, induce, battery, charger.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2008-137996 A1 (MOJO MOBILITY, INC. et al.) 13 November 2008 See abstract; pages 2-91; claims 1-20; figures 1-75.	15 1-14,16-60
Y A	US 2008-0258679 A1 (MANICO JOSEPH A. et al.) 23 October 2008 See abstract; claims 1-20; figures 1-9.	1-14,16-60 15
A	US 7211986 B1 (PLANTRONICS, INC.) 01 May 2007 See abstract; claims 1-14; figures 1-12B.	1-60
A	KR 10-0836634 B1 (HANRIM POSTECH CO., LTD.) 10 June 2008 See abstract; claims 2-6; figure 1-14.	1-60

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 DECEMBER 2010 (10.12.2010)	**13 DECEMBER 2010 (13.12.2010)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	KOO, Young Hoi Telephone No. 0424818376

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2010/032845

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008-137996 A1	13.11.2008	EP 2151037 A1	10.02.2010
		JP 2010-527226 A	05.08.2010
		US 2009-0096413 A1	16.04.2009
		WO 2008-137996 A1	13.11.2008
US 2008-0258679 A1	23.10.2008	CN 101669265 A	10.03.2010
		EP 2140538 A1	06.01.2010
		JP 2010-525785 A	22.07.2010
		KR 10-2010-0015828 A	12.02.2010
		KR20100015828A	12.02.2010
		US 7772802 B2	10.08.2010
		WO 2008-133806 A1	06.11.2008
US 7211986 B1	01.05.2007	None	
KR 10-0836634 B1	10.06.2008	CN 100589304 C	10.02.2010
		CN 101147308 A0	19.03.2008
		EP 1946426 A1	23.07.2008
		JP 2009-501000 A	08.01.2009
		US 2009-0261778 A1	22.10.2009
		US 2010-0289450 A1	18.11.2010
		US 7791312 B2	07.09.2010
		WO 2008-050917 A1	02.05.2008

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AUG 1 1 2008

FLIESLER MEYER LLP

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
KARL F. KENNA
FLIESLER MEYER LLP
650 CALIFORNIA STREET, FOURTEENTH FLOOR
SAN FRANCISCO, CA 94108

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing *(day/month/year)*	0 8 AUG 2008
Applicant's or agent's file reference AFPA01013WO0	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US 08/63084	International filing date *(day/month/year)* 08 May 2008 (08.05.2008)
Applicant MOJO MOBILITY, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 740 1435

   For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/220 (January 2004)

Fliesler Meyer LLP
File: AFPA-01001US1
Action Item: Int'l Search Report-IDS?
Date Due: September 10, 2008
Critical Date: November 8, 2008
Attorney Path: KFK

(See notes on accompanying sheet)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference AFPA01013WO0	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US 08/63084	International filing date *(day/month/year)* 08 May 2008 (08.05.2008)	(Earliest) Priority Date *(day/month/year)* 08 May 2007 (08.05.2007)
Applicant MOJO MOBILITY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

   a. the figure of the **drawings** to be published with the abstract is Figure No. 16

   ☒ as suggested by the applicant.

   ☐ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/63084

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/00 (2008.04)
USPC - 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 320/108

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 320/108 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(USPT,PGPB,EPAB,JPAB); Google
Search Terms: inductive, base, receiver, coil, zener, mosfet, single unit, spiral, non-ferrite, charge, primary coil

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X – Y	US 7,211,986 B1 (FLOWERDEW et al.) 01 May 2007 (01.05.2007), entire document especially the Abstract; Fig 2; col 4, lns 44-60; col 7, lns 52-61; col 6, lns 14-27	9-14 --- 1-8 and 15-20
Y	US 2004/0113589 A1 (CRISP et al.) 17 June 2004 (17.06.2004), entire document especially paras [0088], [0136], [0154]	15-16 and 18
Y	US 2003/0094921 A1 (LAU et al.) 22 May 2003 (22.05.2003), entire document especially the Abstract	17
Y	US 2003/0103039 A1 (BURR et al.) 05 June 2003 (05.06.2003), entire document especially paras [0019], [0023], and [0029]	1-8 and 19-20
Y	US 2005/0127867 A1 (CALHOON et al.) 16 June 2005 (16.06.2005), entire document especially para [0050]	2 and 7
Y	US 2005/0189910 A1 (HUI) 01 September 2005 (01.09.2005), entire document especially paras [0014], [0085]	6 and 8

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 August 2008 (06.08.2008)	08 AUG 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KARL F. KENNA
FLIESLER MEYER LLP
650 CALIFORNIA STREET, FOURTEENTH FLOOR
SAN FRANCISCO, CA 94108

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	0 8 AUG 2008
Applicant's or agent's file reference AFPA01013WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 08/63084	08 May 2008 (08.05.2008)	08 May 2007 (08.05.2007)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H02J 7/00 (2008.04)
USPC - 320/108

Applicant MOJO MOBILITY, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	06 August 2008 (06.08.2008)	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (April 2007)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 08/63084

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. type of material

      ☐ a sequence listing

      ☐ table(s) related to the sequence listing

   b. format of material

      ☐ on paper

      ☐ in electronic form

   c. time of filing/furnishing

      ☐ contained in the international application as filed

      ☐ filed together with the international application in electronic form

      ☐ furnished subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 08/63084

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-8 and 15-20	YES
	Claims	9-14	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	None	NO

2. Citations and explanations:

Claims 9-14 lack novelty under PCT Article 33(2) as being anticipated by US 7,211,986 B1 to FLOWERDEW et al. (hereinafter Flowerdew).

Claim 9; Flowerdew discloses a mobile device capable of being inductively powered or charged (Abstract) comprising:
a battery (320); and
a receiver (304) for one of inductively powering the device or charging the battery in the mobile device, and wherein the receiver is one of attached to or incorporated into the battery or the mobile device (Fig 2).

Claim 13; Flowerdew discloses a system for use with a mobile device or battery for charging or powering the mobile device or battery inductively (Abstract), comprising:
a base unit (302) including one or more primary coils (312, 314) therein, the primary coil having a generally planar shape (pancake coil) so that when a current is passed through the primary coil a magnetic field is generated in a direction substantially perpendicular to the plane of the primary coil (col 7, lns 52-61); and
wherein the perpendicular magnetic field inductively generates a current in a matching receiver coil or coils (316) within a mobile device or battery (320) placed close to and aligned with the base unit, to charge or power the mobile device or battery (Fig 2).

Claim 10; Flowerdew discloses that the coils or wires are formed within a printed circuit board PCB layer of at least two different sizes or shapes (Fig 7).

Claim 11; Flowerdew discloses that the charger or the power supply, and the mobile device, communicate with each other to transfer data (col 15, lns 1-6).

Claim 12; Flowerdew discloses that the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply and/or wherein the charger or power supply stores charging or power requirements for mobile devices which can be charged or powered by the charger or power supply (col 14, lns 29-52).

Claim 14; Flowerdew discloses that one or more of the coils are manufactured on printed circuit boards and are manufactured to have a low resistance (Fig 7 (coils inherently have low resistance)).

Claims 15-16 and 18 lack an inventive step under PCT Article 33(3) as being obvious over Flowerdew in view of US 2004/0113589 A1 to CRISP et al. (hereinafter Crisp).
Claim 15; Flowerdew discloses the system of Claim 13.
Crisp discloses a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an external power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time (para [0154]).
A skilled practitioner would have been motivated to modify the system of Flowerdew in accordance with the teachings of Crisp to include a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an external power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time, since it would allow recharging devices at remote locations.

Claim 16; Flowerdew discloses the system of Claim 13.
Crisp discloses a solar cell coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface
of the base unit or pad includes a decorative or non-slip surface (para [0136]-[0137]).
A skilled practitioner would have been motivated to modify the system of Flowerdew in accordance with the teachings of Crisp to include a solar cell coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface of the base unit or pad includes a decorative or non-slip surface, since it would minimize greenhouse gas emissions.

-- See Continuation Sheet --

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 08/63084

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
Box V. 2. Citations and explanations:

Claim 18; Flowerdew discloses the system of Claim 13.
Crisp discloses a charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device or battery to a predetermined maximum voltage, and a switch means that includes a MOSFET and the circuit includes a capacitor connected in parallel to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the MOSFET when the base unit detects a mobile device or battery placed close to or aligned with the primary coil (para [0088]).
A skilled practitioner would have been motivated to modify the system of Flowerdew in accordance with the teachings of Crisp to include a zener diode and mosfet as claimed, since it would allow control of the battery charging process.

Claim 17 lacks an inventive step under PCT Article 33(3) as being obvious over Flowerdew in view of US 2003/0094921 A1 to LAU et al. (hereinafter Lau).
Claim 17; Flowdrew discloses the system of Claim 13.
Lau discloses a plurality of modular chargers or power supplies that can be interconnected to form a single unit (Abstract).
A skilled practitioner would have been motivated to modify the system of Flowerdew in accordance with the teachings of Lau to include a plurality of modular chargers or power supplies that can be interconnected to form a single unit, since it would allow for scaling the system to provide charging to a large number of devices.

Claims 1, 3-5, and 19-20 lack an inventive step under PCT Article 33(3) as being obvious over Flowerdew in view of US 2003/0103039 A1 to BURR et al. (hereinafter Burr).

Claim 1; Flowerdew discloses a system for inductive powering and charging of portable devices or batteries (Abstract), comprising:
a base unit (302), including one or more primary coils (312, 314) and shaped as planar spiral coils (pancake coil) (col 6, lns 14-27), which are capable of generating an inductive energy for use in powering or charging multiple devices or batteries simultaneously (col 7, lns 52-61);
a receiver unit (304), including a receiver coil (316) which is coupled to or incorporated into a portable device or battery (320), wherein the secondary coil receives energy inductively from the primary coil and uses it to charge or power the portable device or battery (col 4, lns 44-60);
means within the base unit for allowing a degree of position independence of the
devices or batteries on the base unit and selectively activating the one or more primary coils (col 5, lns 32-50); and
wherein the base unit can simultaneously charge or power additional portable devices or batteries with additional secondary coils (col 5, lns 52-61).
However, Flowerdew does not specifically disclose that the coils are comprised of non-ferrite material or that the receiver coil is shaped as a planar spiral coil.
Burr discloses a system for inductive powering and charging of portable devices or batteries wherein the coils are non-ferrite and wherein both coils are planar spiral coils (paras [0019], [0023], and [0029]).
A skilled practitioner would have been motivated to modify the system of Flowerdew to use non-ferrite spiral coils as taught by Burr, since it would provide a lightweight effective charging system.

Claim 3; Flowerdew discloses that the charger and a receiver in the device or battery both include microcontroller units (col 16, lns 1-6), wherein the microcontroller unit in the charger monitors current flow (Abstract), and wherein the microcontroller unit in the portable device or battery provides communication between the charger and the receiver for use in controlling charging (col 16, lns 1-6).

Claim 4; Flowerdew discloses that the charger or power supply includes an additional verification step prior to activating charging, to verify the identity or permissions of a device or battery (col 15, lns 5-6 (Bluetooth links provide for such verification)).

Claim 5; Flowerdew discloses a plurality of coils are integrated into a pad-like charger or power supply and wherein the coils are used to form a coil mosaic and an effective area of charging or power that does not cover more than approximately 90% of pad surface (Fig 7).

Claim 19; Flowerdew discloses the system of Claim 13.
Burr discloses means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power into the coils under different load conditions, to maintain high efficiency during different load conditions or charging stages (para [0031]).
A skilled practitioner would have been motivated to further modify the system of Flowerdew to include the claimed switch means, since it provide an effective means of controlling the power usage.

Claim 20; Burr discloses that the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation (para [0031] (PWM power control necessarily comprises a zero voltage crossing or zero current crossing switch geometry, wherein the controlling of output power is be achieved by changing the frequency of the operation)).

-- See Continuation Sheet --

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box V. 2. Citations and explanations:

Claims 2 and 7 lack an inventive step under PCT Article 33(3) as being obvious over Flowerdew in view of Burr and further in view of US 2005/0127867 A1 to CALHOON et al. (hereinafter Calhoon).

Claim 2; Flowerdew in view of Burr discloses the system of Claim 1.
Flowerdew further discloses that the charger or power supply includes a plurality of coils (312, 314), but doe not specifically disclose that the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery.
Calhoon discloses that the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery (para [0050]).
A skilled practitioner would have been motivated to further modify the system of Flowerdew in accordance with the teachings of Calhoon such that the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery, since it would provide an effective means to use power only when a chargeable device is present.

Claim 7; Flowerdew in view of Burr discloses the system of Claim 1.
Calhoon discloses that the one or more coils includes a switch component, and wherein the microcontroller unit periodically starts the switch components, monitors the current therein, and uses the current to sense the proximity of a receiver and device or battery to that coil, and activate charging in that coil, or a selection of coils in that region (para [0050]).
A skilled practitioner would have been motivated to further modify the system of Flowerdew in accordance with the teachings of Calhoon such that that the one or more coils includes a switch component, and wherein the microcontroller unit periodically starts the switch components, monitors the current therein, and uses the current to sense the proximity of a receiver and device or battery to that coil, and activate charging in that coil, or a selection of coils in that region, since it would provide an effective means to use power only when a chargeable device is present.

Claims 6 and 8 lack an inventive step under PCT Article 33(3) as being obvious over Flowerdew in view of Burr and further in view of US 2005/0189910 A1 (HUI).

Claim 6; Flowerdew in view of Burr discloses the system of Claim 1.
Hui discloses that each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more coils (para [0014]).
A skilled practitioner would have been motivated to further modify the device of Flowerdew in accordance with the teachings of Hui such that each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more coils, since it would increase efficiency by not unnecessarily powering coils.

Claim 8; Flowerdew in view of Burr discloses the system of Claim 1.
Hui discloses a plurality of layers of coils that are layered upon one another to create an effective area, and so that powering anyone or a selection of the coils allows a receiver whose center is within the effective area to be charged (para [0085]).
A skilled practitioner would have been motivated to further modify the device of Flowerdew in accordance with the teachings of Hui to use a plurality of layers of coils, since it would provide means of controlling the intensity of the oscillating magnetic field.

Claims 1-20 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

RECEIVED
FEB 19 2008
FLIESLER MEYER LLP

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: Karl F. Kenna
Fliesler Meyer LLP
650 California Street, Fourteenth Floor
San Francisco, California 94108

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference AFPA01007WO0	Date of mailing *(day/month/year)* 14 FEB 2008 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No PCT/US 07/61406	International filing date *(day/month/year)* 31 January 2007 (31.01.2007)
Applicant PARTOVI, Alshin	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46).

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes, 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 740 14 35

   For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/220 (January 2004) *(See notes on accompanying sheet)*

Ref: AFPA-01007US0/L
Action Item: Int'l Search Report - ISR
Date Due: March 20, 2008
Critical Date: May 14, 2008
Attorney Path: KFK
Docketed By: JAS
Verified By:

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference AFPAG1007WO0	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US 07/61406	International filing date *(day/month/year)* 31 January 2007 (31.01.2007)	(Earliest) Priority Date *(day/month/year)* 31 January 2006 (31.01.2006)
Applicant PARTGVI, Alshin		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1 **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3 ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the drawings to be published with the abstract is Figure No. 1

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (April 2007)

International application No
PCT/US 07/61408

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) H02J 7/00 (2007.01)
USPC 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) H02J 7/00
USPC 320/108, 112

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO WEST - Databases: PGPB,USPT,USOC,EPAB,JPAB - Terms: portable, mobile, charge, charger, battery, induction, inductive, non-contact, coil, printed circuit board, data, transfer, communicate, antenna, align, orient, position, magnet, size, shape, simultaneous, plurality, multiple, mosfet, zener diode, capacitor, parallel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 2002/0094167 A1 (JENSON et al.) 10 January 2002 (10.01.2002) para [0005]; para [0319]	1, 2
X ... Y	US 6,008,622 A (NAKAWATASE) 28 December 1999 (28.12.1999) Col. 1, ln 10-14; Col. 2, ln 5-20; Col. 3, ln 11-28, Col. 3, ln 59-67; Col 4, ln 1-36	3, 11, 26 ..... 4-10, 12-25, 27-36
Y	US 2002/0067238 A1 (LEU) 06 June 2002 (06.06.2002) abstract; para [0045]	4,5,12
Y	US 2005/0127869 A1 (CALHOON et al.) 16 June 2005 (16.06.2005) abstract, para [0042]; [0044]; [0043]; [0045]; [0051]-[0053]; [0047]; claim 7; para [0022]; [0030]; [0060]	6-10, 13-18, 20-25, 27, 28, 30-32, 36
Y	US 2005/0075696 A1 (FORSBERG et al.) 07 April 2005 (07.04.2005) para [0064]-[0065]	18, 19, 29
Y	US 2005/0063488 A1 (TROYK et al.) 24 March 2005 (24.03.2005) para [0006]-[0007]	33-35

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2007 (23.07.2007)	14 FEB 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

From the
INTERNATIONAL SEARCHING AUTHORITY

To: Karl F. Kenna
Fliesler Meyer LLP
650 California Street, Fourteenth Floor
San Francisco, California 94108

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*: 14 FEB 2008

Applicant's or agent's file reference: AFPA01007WO0

FOR FURTHER ACTION: See paragraph 2 below

International application No.	International filing date *(day month year)*	Priority date *(day month year)*
PCT/US 07/61406	31 January 2007 (31.01.2007)	31 January 2006 (31.01.2006)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H02J 7/00 (2007.01)
USPC - 320/108

Applicant: PARTOVI, Afshin

1. This opinion contains indications relating to the following items:

- [x] Box No. I — Basis of the opinion
- [ ] Box No. II — Priority
- [ ] Box No. III — Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV — Lack of unity of invention
- [x] Box No. V — Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI — Certain documents cited
- [ ] Box No. VII — Certain defects in the international application
- [ ] Box No. VIII — Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	23 July 2007 (23.07.2007)	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (April 2007)

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 07/61406

Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of:

a. type of material

☐ a sequence listing

☐ table(s) related to the sequence listing

b. format of material

☐ on paper

☐ in electronic form

c. time of filing/furnishing

☐ contained in the international application as filed.

☐ filed together with the international application in electronic form.

☐ furnished subsequently to this Authority for the purposes of search.

4 ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No
PCT/US 07/81406

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	4-10, 12-36	YES
	Claims	1-3, 11	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-36	NO
Industrial applicability (IA)	Claims	1-36	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1 and 2 lack novelty under PCT Article 33(2) as being anticipated by US 2002/0004187 A1 to Jenson et al. (hereinafter 'Jenson').

As to claims 1 and 2 Jenson teaches an electrically powered portable device (para [0005]) which includes a shell, and a battery integrated with the shell (abstract), wherein an RF antenna 3014 is also placed within the cap so that the battery 1110 imbedded within the cap 3012 can be recharged by passing radio frequency into the cap or inductively coupling the required energy into the cap. (para [0319]).

Claims 3 and 11 lack novelty under PCT Article 33(2) as being anticipated by US 6,008,622 A (Nakawatase).

As to claim 3, Nakawatase teaches a mobile device charger (Col. 1, ln 10-14) comprising: a plurality of coils or wire, wherein the coils or wires are placed in one or more layers and are used to inductively charge a mobile device in proximity to the mobile device charger (Col 2, ln 9-20).

As to claim 11, Nakawatase teaches a mobile device charger (Col. 1, ln 10-14) comprising: a unit comprising a plurality of primary coils of wire, wherein the coils have a generally planar shape so that when a current is passed through the primary coil a magnetic field is generated in a direction substantially perpendicular to the plane of the primary coil (Col. 3, ln 11-26) and wherein the perpendicular magnetic field inductively generates a current in a matching secondary coil or coils within a mobile device placed close to and aligned with the base unit, to charge or power the mobile device (Col. 3, ln 59-67; Col 4, ln 1-36).

Claim 26 lacks an inventive step under PCT Article 33(3) as being obvious over Nakawatase.

As to claim 26, although Nakawatase does not explicitly teach wherein one or more of the primary coils is stacked to improve transfer efficiency, Nakawatase teaches a a flat-faced spiral coil as well as a coil wound on a ferrite core (col 1, ln 41-42). It would have been obvious to a person skilled in the art that a coil wound on a core resembles a stack of connected coils, especially when transposed to a flat substrate, as taught by Nakawatase.

Claims 4, 5 and 12 lack an inventive step under PCT Article 33(3) as being obvious over Nakawatase in view of US 2002/0067238 A1 (Leu).

As to claim 4, Nakawatase teaches wherein coils are formed on a flat surface having two different sizes and shapes (Col. 3, ln 59-67). Although Nakawatase does not explicitly teach wherein said coils may be formed within a printed circuit board, Leu teaches the formation of inductive coils on a printed circuit board (abstract). It would have been obvious to a person skilled in the art to combine the teaching of Leu with that of Nakawatase since printed circuit boards are in common use in portable electronic devices and Leu teaches a method enabling the invention of Nakawatase using the circuit board as a flat substrate.

As to claim 5, Nakawatase teaches wherein two or more coils are activated to charge a mobile device (Col. 3, ln 59-67; Col 4, ln 1-36).

As to claim 12, Nakawatase teaches wherein coils are formed on a flat surface having two different sizes and shapes (Col. 3, ln 59-67). Although Nakawatase does not explicitly teach wherein said coils may be formed within a printed circuit board, Leu teaches the formation of inductive coils on a printed circuit board (abstract). Although Leu does not explicitly teach wherein the coils are low resistance, Leu teaches wherein the coils are formed of silver or gold (para [0045]). Silver and gold are known by those skilled in the art to be low resistance conductors. It would have been obvious to a person skilled in the art to combine the teaching of Leu with that of Nakawatase since printed circuit boards are in common use in portable electronic devices and Leu teaches a method enabling the invention of Nakawatase using the circuit board as a flat substrate.

Claims 6-10, 13-17, 20-25, 27, 28, 30-32, and 36 lack an inventive step under PCT Article 33(3) as being obvious over Nakawatase in view of US 2005/0127869 A1 to Calhoon et al. (hereinafter 'Calhoon').

As to claim 6, although Nakawatase does not explicitly teach wherein the mobile device charger or power supply and the mobile device communicate with each other to transfer data, Calhoon teaches an inductive power adapter (abstract) wherein both a power source and a power adapter may have a microprocessor controller (para [0042]), adapted for data communication between a power supply (320) and a host device (100) or a power adapter (304) and a host device (100) (para [0044]). It would have been obvious to a person skilled in the art to combine the teachings of Nakawatase and Calhoon, as both teach inductive battery charging for portable devices.

- Please see continuation sheet -

WRITTEN OPINION OF THE
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PCT/US 07/61406

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box V 2 - Citations and Explanations.

As to claim 7, Calhoon teaches separate wire for data transfer (a bus with a two-wire interface system; para [0043])

As to claim 8, Calhoon teaches wherein the coils also function as an antenna for data transfer (para [0045]).

As to claim 9, Calhoon teaches wherein the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply (para [0051]-[0053])

As to claim 10, Calhoon teaches wherein the charger or power supply stores charging or power requirements for mobile devices which can be charged or powered by the charger or power supply (para [0047]).

As to claim 13, Calhoon teaches wherein the base unit includes a primary circuit having a switch means for switching the primary coil on and off whenever the mobile device is placed close to the primary coil of the base unit or the presence of the mobile device is to be detected (para [0051]-[0053])

As to claim 14, Calhoon teaches wherein the base unit includes multiple primary coils that can be used to charge devices (claim 7). Although Calhoon does not explicitly teach simultaneous charging, it would have been obvious to a person skilled in the art to suggest simultaneously charging more than one device, based on the teaching of Calhoon.

As to claim 15, Calhoon teaches periodically starting and stopping the alternating switching to automatically detect a presence of a mobile device placed close to or aligned with the primary coil of a base unit (para [0051]-[0053]).

As to claim 16, although Calhoon does not explicitly teach wherein the presence of the device close to or aligned with the primary coil of the base unit is detected by monitoring the current passing through the primary coil or switching means, Calhoon teaches wherein the power adapter 304, via controller 316, is configured to listen for a power source through the power pickup coil 324, then when the device is positioned proximate to the base, the transmission coil 312 and pickup coil 324 are in close enough proximity to establish communications and inductive coupling. (para [0052]). It would have been obvious to a person skilled in the art that the listening taught by Calhoon would have involved sensing the current through the coil. It further would have been obvious that a similar process could have been conducted using the power source, as opposed to the power adapter, as taught by Calhoon.

As to claim 17, Calhoon teaches a charge pad (para [0072]), wherein said pad may comprise a plurality of transmission elements (claim 7).

As to claim 20, although neither Nakawatase nor Calhoon explicitly teaches wherein the charging unit comprises a battery that can occasionally be charged by an external power supply to maintain a charge sufficient to power the inductive device for a period of time, heavy-duty external or internal batteries, such as uninterruptible power supplies, were well known to those skilled in the art, and it would have been obvious to a person skilled in the art to suggest using such a rechargeable power source as a means of maintaining a polling or communication scheme as taught by Calhoon for the sensing of a device to be charged, or for providing power to recharge a device in order to allow the charger, itself to be mobile, or in the event that an external power source failed while portable devices needed recharging.

As to claim 21, although neither Nakawatase nor Calhoon explicitly teaches wherein the charging unit comprises a solar cell for charging a battery in the base or charging unit, solar cells were well known to those skilled in the art. It would have been obvious to a person skilled in the art to suggest charging a storage or back-up battery in an inductive charger as taught by Nakawatase and modified in view of Calhoon, as long as conditions whereby the solar cell would have been able to operatively provide sufficient power to charge the battery on a periodic basis existed.

As to claim 22, Calhoon teaches a nonvolatile data storage component for the storage of data, for subsequent transmission of data to or from the mobile device (para [0030]).

As to claim 23, although neither Nakawatase nor Calhoon explicitly teaches wherein the cover surface of the base unit or pad includes a decorative or non-slip surface, Calhoon teaches wherein the charging unit is built into a work surface or table (para [0060]). It would have been obvious to a person skilled in the art that an electronic consumer product would have been expected to have a housing that was appropriately decorative, stylish, or labeled so as to integrate well with the devices with which it would have been expected to be utilized.

As to claims 24 and 25, although neither Nakawatase nor Calhoon explicitly teaches a charging kiosk, briefcase, bag or clothing, Calhoon teaches wherein the charger may be usefully incorporated into lecterns, desks, vehicles, and the like (para [0060]). It would have been obvious to a person skilled in the art to suggest alternative embodiments of a charger, depending upon the size and type of the device which would have been expected to be used in conjunction with said charger. For smaller devices, a person skilled in the art would have anticipated smaller, more portable applications or embodiments, as claimed.

As to claim 27, Calhoon teaches wherein a charger or power supply senses the location of a mobile device and activates a coil or wire near the device to charge or provide power to the mobile device (para [0051]-[0053]).

As to claim 28, although Calhoon does not explicitly teach a resonant circuit in the charger or power supply for the sensing of the location of a mobile device, Calhoon does teach wherein the power adapter 304, via controller 316, is configured to listen for a power source through the power pickup coil 324, then when the device is positioned proximate to the base, the transmission coil 312 and pickup coil 324 are in close enough proximity to establish communications and inductive coupling. (para [0052]). It would have been obvious to a person skilled in the art that the listening taught by Calhoon could have involved sensing the current through the coil, potentially by a resonant circuit.

- Please see next continuation sheet -

Supplemental Box

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Continuation of

Box V.2 - Citations and Explanations:

As to claim 30, although Calhoon does not explicitly teach wherein the charger or power supply is made in the shape of a bowl, cup or other container, Calhoon describes power systems for computing devices wherein embodiments include work surfaces, lecterns, desks, vehicles, and the like (para [0060]), as well as a seatback tray of a commercial aircraft (para [0006]). It would have been obvious to a person skilled in the art that an inductive charger could be used in nearly any shape or form appropriate for the devices to be inductively charged.

As to claim 31, although Calhoon does not explicitly teach a plurality of modular devices, Calhoon teaches wherein the charger may be usefully incorporated into lecterns, desks, vehicles, and the like (para [0060]). It would have been obvious to a person skilled in the art to suggest modularly linking desks or other small work surfaces into a larger work surface incorporating a plurality of chargers, as taught by Calhoon.

As to claim 32, although neither Nakawatase nor Calhoon explicitly teaches wherein the mobile device to be powered is a kitchen appliance, dish, or a toy, it would have been obvious to a person skilled in the art to use an inductive battery charger to power a toy, particularly toys used by smaller children, as battery consumption by such devices is high, while children do not possess the capacity to safely handle and change batteries.

As to claim 36, Calhoon teaches wherein the adapter 304 housing may be provided in any appropriate shape and may fit into a battery port of typical portable electronic devices (para [0038]). It would have been obvious to a person skilled in the art to design a form-factored replacement for an existing battery design or pack as an aftermarket replacement, based on the teaching of Calhoon.

Claims 19 and 29 lack an inventive step under PCT Article 33(3) as being obvious over Nakawatase in view of US 2005/0075696 A1 to Forsberg et al. (hereinafter 'Forsberg').

As to claim 19, although Nakawatase does not explicitly teach wherein a magnet is place at the center of a primary coil, wherein the magnet at the center has a magnetic axis that is perpendicular to the plane of the coil, and wherein one or more of the devices to be charged include a magnet at the center of the receiver (secondary) coil, so that the magnets in the devices and the magnets in the charger are oriented to attract each other when a coil in a device is placed directly on top of a coil in the base, Forsberg teaches a magnetic core positioned in a primary coil in order to position the primary coil properly for maximizing the magnetic flux received by the secondary coil (para [0064]-[0065]). Although Forsberg does not explicitly teach wherein a magnet is also present in the secondary coil for the purpose of alignment, it would have been obvious to a person skilled in the art that it would have been possible to also include a magnetic core in the secondary coil in such a manner as to attract the magnetic core in the center of the primary coil, as taught by Forsberg.

As to claim 29, although Nakawatase does not explicitly teach a flexible PCB material as a substrate for a receiver of inductive power, Forsberg teaches a flexible material as a shield for a primary coil (para [0010]). It would have been obvious to a person skilled in the art that the substrate could similarly be constructed of a flexible polymer material.

Claim 18 lacks an inventive step under PCT Article 33(3) as being obvious over Nakawatase and Calhoon, further in view of Forsberg.

As to claim 18, although neither Nakawatase nor Calhoon explicitly teaches wherein the primary coils can move within their plane to more closely align with the secondary coil or mobile device, Forsberg teaches a repositionable magnetic core 58 can help to focus electromagnetic energy from primary coil 46 to more closely be aligned with secondary coil 34 (para [0052]) for an inductively rechargeable, implantable medical device (abstract). It would have been obvious to a person skilled in the art to combine the teaching of Forsberg regarding a repositionable primary coil to a charging base as taught by Nakawatase, modified as taught by Calhoon because all three references teach inductive charging of portable or mobile devices.

Claims 33-35 lacks an inventive step under PCT Article 33(3) as being obvious over Nakawatase and Calhoon, further in view of US 2009/0063488 A1 to Troyk et al. (hereinafter 'Troyk').

As to claim 33, Troyk teaches a magnetically coupled data and power transmission system (para [0004]) that may also be effectively applied to other applications, such as some RFID transponders (para [0001]). It would have been obvious to a person skilled in the art that an active RFID transponder, which also incorporates a power-storing device, would have been enabled by the teachings of Troyk.

As to claim 34, although Nakawatase does not explicitly teach wherein a mobile device to be charged or powered includes a charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device to a predetermined maximum value, Troyk teaches a diode rectifying bridge in a circuit with the receiving coil (para [0034]). While Troyk does not explicitly teach wherein said diode is a Zener diode to clamp the voltage at a maximum value, Troyk teaches a resonant circuit comprised of inductor 8 (a coil), and capacitors 4 and 5, wherein capacitor 5 is chosen to be substantially larger than capacitor 4 results in a beneficial capacitive voltage division, thereby reducing the voltage stresses on MOSFET switch 3 (para [0029]). It would have been obvious to a person skilled in the art to suggest a different, well-known means of limiting the voltage in the inductive system, such as using a Zener diode.

As to claim 35, although neither Nakawatase nor Calhoon teaches wherein a mosfet and capacitor may be used in a switching circuit, Troyk teaches wherein, in the prior art, a mosfet switch is used to place a capacitor directly across an antenna coil, wherein the drain capacitance appears in parallel with the transmitter coil when the mosfet is off, lowering the resonant frequency of the system for modulation of the current in the transmitter coil. This allows communication with a device over the magnetic link (para [0006]-[0007]). It would have been obvious to a person skilled in the art to apply the teaching of Troyk to a charging system as taught by Calhoon, further specifying wherein the alternating switching described by Calhoon (para [0051]-[0053]) for the primary coil is started by the MOSFET.

Claims 1-36 have industrial applicability as defined by PCT Article 33(4), because the subject matter can be made or used in industry.

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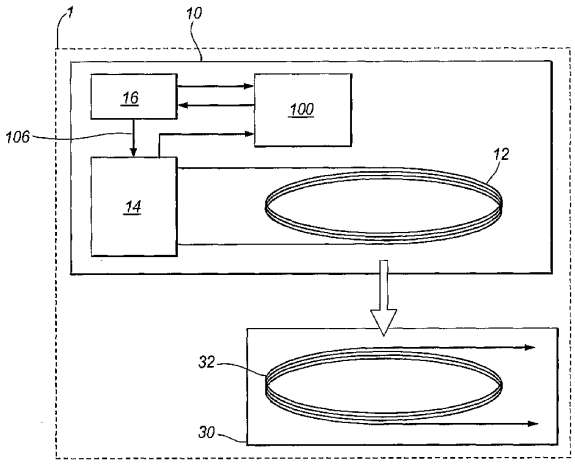
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(54) Title: CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS



(57) Abstract: An inductive power transfer system (1) comprises a primary unit (10) operable to generate an electromagnetic field and at least one secondary device (30), separable from the primary unit, and adapted to couple with the field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween. The system detects if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices. Following such detection, the system restricts or stops the inductive power supply from the primary unit. Such a system can detect the presence of unwanted parasitic loads in the vicinity of the primary unit reliably.

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FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS

The present invention relates to controlling inductive power transfer systems for use, for example, to power portable electrical or electronic devices.

This application claims priority from the applicant's copending applications GB 0410503.7 filed on 11th May 2004 and GB 0502775.0 filed on 10th February 2005, the entire content of each of which is incorporated herein by reference.

Inductive power transfer systems suitable for powering portable devices may consist of two parts:

- A primary unit having at least one primary coil, through which it drives an alternating current, creating a time-varying magnetic flux.
- A secondary device, separable from the primary unit, containing a secondary coil. When the secondary coil is placed in proximity to the time-varying flux created by the primary coil, the varying flux induces an alternating current in the secondary coil, and thus power may be transferred inductively from the primary unit to the secondary device.

Generally, the secondary device supplies the transferred power to an external load, and the secondary device may be carried in or by a host object which includes the load. For example the host object may be a portable electrical or electronic device having a rechargeable battery or cell. In this case the load may be a battery charger circuit for charging the battery or cell. Alternatively, the secondary device may be incorporated in such a rechargeable cell or battery, together with a suitable battery charger circuit.

A class of such an inductive power transfer systems is described in our United Kingdom patent publication GB-A-2388716. A notable characteristic of this class of systems is the physically "open" nature of the magnetic system of the primary unit – a significant part of the magnetic path is through air. This is necessary in order that the primary unit can supply power to different shapes and sizes of secondary device, and to multiple secondary devices simultaneously. Another example of such an "open" system is described in GB-A-2389720.

Such systems may suffer from some problems. A first problem is that the primary unit cannot be 100% efficient. For example, switching losses in the electronics and I^2R losses in the primary coil dissipate power even when there is no secondary device present, or when no secondary devices that are present require charge. This wastes energy. Preferably the primary unit should enter a low-power "standby mode" in this situation.

A second problem in such systems is that it is not possible to mechanically prevent foreign objects from being placed into proximity with the primary coil, coupling to the coil. Foreign objects made of metal will have eddy-currents induced therein. These eddy currents tend to act to exclude the flux, but because the material has resistance, the flowing eddy currents will suffer I^2R losses which will cause heating of the object. There are two particular cases where this heating may be significant:

- If the resistance of any metal is high, for example if it is impure or thin.
- If the material is ferromagnetic, for example steel. Such materials have high permeability, encouraging a high flux density within the material, causing large eddy currents and therefore large I^2R losses.

In the present application, such foreign objects that cause power drain are termed "parasitic loads". Preferably the primary unit should enter a "shutdown mode" when parasitic loads are present, to avoid heating them.

Various approaches to solve these two problems have been proposed in the prior art.

Solutions to the first problem, of not wasting power when no secondary device requires charge, include:

- In EP0533247 and US 6118249 the secondary device modulates its inductive load during charging, causing a corresponding variation in the power taken from the primary unit. This indicates to the primary unit that it should stay out of the standby state.
- In EP1022840 the primary unit varies the frequency of its drive, and thus the coupling factor to a tuned secondary unit. If the secondary unit is not taking power, there is no difference in the power taken as the frequency is swept and thus the primary unit goes into a standby state.
- In US5536979 the primary unit simply measures the power flowing in the primary coil, and enters a pulsing standby state if this is below a threshold.

- In US5896278 the primary unit contains detecting coils which have power coupled back into them according to the position of the secondary device. If the device is not present the primary unit enters a standby mode.
- In US5952814 the secondary device has a mechanical protrusion which fits a slot in the primary unit, activating it.
- In US6028413 the primary unit drives two coils, and there are a corresponding two power receiving secondary coils in the secondary unit. The primary unit measures the power delivered from each primary coil and enters standby mode if it is below a threshold.

Solutions to the second problem, of parasitic loads, include:

- As mentioned above, in EP1022840 the primary unit varies the frequency of its drive. In this system, the secondary device is tuned, so this frequency variation will result in a variation of the power taken from the primary unit. If the load is instead a piece of metal, then varying the frequency will not have as much effect and the primary unit will enter a shutdown state.
- As mentioned above, in US5952814 a key in the secondary device activates the primary unit. The assumption is that if a secondary device is present then this will physically exclude any foreign objects.
- As mentioned above, in US6028413 the primary unit supplies power to the secondary device by driving two primary coils. If the amount of power supplied by the two coils is different, the primary unit assumes that the load is not a valid secondary device and enters shutdown mode.

These approaches all assume a 1:1 relationship between the primary unit and the secondary device. Therefore they are not sufficient for systems such as those described in GB-A-2388716 where more than one secondary device at a time may be present. For example, they would not work when there are two secondary devices present, one requiring charge and the other not.

Some of these approaches also assume that the physical or electrical presence of a valid secondary device implies that all foreign objects are physically excluded by the secondary device. This is not necessarily the case, particularly when the secondary devices may be positioned arbitrarily in respect of the primary unit, as in those described in GB-A-2388716.

According to a first aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit operable to generate an electromagnetic field and at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween, which method comprises: setting the or each secondary device to a no-load state in which supply of any of the power received inductively by the secondary device to an actual load thereof is substantially prevented; and in the primary unit, measuring a power drawn from the primary unit when the or each secondary device is set into said no-load state, and restricting or stopping the inductive power supply from the primary unit in dependence upon the measured power.

Because the secondary device(s) are set into the no-load state during the power measurement, it can be detected easily from the measured power if there is a substantial parasitic load. If so, the primary unit can enter a shutdown mode. For example, the if the measured power is greater than a threshold value in the no-load state, then the power supply may be restricted or stopped.

This method is convenient because it is unnecessary for the secondary devices to communicate their power requirements to the primary unit or for the primary unit to carry out any summation of the power requirements: it is known that since the secondary devices are in the no-load state their combined power requirement is zero or at least a small value influenced by any parasitic load imposed on the primary unit by the secondary devices themselves.

According to a second aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit operable to generate an electromagnetic field and at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween, which method comprises: in the primary unit, receiving, from the or each secondary device that is in a power-requiring state, information relating to a power requirement of the secondary device concerned; and in the primary unit, measuring the power drawn from the primary unit when power is being

supplied to the or each secondary device having the power-requiring state, and restricting or stopping the inductive power transfer from the primary unit in dependence upon the measured power and the received power requirement information.

In this case, the inductive power supply from the primary unit may be restricted or stopped in dependence upon a difference between said measured power and a sum of the respective power requirements of the secondary devices having said power-requiring state. For example, the inductive power supply may be restricted or stopped in the event that the measured power exceeds said sum by more than a threshold value.

This method has the advantage over the method of the first aspect that it does not need to set the secondary devices into the no-load state during the power measurement. Thus, power can be supplied continuously to the actual loads of the secondary devices.

Of course, in the method of the first aspect, the power measurement period can be very short, so that any interruption to the power supply to the load may be unnoticeable. If interruption of the load is a problem, it is possible to provide an energy storage means such as a capacitor in the secondary device to maintain the power supply to the actual load during the power measurement period.

In the method of the second aspect, any suitable communication method may be used to transmit the power requirement information from each secondary device to the primary unit. One preferred method for the or each secondary device to transmit its power requirement information to the primary unit is an RFID method. Alternatively, the or each secondary device may transmit its power requirement information to the primary unit by varying a load imposed by the secondary device on the primary unit.

It will be appreciated that the methods embodying the first and second aspects of the invention provide different ways of detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices. Following such detection, the inductive power supply from the primary unit can be restricted or stopped.

In the methods of the first and second aspects it is possible to vary a load imposed by the secondary device on the primary unit to communicate a signal or information from the secondary device to the primary unit. For example, the power requirement information needed in the second aspect may be transmitted this way.

An advantage of communicating using load variation is that it can permit two or more, or possibly all, secondary devices to supply respective items of information simultaneously to the primary unit. For example, if any secondary device requires power it may vary its load. If the primary unit detects no or no substantial overall load variation it can conclude that no secondary device requires power and hence enter a standby mode. Similarly, the primary unit will detect the sum of any load variations. If the load variation from each individual secondary device is proportional to some analog quantity to be communicated to the primary unit, for example the power requirement or parasitic load of the secondary device, then the sum of the respective analog quantities will be detected by the primary unit in the power measurement. This means that the sum can be obtained directly without the need for additional processing in the primary unit which may be time-consuming and/or costly to implement.

It may also be desirable to detect a condition for entering a standby mode in addition to detecting when to enter the shutdown mode. For example, in the method of the first aspect it is possible to restrict or stop the inductive power supply in the event that the measured power is less than a standby threshold value (different from the shutdown threshold mentioned above). Another possibility is that the or each said secondary device reports to the primary unit state information indicating whether the secondary device is in a no-power-requiring state, in which an actual load of the secondary device currently requires no power from the primary unit, or a power-requiring state in which said active load does currently require power from the primary unit. The primary unit then restricts or stops the inductive power supply therefrom in dependence upon the state information reported by the or each secondary device. For example, the primary unit may restrict or stop the inductive power transfer unless the state information reported by at least one secondary device indicates that it has said power-requiring state. Preferably, for speed of response, two or more secondary devices report their respective state information simultaneously to the primary unit. One convenient possibility, as noted above, is for the or each said secondary device to report its said state information by varying a load imposed by it on the primary unit.

In general, it is possible to carry out two or more measurements of the power drawn from the primary unit in different measurement periods. If the secondary devices are synchronised with the primary unit, then they can behave differently in one measurement period from another, so that the primary unit can detect two or more different conditions under which power restriction or stopping is appropriate.

One preferred embodiment has three measurement periods. In the first period, each secondary device turns off a dummy load. In the second period, each secondary device that requires power turns on its dummy load. The other secondary devices turn their dummy loads off. In the third period, each secondary device turns on its dummy load. The primary unit can detect from a comparison of the power measurements in the three periods whether there is a substantial parasitic load requiring shutdown or no device requiring power so that standby is appropriate.

It is also possible to vary the load during a measurement period. For example, the amplitude of the load change may be fixed but the duration may be varied to supply information.

The primary unit may have registered therein a power requirement of at least one said secondary device. In this case the power requirement information transmitted from that secondary device may simply be information identifying the secondary device. The primary unit employs the identifying information to retrieve the registered power requirement for the device. The identifying information can be a code or a type, model or serial number assigned to the secondary device. This can reduce the amount of information to be transmitted to the primary unit and also improve speed of response and reliability.

Although each secondary device that is in the power-receiving state transmits power requirement information to the primary unit in the method of the second aspect, the or each said secondary device not having the power-requiring state may also transmit such power requirement information to the primary unit, if desired. One possibility is for the power requirement information transmitted by the or each said secondary device not in said power-requiring state to be representative of a parasitic load imposed on the primary unit by the secondary device. This can then be used to make the shutdown

detection more reliable. It is also possible for the power requirement information to be the sum of power requirement of the actual load and the parasitic load of the secondary device when in the power-requiring state and just the power requirement of the parasitic load when not in that state.

Generally, it is desirable for the detection of the conditions for restricting or stopping the inductive power supply to take account of any losses in the primary unit and the secondary devices. There are a number of ways of doing this.

One way is to employ, when carrying out said detection, first compensation information relating to losses in the primary unit itself so as compensate for said losses. It is possible to derive part or all of said first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation. The first compensation information may be stored in a calibration unit of the primary unit.

Another way is to employ, when carrying out said detection, second compensation information relating to a parasitic load imposed on the primary unit by the or each secondary device so as to compensate for said parasitic load of the or each secondary device. The or each said secondary device preferably communicates its said second compensation information directly to said primary unit or communicates to the primary unit other information from which the primary unit derives said second compensation information. The secondary device may communicate its said second compensation information or its said other information to the primary unit by varying a load imposed by it on the primary unit, as mentioned above.

A particularly convenient and efficient way is for the or each said secondary device to have a dummy load, representative of its said parasitic load, which it imposes on said primary unit to vary the load imposed by it on the primary unit.

Part or all of said first compensation information and/or part or all of said second compensation information may be information stored in the primary unit during manufacture and/or testing of the primary unit.

It may be advantageous to vary one or both of said first and second compensation information when one or more operating conditions (e.g. temperature) of the primary unit varies. A secondary device may be capable of being used either by itself or

combination with another object. For example, the secondary device may be removable from a host object. If it can be powered when removed or when installed in the host object, the parasitic load of the device alone is likely to be quite different from the parasitic load of the device and host object together. To deal with this situation, the second compensation information may be varied in dependence upon whether the device is used by itself or in combination with another object.

In many implementations, the secondary devices need to operate in synchronism with primary unit. It is therefore preferable to transmit a synchronising signal from the primary unit to the or each said secondary device, or from the or each said secondary device to the primary unit, to synchronise operation of the primary unit and the or each said secondary device. This is conveniently done by modulating a drive signal applied to a primary coil in the primary unit. Frequency, amplitude or phase modulation, or a combination thereof, may be used.

Many different techniques can be used to measure the power drawn from the primary unit by the secondary devices. In one technique, the electromagnetic field is generated by a primary coil driven by an electrical drive unit, and electrical power for the drive unit is supplied from a power supply of the primary unit to a power input of the drive unit. The power drawn from the primary unit is measured by temporarily disconnecting the power supply and detecting a change at said power input during the disconnection. The change may be a voltage decay. The advantage of this technique is that there is no series resistance through which the current for drive unit passes. Such a series resistance dissipates significant power.

It is preferable to store energy in an energy storage unit such as a capacitor connected to said power input so that power can continue to be supplied to said power input whilst said power supply is disconnected.

Another way to measure the power drawn may be available if the electrical drive unit has a feedback circuit to control the current or power of the drive to the primary coil. In this case, a feedback signal in the feedback circuit may provide a measure of the power being drawn without the need to add in a power measurement unit at all.

Another way to measure the power involves causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which

the application of drive signals to the primary coil is suspended so that energy stored in the circuit decays over the course of said period. One or more measures of such energy decay are then taken during said period and employed to measure said power drawn from the primary unit.

Two or more power measurements may be taken under the same conditions and the results averaged to improve accuracy.

In operation it may be desirable to set the field magnitude of the electromagnetic field to a value lower than the maximum value even in the operating mode. In the method of the second aspect the primary unit has the power requirement information from each secondary device and can therefore easily set the field magnitude in dependence upon the power required by the secondary device or, if there is more than one secondary device, the combined power required by the secondary devices. In this way a minimum power output for powering the secondary devices can be found. However, there are other ways to achieve a similar result. For example, a secondary device that is not getting enough power may modulate its load in some way. The primary unit may start operating at maximum power and reduce the power until the load modulation is detected from at least one secondary device. This enables minimum power to be determined in a simple and quick way.

According to a third aspect of the present invention there is provided an inductive power transfer system comprising: a primary unit operable to generate an electromagnetic field; at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; means for detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices; and means operable, following such detection, to restrict or stop the inductive power supply from the primary unit.

According to a fourth aspect of the present invention there is provided a primary unit, for use in an inductive power transfer system that also has at least one secondary device separable from the primary unit, the primary unit comprising: means for

generating an electromagnetic field which couples with said at least one secondary device when it is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; means for detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices; and means operable, following such detection, to restrict or stop the inductive power supply from the primary unit.

According to a fifth aspect of the present invention there is provided a secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising: a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; detecting means for detecting a synchronisation signal transmitted by the primary unit; and control means, responsive to the detection of the synchronisation signal, to set the secondary device into a no-load state in which supply by the load connection means of any of the inductively-received power to said load is substantially prevented.

This can provide a secondary device adapted for use in the method embodying the first aspect of the invention described above.

According to a sixth aspect of the present invention there is provided a secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising: a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a

load requiring power from the primary unit, for supplying such inductively-received power to the load; and RFID communication means operable to supply to the primary unit, using an RFID communication method, information relating to a power requirement of the secondary device.

This can provide a secondary device adapted for use in the method embodying the second aspect of the invention described above. In this case the load connection means does not disconnect the actual load during the power measurement.

According to a seventh aspect of the present invention there is provided a method of controlling conductive power transfer in an inductive power transfer system comprising a primary unit operable to generate an electromagnetic field and at least one secondary device, separable from primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween, which method comprises: in an information supplying phase, permitting two or more secondary devices to supply simultaneously to the primary unit information relating respectively to the secondary devices concerned; and interpreting the simultaneously-supplied information at the primary unit and determining based on the interpreted information whether to restrict or stop the inductive power supply from the primary unit.

This method can permit rapid supply of information or signals from the secondary devices to enable restriction or stopping of the power supply to be achieved quickly.

In one embodiment, the information supplied from each secondary device indicates whether or not the secondary device concerned is in a power-requiring state in which an actual load of the secondary device requires power from the primary unit, and the primary unit determines that the inductive power supply therefrom should be restricted or stopped unless the information supplied in said information supplying phase by at least one of the secondary devices indicates that it has said power-receiving state.

The information supplied from each secondary device may represent an analog quantity of the secondary device concerned. In this case, the primary unit can derive directly from the simultaneously-supplied information a sum of the respective analog quantities of the secondary devices.

The analog quantity may be representative of a parasitic load imposed on the primary unit by the secondary device itself.

The analog quantity may be representative of a power requirement of an actual load of the secondary device.

The analog quantity may be representative of a total load imposed on the primary unit by the secondary device, said total load including an actual load of the secondary device and a parasitic load imposed on the primary unit by the secondary device itself.

In one embodiment, each said secondary device supplies its said information by varying a load imposed by it on the primary unit. For example, each said secondary device may have a dummy load which it imposes selectively on the primary unit during said information supplying phase. The dummy load is preferably representative of said analog quantity. Different dummy loads may be used to represent different analog quantities, for example a power requirement and a parasitic load.

In one embodiment each said secondary device has its said information supplying phase at a time determined by the primary unit.

According to an eighth aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit operable to generate an electromagnetic field and at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween, in which method: in a reporting phase the or each said secondary device reports to the primary unit information indicating whether the secondary device is in a no-power-requiring state, in which an actual load of the secondary device currently requires no power from the primary unit, or a power-requiring state in which said active load does currently require power from the primary unit; and the primary unit determines that the inductive power supply therefrom should be restricted or stopped in dependence upon the information reported by the or each secondary device in said reporting phase.

Preferably, the or each said secondary device has its said reporting phase at a time determined by the primary unit.

In one embodiment there are at least two secondary devices and each said secondary device has its said reporting phase at the same time.

The or each said secondary device may report its said information by varying a load imposed by it on the primary unit. For example, the or each said secondary device may have a dummy load which it imposes selectively on the primary unit during its said reporting phase.

In one embodiment, the or each said secondary device that has said power-requiring state imposes its said dummy load during said reporting phase and the or each said secondary device that has said non-power-requiring state does not impose its said dummy load during said reporting phase.

According to a ninth aspect of the present invention there is provided a secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising: a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and communication means operable to communicate to the primary unit information relating to a parasitic load imposed on the primary unit by the secondary device.

Such a secondary device can communicate its parasitic load to the primary unit for the primary unit to use to compensate for that load. For example, the communicated parasitic load can be used when detecting conditions for restricting or stopping inductive power transfer from the primary unit.

Any communication method can be used, and the method is not limited to load variation. For example, infrared or ultrasonic communication can be used. RFID can also be used.

In one embodiment, said communication means are operable to communicate said information by imposing a dummy load on said primary unit. The communication means may be operable to impose a first dummy load on the primary unit at a first time and a second dummy load, different from said first dummy load, at a second time, a difference between said first and second dummy loads being set in dependence upon said parasitic load. One of said first and second dummy loads may be zero.

According to a tenth aspect of the present invention there is provided a portable electrical or electronic device comprising: a load which at least at times requires power from said primary unit; and a secondary device embodying the aforesaid fifth, sixth or ninth aspect of the present invention, said load connection means of said secondary device being connected to said load for supplying such inductively-received power to the load at said times.

According to an eleventh aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit, having a primary coil to which electrical drive signals are applied to generate an electromagnetic field, and also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, which method comprises: causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil is suspended so that energy stored in the circuit decays over the course of said period; taking one or more measures of such energy decay during said period; and restricting or stopping inductive power transfer from the primary unit in dependence upon said one or more energy decay measures.

Such a method can enable either or both of parasitic load and standby detection to be achieved in a robust and cost-effective manner. It is particularly advantageous in

systems which may have multiple secondary devices and/or whose open magnetic nature makes it easy for parasitic objects to couple to the primary coil.

Reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a block diagram showing parts of an inductive power transfer system embodying the present invention;

Figure 2 is a flowchart for use in explaining a first method of detecting a shutdown condition in accordance with the present invention;

Figure 3 is a flowchart for use in explaining a first method of detecting a standby condition in accordance with the present invention;

Figure 4 is a block diagram showing parts of an inductive power transfer system according to a first embodiment of the present invention;

Figure 5 shows waveform diagrams for use in explaining operation of the Figure 4 system;

Figures 6 show waveform diagrams showing the timing of the various signals within the Figure 4 system: Figure 6(a) shows a frequency of an AC voltage signal applied to a primary coil; Figure 6(b) shows a power drawn from the primary unit; Figure 6(c) shows a state of a switch in the primary unit; and Figure 6(d) shows the voltage across the switch in the primary unit;

Figure 7 is a diagram showing the load drawn during three different measurement operations;

Figure 8 is a diagram illustrating different modes of operation in the Figure 4 system;

Figure 9 is a block diagram showing parts of a primary unit in a power transfer system according to a second embodiment of the present invention;

Figure 10 is a flowchart for use in explaining a second method of detecting a shutdown condition in accordance with the present invention; and

Figure 12 is a block diagram showing parts of a power transfer system according to a third embodiment of the present invention.

Figure 1 illustrates parts of an inductive power transfer system embodying the present invention. The system 1 comprises a primary unit 10 and at least one secondary device 30. The primary unit 10 has a primary coil 12 and an electrical drive unit 14 connected to the primary coil 12 for applying electrical drive signals thereto so as to generate an electromagnetic field. A control unit 16 is connected to the electrical drive unit 14. This control unit generates an AC voltage signal 106. The electrical drive unit takes the AC voltage signal 106 and converts it to an AC current signal in the primary coil 12, so as to generate an induced electromagnetic field in the proximity of the primary coil 12.

The primary unit 10 may have any suitable form but one preferred form is a flat platform having a power transfer surface on or in proximity to which each secondary device 30 can be placed. In this case, the field may be distributed over a power transfer area of the surface, as described in GB-A-2388716.

The secondary device 30 is separable from the primary unit 10 and has a secondary coil 32 which couples with the electromagnetic field generated by the primary unit 10 when the secondary device 30 is in proximity to the primary unit 10. In this way, power can be transferred inductively from the primary unit 10 to the secondary device 30 without direct electrical conductive contacts therebetween.

The primary coil 12 and the secondary coils 32 can have any suitable forms, but may for example be copper wire wound around a high-permeability former such as ferrite or amorphous metal.

The secondary device 30 is usually connected to an external load (not shown - also referred to herein as the actual load of the secondary device) and supplies the inductively-received power to the external load. The secondary device 30 may be carried in or by an object requiring power such as a portable electrical or electronic device or a rechargeable battery or cell. Further information regarding designs of

secondary device 30 and the objects which can be powered using the secondary devices 30 can be found in GB-A-2388716.

The primary unit 10 in the Figure 1 system also comprises a power measurement unit 100 connected to the control unit 16. The power measurement unit 100 performs a measurement of the electrical power drawn by the electrical drive unit 14, on receipt of a signal provided by the control unit 16. The power measurement unit 100 provides an output representative of the electrical power drawn by the electrical drive unit 14 to the control unit 16. The power drawn by the electrical drive unit 14 is representative of the power drawn by the primary coil 12 and hence also the power drawn by all the secondary devices 30 plus other losses.

In the Figure 1 system it is desirable to detect certain conditions and restrict or stop the inductive power supply from the primary unit under those conditions.

One such condition is the presence of a substantial parasitic load in the vicinity of the primary unit. In this case, the control unit 16 may enter a shutdown mode in which the drive to the primary coil 12 is reduced or stopped, preventing heating of the parasitic load.

Another such condition is when no secondary device 30 of the system is present in the vicinity of the primary unit 10. Another such condition is when there is at least one secondary device 30 present but none of the devices has a load currently requiring power. A load does not require power, for example, when turned off or when, in the case of a rechargeable battery or cell, the battery or cell is fully charged. Under both these conditions the control unit 16 may enter a standby mode in which the drive to the primary coil 12 is reduced or stopped, preventing unnecessary power consumption in the primary unit 10.

Fig. 2 is a flowchart for use in explaining a first method for detecting the presence of a substantial parasitic load in the vicinity of the primary unit in accordance with the present invention.

In this first method, when the system of Fig. 1 is in use, from time to time all of the secondary devices in the vicinity of the primary unit are deliberately set to a no-load state. In this no-load state, supply of any of the power received inductively by the

secondary device to an actual load thereof (the external load mentioned above) is prevented.

In step S2, with all of the secondary devices in the no-load state, the power measurement unit 100 in the primary unit measures the power drawn by the secondary devices from the primary unit. In step S3, the control unit 16 in the primary unit determines, in dependence upon the power measured in step S2, whether to restrict or stop the inductive power supply from the primary unit.

In the simplest case, in step S3 the control unit 16 simply compares the measured power with a predetermined shutdown threshold. If the measured power exceeds the shutdown threshold value, the control unit 16 determines that the inductive power supply from the primary unit should be restricted or stopped. As described in more detail below, however, it is preferable to take into account losses which inevitably occur in the power transfer system. In particular, these losses include losses in the primary unit itself and/or any secondary devices/host objects present. These losses include inefficiencies in the primary coil itself and any other components associated with the primary coil such as the electrical drive unit, for example I^2R losses in the copper of the coil or effective series resistance of any resonating capacitor. The losses also include any magnetic losses in the primary unit and the secondary devices, for example magnetic is hysteretic loop losses in any coils associated with the primary unit and/or secondary devices. According, the control unit 16 may employ, in addition to the measured power, first compensation information relating to losses in the primary unit itself, so as to compensate for those losses in step S3. Alternatively, or in addition, the control unit 16 may employ, in addition to the measured power, second compensation information relating to a parasitic load imposed on the primary unit by the or each secondary device, so as to compensate for the parasitic load of the or each secondary device in step S3.

If it is determined in step S3 that the power supply should be restricted or stopped, then in step S4 the control unit 16 places the primary unit in a shutdown mode in which the inductive power supply from the primary unit is restricted or stopped.

The primary unit will remain in the shutdown mode until it is reset in some way. Such a reset could be manually initiated by a user of the primary unit, or alternatively the

control unit 16 could periodically start to supply inductive power again and repeat steps S1 to S3 to determine whether to remain in the shutdown mode or not.

In step S3, if the control unit 16 determines that the power supply does not need to be restricted or stopped, then in step S6 secondary devices requiring power resume receiving power from the primary unit. Processing then returns, for example after a predetermined interval, to step S1 again.

Next, a first method of detecting the conditions for entering the standby mode will be described with reference to Fig. 3.

In Fig. 3, as shown in step S11, from time to time each secondary device (if any) that is present in the vicinity of the primary unit 10 has a reporting phase. All of the secondary devices which are present may enter a reporting phase simultaneously. Alternatively, each of the secondary devices in turn may enter the reporting phase individually. In either case, in the reporting phase each secondary device reports to the primary unit state information indicating whether the secondary device is in a no-power-requiring state or a power-requiring state. In the no-power-requiring state, an actual load of the secondary device currently requires no power from the primary unit. In the power-requiring state, on the other hand, the actual load does currently require power from the primary unit.

In step S12 the control unit 16 in the primary unit determines if the inductive power supply therefrom should be restricted or stopped in dependence upon the state information reported in step S11. In particular, unless at least one secondary device reports in the reporting phase to the primary unit that it is in the power-requiring state the control unit 16 determines that the inductive power supply should be restricted or stopped and processing proceeds to step S13 in which the primary unit is set into the standby mode. Of course, if no secondary device is present in the vicinity of the primary unit at all, so that in step S11 no or no valid state information is received by the primary unit, then the control unit 16 also sets the primary unit into the standby mode.

As described above in relation to step S5 of the method of Fig. 2, once the primary unit has been set into the standby mode it may be reset into an operating mode again either by manual intervention from a user or automatically.

If in step S12 the control unit 16 determines that the inductive power supply should not be restricted or stopped based on the reported state information, then processing returns to step S11, for example after a predetermined interval. In this way, each secondary device present periodically has a reporting phase in which it reports its state information to the primary unit.

The methods of Figs. 2 and 3 may be carried out independently of one another. However, it is preferable for the control unit 16 of the primary unit to be able to detect both when to enter the shutdown mode and to enter the standby mode. This can be achieved by a combination of the methods of Figs. 2 and 3 as will now be described with reference to Fig. 4.

Figure 4 shows parts of an inductive power transfer system according to a first embodiment of the present invention. The system 1 has a primary unit 10 and a secondary device 30. Figure 4 also shows a parasitic load 500 on the primary unit, caused for example by a foreign object placed in the vicinity of the primary unit 10. The secondary device 30 in this case is assumed to be carried in or by a host object such as a portable electrical or electronic device. As explained hereinbefore the secondary device 30 and/or host object also inevitably impose a "friendly" parasitic load 501 on the primary unit 10.

As described earlier with reference to Figure 1, the primary unit 10 comprises a primary coil 12, an electrical drive unit 14, a control unit 16 and a power measurement unit 100. The electrical drive unit 14 has an input connected to an output of the control unit 16 supplying the AC voltage signal 106. The output nodes of the electrical drive unit 14 are connected to the primary coil 12. The electrical drive unit is connected to the power supply 105, via the power measurement unit 100. The power supply 105 supplies direct current to the electrical drive unit 14. The electrical drive unit 14 presents a high input impedance for the AC voltage signal 106, so that essentially all the load current is drawn from power supply 105.

The control unit 16 is a microprocessor in this embodiment. The microprocessor has an inbuilt digital-to-analogue converter (not shown) to drive the output supplying the AC voltage signal 106. Alternatively, an ASIC could be used to implement the control unit 16, as well as some or all of the other circuit elements of the primary unit.

The control unit 16 in this embodiment is adapted to modulate the AC voltage signal 106 for transmitting a synchronisation signal to a secondary device. The modulation is a frequency modulation of the AC voltage signal. Other modulation techniques such as amplitude or phase modulation may also be used. The control unit 16 is adapted to send a synchronisation signal to any secondary devices 30 present. The secondary devices 30 alter their load conditions in response to the synchronisation signal. This information is used to detect the conditions for entering the shutdown and standby modes.

It is desirable for the power measurement unit 100 to be operative without the need to disconnect the electrical supply to the primary coil 12, as this means that supply to the secondary device 30 is not interrupted and it reduces stray electromagnetic interference into the surrounding environment. This is challenging because there is a lot of noise and the measurement is required in a short time.

The power measurement unit 100 comprises a switch 102 between the 0V supply in the power supply 105 and the ground terminal of the electrical drive unit 14. The switch 102 is controlled by the control unit 16. The power measurement unit also comprises a capacitor 101 connected between the positive and ground terminals of the electrical drive unit 14. The capacitor functions as an energy storage unit. There is a differential amplifier 103 with inputs either side of the switch 102 which has an output coupled to an analogue-to-digital converter 104. The analogue-to-digital converter output is coupled to the control unit 16.

When the switch 102 is closed, the power measurement unit 100 is not operative and the power is directly coupled from the power supply 105 to the electrical drive unit 14. A power measurement is performed when the switch 102 is opened. The capacitor 101 is now disconnected from the 0V rail on the power supply 105, but still retains its charge. The electrical drive unit 14 meanwhile continues to draw current and therefore discharges the capacitor 101. In so doing the voltage across the capacitor 101 decays slightly and consequently the voltage at the point between the capacitor 101 and switch 102 rises slightly above 0V. The reservoir capacitor 107 ensures that the positive supply voltage remains constant. The differential amplifier 103 measures the voltage across the switch 102 and the resulting measurement is converted into a digital signal by the analogue-to-digital converter 104 and passed to the control unit 16. The small

temporary voltage drop across the electrical drive unit 14 does not have any noticeable effect on the power transfer to the secondary devices 30.

Whilst the switch 102 is open, two separate measurements are taken at time t_1 and t_2, giving measurements V_1 and V_2 respectively, shown in Figure 5. There is a delay t_1 after the switch is opened to allow transient effects to stabilise. The power, P is then given by

$$P = CV\frac{dV}{dt} = C\left(V^+ - \frac{(V_1+V_2)}{2}\right)\frac{(V_2-V_1)}{(t_2-t_1)} \approx CV^+\frac{(V_2-V_1)}{(t_2-t_1)}$$

where V^+ is the supply voltage, assuming V_1, $V_2 << V^+$. It is advantageous to sample the voltage level at the same point in the cycle, so that the periodic perturbation in voltage is removed (also shown in Figure 5). The switch 102 is then closed again to reconnect the power supply 105 to the electrical drive unit 14.

Incidentally, instead of the capacitor 101 an inductor could be used as an energy storage unit. In this case, the change measured by the circuitry during the disconnection of the power supply might be a change in current, for example measured as a voltage drop across a series resistor.

The primary unit 10 further comprises a calibration unit 29 in this embodiment. The calibration unit 29 stores compensation information about the losses in the primary unit (e.g. electrical or magnetic losses). By design, at manufacture, and/or periodically thereafter, the losses in the primary unit may be calibrated and stored within the calibration unit 29. The calibration unit 29 supplies the stored information to the control unit 16 to enable the control unit 16 to subtract the losses from the total measurement, thus calculating a number for the loss due to parasitic loads alone. This calibration unit 29 may vary the compensation information to cope with variable losses in the primary unit, for example losses which vary with temperature.

The secondary device 30 comprises a secondary coil 32, a rectifier 34, a secondary control unit 36, a dummy load switch 38, a dummy load 40, a load switch 42, a storage unit 44 and an actual load 46. The dummy load switch 38 and the load switch 42 may each be an FET, for example. The dummy load 40 is, for example, a resistor. The storage unit 44 is a capacitor in this embodiment but an inductor could be used instead.

The actual load 46 is external to the secondary device 30 in this embodiment and is part of the host object. It could be a battery charge controller for a Lithium-ion cell.

There is also a detection unit 200 for detecting a modulation imposed on the received AC signal. To detect a frequency modulated signal, the detection unit 200 may be a zero crossing detector which passes a signal to the control unit every time the AC signal crosses zero volts. The control unit 36 may then comprise an internal clock and counter circuit (not shown). The clock and counter circuit may be used to measure the time interval between successive zero crossings and hence derive the frequency of the AC signal 106 imposed by the primary unit control unit 16. Hence, the secondary unit may detect a change in frequency and respond by altering its load conditions by adjusting switches 42 and 38.

Other forms of load detection circuit 200 may comprise a threshold detector for digital amplitude modulation or an analogue-to-digital converter for multiple level amplitude modulation or a phase detector for phase modulation or any combination thereof.

Operation of the system will now be described.

In an "operating mode" of the system, the host object incorporating the secondary device 30 is placed on or in proximity to the primary unit 10. Switch 102 is closed. The control unit 16 applies an AC voltage signal 106 to the electrical drive unit 14. The electrical drive unit 14 takes DC power from the power supply 105 and amplifies the AC voltage signal 106 and applies it to the primary coil 12.

In the operating mode, the primary coil 12 generates an electromagnetic field in the vicinity of the primary unit 10. The secondary coil 32 couples with this field and an alternating current is induced in the coil by the field. The dummy load switch 38 is open and the load switch 42 is closed. The alternating current induced in the secondary coil 32 is rectified by the rectifier 34 and the rectified current is supplied via the load switch 42 to the storage unit 44 and the actual load 46. In this way, power is transferred inductively from the primary unit 10 to the secondary device 30 and from there to the load 46. The storage unit 44 stores energy in the operating mode.

Whilst in the operating mode, from time to time the control unit 16 in the primary unit 10 initiates a measurement. The measurement starts with the primary unit 10 sending a

synchronisation signal to the secondary unit 30 by applying a momentary frequency change to the AC drive voltage signal 106. The secondary devices 30 receive the AC voltage signal and in each receiving secondary device the detection unit 200 in conjunction with the control unit 36 determine when the synchronisation signal has occurred. In response to a synchronisation signal, the secondary units present alter their load conditions for a set time period and the primary unit 10 measures the total load (power drawn) within this time period.

The secondary device 30 uses the storage unit 44 to store energy from the primary unit 10 during normal operation. During the measurement, the actual load 46 is disconnected by opening switch 42. The energy stored in the storage unit 44 of the secondary device gradually decays as energy is delivered to the load. Provided that the storage unit has sufficient capacity, and is sufficiently well-charged before a measurement commences, the storage unit can deliver continuous power to the secondary device load throughout the measurement, so the actual load 46 is not interrupted.

In this embodiment the primary unit 10 initiates a series of three power measurements for the purposes of determining: 1) whether the there is a parasitic metal present requiring it to enter the shutdown mode to prevent overheating and 2) if there are no devices requiring any power, such that the unit can enter the standby mode. The behaviour of the primary unit 10 and the secondary device 30 is slightly different in each of the three measurements of the series.

During the first measurement, the secondary control unit 36 has the dummy load switch 38 open so that the dummy load 40 is not connected to the secondary coil 32. As a result, the first measurement is a measure of the power delivered to any parasitic loads 500 from foreign objects in the vicinity of the primary unit and any parasitic load 501 imposed by losses in the secondary device and/or its host object and any losses in the primary unit itself. Thus, operation during the first measurement corresponds to the steps S1 to S3 of Figure 2 above.

During the second measurement, the secondary control unit 36 selectively closes the dummy load switch 38. The secondary control unit 36 decides whether to have the dummy load switch 38 open or closed during the second measurement based on the power requirement of the actual load 46. If the load 46 does not require any power at

the present time, for example because it has a rechargeable battery which is presently fully charged, then the dummy load switch 38 is kept open during the second measurement. If, on the other hand, the load 46 does require power at the present time, then the dummy load switch 38 is closed so that the dummy load 40 is connected to the primary coil 32.

The control unit 16 produces another measure of the power load during the second measurement. If the second power measurement is substantially different from the first power measurement, the control unit 16 detects that a secondary device requiring power is present in the vicinity of the primary unit. Thus, operation during the second measurement corresponds to steps S11 and S12 of Figure 3 above.

During the third measurement, the secondary control unit 36 always closes the dummy load switch 38 so that the dummy load 40 is connected to the secondary coil 32.

Another power measure is taken by the control unit 16 in the primary unit. In this case, the measurement is the sum of the parasitic loads 500, the parasitic load 501 of the secondary device and/or host object, primary unit losses, and the dummy load 40. Based on the difference between the first and third power measurements, the control unit calculates the value of the total of the dummy loads 40 in all of the secondary devices present in the vicinity of the primary unit.

The timing of the various signals and measurements is illustrated diagrammatically in Figures 6 (not to scale). Figure 6(a) represents the frequency of the drive applied to the primary coil 12, Figure 6(b) represents the load presented by the secondary device 30, Figure 6(c) represents the state of the switch 102 in the primary unit 10 and Figure 6(d) represents the voltage across the switch 102.

At the start of each measurement, the primary unit 10 first momentarily changes the frequency of the drive to the primary coil 510, 511, 512, for the first, second and third measurements respectively. Then each secondary device 30 isolates its actual load 513, 514, 515 and depending on the circumstances introduces a dummy load 514, 515. Within this time frame, the switch 102 in the primary unit opens 516, 517, 518. Within the window of the switch opening, the voltage across the switch 106 ramps up 519, 520, 521. This voltage is sampled at several points within this window to measure the power. On the first measurement, there is no dummy load 513, on the second

measurement each device only connects the dummy load if its actual load requires power 514, on the third measurement the dummy load is always connected 515.

The secondary device 30 knows which measurement is which by the order in which they occur. If there has been a long gap of say a few ms since the last synchronisation signal then the secondary device knows that it must be the first measurement. The secondary device can count the number of periods in the received alternating current to determine this. The second and third measurement synchronisation signals naturally follow in that order within a set number of cycles. In order to get more accurate measurements, it is possible to average each measurement over a number of sequences.

Each dummy load 40 in a secondary device 30 in the system of this embodiment is set to a particular value (at manufacture or during calibration or testing) so that the value represents the parasitic load 501 imposed by the secondary device concerned and/or by its host object.

Thus, the total dummy load for all secondary devices present, as calculated by the control unit 16, can be used by the control unit 16 as second compensation information to compensate for the parasitic loads 501 of the secondary devices present. For example, if the control unit 16 detects that a substantial parasitic load 500 is present in the vicinity of the primary unit when the measured power exceeds some threshold, the threshold may be increased by an amount dependent on the total parasitic load 501 of all the secondary devices present, so that the detection of parasitic loads 500 from foreign objects is not influenced by the number of secondary devices present.

Figure 7 shows diagrammatically the load drawn for the three measurements. The load drawn is the sum of: the losses associated with the primary coil in the primary unit (pad) 543, the parasitic load associated with foreign metal objects 542, 'friendly parasitics' of metal associated with host object (portable device) to be powered 541 and the current load associated with all the secondary devices 540. The first measurement 530 has all of these components except the load 540. If no devices require power then the second measurement 531 will be the same as the first measurement 530, so the primary unit can be placed into the standby mode (step S4 in Figure 3). However, if at least one device requires power then the second measurement 531 will be greater than the first measurement 530, and power is

required. On the third measurement, each secondary device 30 connects its dummy load. The dummy load of each device 40 is made equal to that device's 'friendly parastics'. By subtracting the first measurement from the third measurement, the result is the 'friendly parasitics' 541. The primary unit loss 543 is known (and stored in the calibration unit 29). To produce a measure of the total parasitic load 542 present, the calculated 'friendly parasitics' 541 and the known primary unit loss 543 may be subtracted from the first measurement 530. If this figure is above a certain threshold then the unit can be placed into the shutdown mode (step S4 in Figure 2).

A system embodying the present invention is capable of measuring loads imposed on the primary unit sensitively, for example to within 50mW or so. With this degree of sensitivity, it is possible to ensure that very little power is coupled into parasitic loads 500 such as foreign objects.

Figure 8 is a diagram illustrating the different modes of operation in the Figure 4 system and the conditions for switching between these different modes. The three modes of operation are an operating mode, a shutdown mode and a standby mode.

In the operating mode, the primary unit is in the normal state (driven condition) most of the time, but periodically does a sequence of three measurements as described above. If the result of the measurement sequence is that no secondary device requires power, the primary unit goes into a standby mode. If the result of the measurement sequence is that a significant parasitic load 500 is present, the primary unit goes into a shutdown mode.

In the standby mode, the electrical drive unit 14 is stopped for most of the time, thus consuming little power. Periodically the primary unit enters the normal mode, then does a series of measurements in respective probing periods, to check whether it should enter either the operating mode or the shutdown mode. Otherwise it remains in the standby mode.

The shutdown mode is functionally identical to standby mode. However, the two modes may be distinguished by some user-interface feature such as an LED to prompt the user to remove any substantial parasitic load 500.

In addition to this first embodiment of the invention, there are many other possible embodiments and combinations of features that may be utilised to advantage.

There are other inductive power transfer systems, which rather than have a single primary coil 12 have a plurality of coils, for instance as described in GB-A-2398176. In such a system there may be two sets of coils which are arranged orthogonally to each other. They may each be driven with the same AC voltage signal, but driven in quadrature (i.e. separated in phase by 90°), such that the induced magnetic field rotates with time. This allows the secondary device 30 to be placed at any orientation and still be able to receive electrical power. The present invention may be used in such a configuration directly. The electrical drive unit 14 not only supplies the AC current drive to the first coil, but also to the second coil. The transmitted synchronisation signals will be present on both coils. Furthermore, since the current measurement is performed by determining the current drawn from the power supply, the power measurement will be the total sum of all the load drawn regardless of what proportion is drawn by each coil. In such a 2 channel rotating system, the orientation of the secondary device 30 is arbitrary. Therefore the secondary device 30 will see a +/- 180° phase difference relative to the primary unit. Therefore the secondary devices 30, must each lift their load for at least 1/2 cycle each side of the primary unit's measurement period.

In addition to the three measurements described, a fourth measurement may be made. This measure is initiated by the control unit 16 in the primary unit 10, and results in the power measurement unit 100 taking a power measurement, but without any synchronisation signal being sent to the primary coil 12. The secondary units 30 do not alter their load conditions and this is therefore a measurement of the power whilst in the operating state. This measurement can be performed at any time other than during a measurement sequence of the first three measurements. This fourth measurement is used to determine if the total load drawn is greater than the power specification of the device and hence put the primary unit into an 'overload state'. The 'overload' state is functionally identical to the 'shutdown state', but may be distinguished by some use-interface feature such as an LED.

Another possibility is for the electrical drive unit 14 to be adapted to modify the magnitude of its output current into the primary coil for the purpose of varying the field magnitude of the generated magnetic field. This would allow the field magnitude to be

reduced for small loads, thereby conserving electrical power. An implementation of this feature is to use the first and second measurements in a different way, not only to detect if devices require power, but also to set the required field magnitude. Instead of switching in the dummy load 40 during the second measurement if it needs power, a secondary device could switch in its dummy load if it is not getting sufficient power. The presence of a difference between the first and second measurements would then be taken by the primary unit as a "not enough power" signal. The primary unit 10 could periodically bring the field up to maximum magnitude and then gradually reduce it until the difference between the first and second measurements was greater than a certain threshold ("not enough power" signal). This way the primary unit would always be operating at the lowest possible field magnitude.

In another embodiment, the secondary devices are adapted for changing the magnitude of their dummy loads dynamically. This could be achieved for instance by incorporating a load which may be altered in value by a control means. A simple example might be a resistor ladder with an array of switches, which may be arranged with values in binary increments. The load may be adapted to have a continuously variable magnitude by use of a transistor circuit or by incorporation of some other nonlinear element. Another way of dynamically changing the load is to modulate the switch 40 which connects the load, such that when the power measurement is averaged over the measurement time interval, the effective load is altered. The pulse width or duty cycle could be altered to change the effective load magnitude.

The ability to change the dummy load dynamically is useful for devices whose 'friendly parasitic' load may change. For instance a self-charging battery may have a different 'friendly parasitic' load when charged alone, compared to when it is charged whilst connected to a mobile phone. The control unit 36 could detect whether the phone was attached and modify the dummy load accordingly. Alternatively, the phone could communicate its 'friendly parasitics' to the battery. Other removable attachments which contribute additional 'friendly parasitic' load could also be detected and the dummy load modified accordingly. These include for example, but are not limited to, removable camera attachments, cases and speakers.

In addition to giving information about the load requirements and parasitic information of the secondary device 30, this method could be used such that the primary unit 10 could deduce other information about the secondary device 30. For example the

primary unit 10 could receive information about the serial number, model number, power requirements or other information stored in the secondary device. The load could be altered dynamically either synchronously or asynchronously to achieve this. Amplitude modulation or pulse width modulation may be used. A number of 'bits' or 'symbols' may be used (where a 'symbol' represents a plurality of amplitude levels or pulse width durations and therefore more than one 'bit').

In another embodiment, the primary unit 10 could communicate information to the secondary device 30, other than synchronisation signals, by means of modulating the AC voltage signal 106 applied to the electrical drive unit. This information may include but is not limited to information about the primary unit 10, such as cost of a charge, power capability, codes; information about the location of the primary unit, such as nearby facilities; and other information such as advertising material. The secondary device 30 could receive such information by means of the detection element 200 and the control unit 36.

It will be apparent to those skilled in the art that it is not necessary to implement all these features simultaneously in order to gain advantage. For instance by only using the first and second measurements, the standby detect feature may be implemented. Similarly, by only using the first and third measurements, the parasitic detect feature may be implemented. By only using the fourth measurement, the overload detect feature may be implemented. Information about the secondary device 30 may be deduced by the primary unit, without implementing other features. Similarly, information may be sent from the primary unit to the secondary device without implementing other features. Further measurements may be used to implement additional features. It should be appreciated that the labelling of each measurement is purely for identification purposes and the measurements may be performed in any order.

In addition to the described method of sending a synchronisation signal before each measurement and identifying each measurement by the order in which they occur, there are other methods of identifying each measurement. These include but are not limited to: sending a different synchronisation signal before each measurement, whereby synchronisation signals may differ in frequency offset, amplitude or phase; or sending only a first synchronisation signal and deducing the timing of the other measurements may be means of either a counter to count cycles of the received signal or an internal clock within each secondary device. It is even possible to perform the

measurements back to back, with no substantial gap between them. Alternatively measurements are initiated by the secondary device rather than the primary unit. The secondary device could initiate a 'preamble' dynamic load modulation, which the primary unit would detect and then synchronise on, so that its power measurements coincided with the timing of the secondary device adapting its load conditions. For primary units capable of simultaneously supplying power to more than one secondary device, the 'preamble' could involve the use of some unique identifier, so that each secondary device may be interrogated independently. 'Preambles' could also be used in communication from the primary unit to the secondary device to address each device independently.

As described above, the dummy load may be used to represent the 'friendly parasitic' load of the host device. Of course, the ratio between the dummy load value and the friendly parasitic load to be communicated is not limited to any particular value. For instance the dummy load could be twice or three times the 'friendly parasitic' value or a noninteger multiple of the value. The primary unit can deduce the total 'friendly parasitic load' so long as it knows what the ratio is. Furthermore, if a device does not have any significant 'friendly parasitic' load, it may be desirable to 'assign' it a particular value, so that it may be used for indicating whether the device requires charge. It may be desirable to use more than one dummy load. A first dummy load may be used for the second measurement and a second dummy load may be used for the third measurement. The first dummy load would be used for standby detection and the second dummy load would be representative of the 'friendly parasitics'. This is particularly advantageous if the secondary devices have widely varying parasitic loads. The first dummy load could also be used for determining the power requirements of the secondary devices requiring charging, rather just making a standby decision. The dummy load value would be adapted to be representative of the power requirements of that particular device. The first and second dummy loads may be implemented by a single dynamically variable dummy load described above, or fixed loads may be used, or a combination of the two.

In addition to the power measurement method and apparatus described, it will be appreciated that there are many methods which can be used to detect the load on the primary coil or coils. The simplest power measurement may comprise inserting a series resistor on one supply rail. The voltage could be measured across that resistor and the power deduced from the observed voltage and the known resistor value. With such a

method it may be desirable to incorporate a switch across the resistor, so that during periods outside of the measurement time, the resistor may be short circuited, such that there is no unnecessary power dissipation in the resistor.

Another method of power measurement is to measure the power within the electrical drive unit. For instance, it is desirable for the electrical drive to the coil or coils to be regulated by means of a feedback circuit. The feedback signal may be used to derive a power measurement.

It is also possible to combine the functions of sending a synchronisation signal and power measurement within a single element as described for instance, in the applicant's copending application GB 0410503.7 filed on 11th May 2004, from which the present application claims priority. In that system, the power measurement involves disconnecting the power to the primary coils and detecting the decay in the undriven resonant circuit. The act of disconnecting the power to the primary coil 12 also has the effect of modulating the signal in the primary coil and as a result the signal received in the secondary device 30.

Figure 9 shows a second embodiment of a power transfer system according to the present invention. This embodiment differs from the first embodiment of Fig. 4 mainly in the way in which the power measurements are carried out. The primary unit 110 comprises a primary coil 112, an electrical drive unit 114, a control unit 116 and a decay measurement unit 118. The electrical drive unit 114 in this embodiment has a conventional half bridge configuration in which a first switch 120 is connected between a first power supply line of the primary unit and an output node of the electrical drive unit, and a second switch 121 is connected between the output node and a second power supply line of the primary unit. The first and second switches 120 and 121 may, for example, be field-effect transistors (FETs).

The electrical drive unit 114 also comprises a drive controller 119 which applies control signals to the switches 121 and 122 to turn them on and off. The drive controller 119 has a control input connected to an output of the control unit 116. The output node of the electrical drive unit 114 is connected via a capacitor 117 to one side of the primary coil 112.

The control unit 116 is a microprocessor in this embodiment. Alternatively, an ASIC could be used to implement the control unit 116, as well as some or all of the other circuit elements of the primary unit.

The decay measurement unit 118 comprises a resistor 125 which has a first node connected to one side of a switch 128 and a second node connected to the second power supply line. The resistor 125 is a low-value resistor. The decay measurement unit 118 further comprises an operational amplifier 126 having an input connected to the first node of the resistor 125. The decay measurement unit 118 also comprises an analog-to-digital converter (ADC) 127 connected to an output of the operational amplifier 126. An output of the ADC 127 is connected to a measurement input of the control unit 116.

The other side of the switch 128 is connected to the other side of the primary coil 112. A snubber unit 122 is connected in parallel with the switch 128. The snubber unit 122 comprises a capacitor 123 and a resistor 124 connected in series with one another. The calibration unit 129 is the same as the calibration unit 29 in Figure 4.

Each secondary device in this embodiment can be substantially the same as the secondary device 30 in Figure 4, and accordingly a description thereof is omitted here and no secondary device is illustrated in Figure 9.

Operation of the Figure 9 system will now be described with reference to Figure 10.

Initially, the system has a normal state in which the control unit 116 causes the electrical drive unit 114 to apply drive signals to the primary coil 112 to cause it to oscillate. It will be appreciated that in the operating mode, the system is in this state for almost all the time. The switch 128 is closed, and the circuit including the capacitor 117 and primary coil 112 forms a resonant tank.

The next state is a "snub" state. The application of drive signals to the primary coil 112 by the electrical drive unit 114 is suspended under the control of the control unit 116. The drive controller 119 closes the switch 121. The control unit 116 also opens the switch 128 at a time when most of the energy in the resonant tank resides in the capacitor 117. The opening of the switch 128 brings the snubber unit 122 in series with the resonant tank. The snubber unit 122 quickly dissipates any energy which remains

in the primary coil 112, stopping it from resonating within one cycle or so. Most of the energy stored in the resonant tank is left in the capacitor 117. The sudden cessation of cycles is detected by the detection unit 200 and the secondary control unit 36 in the secondary device 30. The secondary control unit 36 opens the load switch 42. Incidentally, it will be appreciated that he detection unit 200 in Figure 4 needs to be modified to detect the sudden cessation of cycles in the snub state in the present embodiment. A threshold detector (as mentioned above) may be used as the detection unit in the present embodiment.

In this embodiment, therefore, the snub state is used as the synchronisation signal to the secondary device, though the other forms (e.g. frequency or phase modulation) could also be used. It is not always necessary to have a synchronisation signal before every measurement as described above.

The system then enters the decay state from the snub state. The control unit 116 closes the switch 128, removing the snubber unit 122 from the resonant tank, and thus allowing the energy in capacitor 117 to flow again within the resonant tank. In the decay state, the resonant tank operates in an undriven resonating condition. Energy stored in the resonant tank decays over the course of time in the decay state. In this embodiment, the decay measurement unit 118 measures the energy decay in the resonant tank by measuring the current flowing through the primary coil 112. The same current flows through the resistor 125 and generates a voltage at the first node of that resistor. This voltage is buffered by the operational amplifier 126 and converted into a digital signal by the ADC 127. The resulting digital signal is applied to the measurement input of the control unit 116.

Figure 10 shows how the current flowing through the primary coil 12 varies in the normal, snub and decay states which occur during a power measurement. In this embodiment, the digital signals representing the current flowing in the primary coil within a measurement period are received and processed within the control unit 16 to calculate a measure of the rate of energy decay in the resonant tank.

An equation describing the energy stored in the resonant tank, at resonance, is:

$$E = \frac{1}{2} L\hat{I}^2 = \frac{1}{2} C\hat{V}^2$$

where E is the energy, L the inductance, $\hat{I}$ is the peak current, C is the capacitance and $\hat{V}$ is the peak voltage.

Therefore the energy stored in the resonant tank of the primary unit at any given moment can be calculated if the inductance and peak current are known, or if the capacitance and peak voltage are known, or combinations thereof. Typically the capacitance is known by design, the peak current and voltage can be measured by suitable circuitry, and the inductance can be deduced by observing the natural resonant frequency during the measurement and applying the formula:

$$L = \frac{1}{4\pi^2 f^2 C}$$

The power measure, *P*, is given by the rate of decay of energy (and thus the loss) from the resonant tank and can be calculated by measuring E_1 at time T_1 and E_2 at another time T_2.

$$P = \frac{E_2 - E_1}{T_2 - T_1}$$

Since at resonance the voltage and current in the resonant tank will be 90 degrees out of phase with one another, a convenient method of reading the peak voltage of one is to trigger the measurement on the zero-crossing of the other.

A second method for detecting a shutdown condition in accordance with the present invention will be described with reference to Fig. 11. This method can be used in the Figure 1 system.

When the Fig. 1 system is in use, from time to time each secondary device which is in the power-requiring state supplies information to the primary unit relating to its own power requirement. The power requirement information may take many different forms. For example, the information may comprise a binary part used to indicate either "no power required" or "power required". In this case, in the event that a binary part is "power required", supplemental information may be provided by the secondary device to indicate the amount of power required. Alternatively the power requirement information may simply be representative of the amount of power required, and "0" may be transmitted if the device requires no power at all. It is also possible that the power requirement of the secondary device may already be known to the primary unit. For example, it may be known that all secondary devices of a certain type will have a

particular power requirement. In this case, the power requirement information may simply be a code (or some other identifying information) indicating the type of the secondary device.

All of the secondary devices may supply the power requirement information simultaneously to the primary unit. Alternatively, each secondary device supplies its power requirement information individually in turn to the primary unit.

The power requirement information supplied by each secondary device that has the power-requiring state is received by the primary unit.

In step S22, the control unit 16 in the primary unit causes the power measurement unit 100 to measure the power drawn by the secondary devices from the primary unit as described previously. In practice, the measured power will also reflect any losses in the system.

In step S23 the control unit 16 determines whether inductive power supply from the primary unit should be restricted or stopped in dependence upon the measured power in step S22 and the power requirement information received in step S21. For example, the control unit 16 calculates a sum of the respective power requirements of all of the secondary devices that are in the power-requiring state. This sum is compared with the measured power found in step S22. If the measured power exceeds the sum of the power requirements by more than a threshold value, then the control unit determines that a substantial parasitic load must be present in the vicinity of the primary unit. In that case, processing proceeds to step S24 in which the primary unit enters the shutdown mode and inductive power supply from the primary unit is restricted or stopped. As described previously in relation to the method of Fig. 2, the system may be reset manually or automatically in step S25.

If in step S23 the control unit 16 determines that the power supply need not be restricted or stopped, then processing returns to step S21, for example after a predetermined time interval.

To compensate for the losses in the primary unit and/or secondary devices, the shutdown threshold employed in step S23 may be adjusted. One way in which this can be done is for each secondary device (whether or not in the power-requiring state) to

also supply to the primary unit information relating to its "friendly parasitic" load. Similarly, losses as in the primary unit may be accounted for using a calibration unit as described with reference to Fig. 4.

Fig. 12 shows parts of a power transfer system according to a third embodiment of the present invention. This system implements the shutdown detection method of Fig. 11 using an RFID communication method.

The Fig. 12 system comprises a plurality of secondary devices 600_1, 600_2, ..., 600_n. The system of Fig. 12 also comprises a primary unit 700. The primary unit 700 comprises an RFID unit 710, a control unit 720 and a power measurement unit 730. The control unit 720 corresponds generally to the control unit 16 described previously with reference to Fig. 1, and the power measurement unit 730 corresponds generally to the power measurement unit 100 described in reference to Fig. 1.

The features of the secondary device 600 are generally the same as those of the secondary device 30 in Figure 4 except that the elements 38, 40, 42, 44 and 200 may be omitted. Instead of these elements, each secondary device 600 comprises its own load measuring unit 610 and an RFID unit 620. The load measuring unit 610 measures the power being supplied to the actual load (46 in Fig. 4) of that secondary device. For example, the load measuring unit 610 may measure the current and/or voltage being supplied to the actual load 46 and may possibly integrate these measures over time for averaging purposes. For example, the averaging period may be ten seconds.

The RFID unit 620 in each secondary device is capable of communicating with the RFID unit 710 in the primary unit 700 using an RFID link 630. The load measure produced by the load measuring unit 610 in each secondary device is supplied to the RFID unit 620 in the device and then transmitted via the relevant RFID link 630 to the RFID unit 710 in the primary unit. For example, the RFID unit 710 may poll the RFID unit 610 in each of the secondary devices from time to time. In response, the RFID unit 620 that has been polled transmits its load measure. This load measure corresponds to the power requirement information of step S21 in Fig. 11.

The power measurement unit 730 in the primary unit also measures the power being drawn by the secondary devices from the primary unit, as in step S22 in Fig. 11. Then, the control unit 720 determines, in dependence upon the measured power and the sum

of the received load measures from the secondary devices, whether or not the power supply to the secondary devices should be restricted or stopped. In particular, if the measured power from the power measurement unit 730 exceeds the sum of the load measures from the secondary devices by more than a shutdown threshold, then the control unit 720 concludes that a substantial parasitic load must be present and places the primary unit in the shutdown mode, as in step S24 in Fig. 11.

It is also possible for the load measure produced by each secondary device to represent a total load from the secondary device including the amount of power required by the actual load and any friendly parasitic load of the secondary device/host object. If the actual load requires no power the load measure may change to represent only the friendly parasitic load.

Some anti-collision or collision avoidance technique is necessary in the Fig. 12 embodiment. In one known collision avoidance technique, every RFID unit 620 has an unique code (or one which will be practically unique based on statistics). The RFID unit 710 in the primary unit would send out a signal requesting that all RFID units 620 within a certain range reply. The RFID units 620 send out their reply in code (e.g. Manchester code), so that the RFID unit 710 can tell if more than one device has replied. The primary unit gradually narrows down the range until it can uniquely identify the code of each device present. Typically, it may halve the range of codes in each iteration to home in quickly.

It will be appreciated that instead of RFID, any suitable communication link can be used to permit each secondary device to communicate its power requirement information to the primary unit. For example, infrared or ultrasound communication could be used. Alternatively, each secondary device could vary the load it imposes on the primary unit to communicate the power requirement information. For example, each secondary device could impose a dummy load representing the amount of power required by its actual load. In this technique, all the secondary devices in the power-requiring state can impose their respective dummy loads simultaneously, so that the primary unit can directly derive the sum of the power requirements of all the secondary devices in one measurement. Alternatively, the dummy load may represent a total load from the secondary device including the amount of power required by the actual load and any friendly parasitic load of the secondary device/host object.

CLAIMS:

1. A method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit operable to generate an electromagnetic field and at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween, which method comprises:

detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices; and

following such detection, restricting or stopping the inductive power supply from the primary unit.

2. A method as claimed in claim 1, further comprising:

setting the or each secondary device to a no-load state in which supply of any of the power received inductively by the secondary device to an actual load thereof is substantially prevented; and

in the primary unit, measuring a power drawn from the primary unit when the or each secondary device is set into said no-load state, and restricting or stopping the inductive power supply from the primary unit in dependence upon the measured power.

3. A method as claimed in claim 2, wherein the inductive power supply is restricted or stopped in the event that the measured power is greater than a threshold value.

4. A method as claimed in claim 2 or 3, further comprising restricting or stopping the inductive power supply in the event that the measured power is less than a standby threshold value.

5. A method as claimed in claim 1, further comprising:

in the primary unit, receiving, from the or each secondary device that is in a power-requiring state, information relating to a power requirement of the secondary device concerned; and

in the primary unit, measuring the power drawn from the primary unit when power is being supplied to the or each secondary device having the power-requiring state, and restricting or stopping the inductive power transfer from the primary unit in dependence upon the measured power and the received power requirement information.

6. A method as claimed in claim 5, wherein the inductive power supply from the primary unit is restricted or stopped in dependence upon a difference between said measured power and a sum of the respective power requirements of the secondary devices having said power-requiring state.

7. A method as claimed in claim 6, wherein the inductive power supply is restricted or stopped in the event that the measured power exceeds said sum by more than a threshold value.

8. A method as claimed in any one of claims 5 to 7, wherein the or each secondary device transmits its power requirement information to the primary unit using an RFID method.

9. A method as claimed in any one of claims 5 to 7, wherein the or each secondary device transmits its power requirement information to the primary unit by varying a load imposed by the secondary device on the primary unit.

10. A method as claimed in any one of claims 5 to 9, wherein the primary unit has registered therein a power requirement of at least one said secondary device, and said power requirement information transmitted from that secondary device is information identifying the secondary device, and the primary unit employs said identifying information to retrieve the registered power requirement for the device.

11. A method as claimed in any one of claims 5 to 10, wherein the or each said secondary device not having the power-requiring state also transmits such power requirement information to the primary unit.

12. A method as claimed in claim 11, wherein the power requirement information transmitted by the or each said secondary device not in said power-requiring state is representative of a parasitic load imposed on the primary unit by the secondary device.

13. A method as claimed in any preceding claim, further comprising employing, when carrying out said detection, first compensation information relating to losses in the primary unit itself so as compensate for said losses.

14. A method as claimed in claim 13, further comprising deriving part or all of said first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation.

15. A method as claimed in any preceding claim, further comprising employing, when carrying out said detection, second compensation information relating to a parasitic load imposed on the primary unit by the or each secondary device so as to compensate for said parasitic load of the or each secondary device.

16. A method as claimed in claim 15, wherein the or each said secondary device communicates its said second compensation information directly to said primary unit or communicates to the primary unit other information from which the primary unit derives said second compensation information.

17. A method as claimed in claim 16, wherein the or each said secondary device communicates its said second compensation information or its said other information to the primary unit by varying a load imposed by it on the primary unit.

18. A method as claimed in claim 17, wherein the or each said secondary device has a dummy load, representative of its said parasitic load, which it imposes on said primary unit to vary the load imposed by it on the primary unit.

19. A method as claimed in any one of claims 13 to 18, wherein part or all of said first compensation information and/or part or all of said second compensation information is information stored in the primary unit during manufacture and/or testing of the primary unit.

20. A method as claimed in any one of claims 13 to 19, further comprising varying one or both of said first and second compensation information when one or more operating conditions of the primary unit varies.

21. A method as claimed in any one of claims 13 to 20, wherein the or one said secondary device is capable of being used either by itself or combination with another object, and said second compensation information is varied in dependence upon whether the device is used by itself or in said combination.

22. A method as claimed in any preceding claim, wherein:

the or each said secondary device reports to the primary unit state information indicating whether the secondary device is in a no-power-requiring state, in which an actual load of the secondary device currently requires no power from the primary unit, or a power-requiring state in which said active load does currently require power from the primary unit; and

the primary unit restricts or stops the inductive power supply therefrom in dependence upon the state information reported by the or each secondary device.

23. A method as claimed in claim 22, wherein the primary unit restricts or stops the inductive power transfer unless the state information reported by at least one secondary device indicates that it has said power-requiring state.

24. A method as claimed in claim 22 or 23, wherein two or more secondary devices report their respective state information simultaneously to the primary unit.

25. A method as claimed in claim 22, 23 or 24, wherein the or each said secondary device reports its said state information by varying a load imposed by it on the primary unit.

26. A method as claimed in any preceding claim, further comprising transmitting a synchronising signal from the primary unit to the or each said secondary device, or from the or each said secondary device to the primary unit, to synchronise operation of the primary unit and the or each said secondary device.

27. A method as claimed in claim 26, wherein said electromagnetic field is generated by a primary coil of the primary unit, and the synchronising signal is transmitted from the primary unit to the or each said secondary device by modulating a drive signal applied to said primary coil.

28. A method as claimed in any preceding claim, wherein the electromagnetic field is generated by a primary coil driven by an electrical drive unit, electrical power for the drive unit is supplied from a power supply of the primary unit to a power input of the drive unit, and the power drawn from the primary unit is measured by temporarily disconnecting the power supply and detecting a change at said power input during the disconnection.

29. A method as claimed in claim 28, further comprising storing energy in an energy storage unit connected to said power input so that power can continue to be supplied to said power input whilst said power supply is disconnected.

30. A method as claimed in any one of claims 1 to 27, wherein the electromagnetic field is generated by a primary coil, and the method further comprises:

causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of drive signals to the primary coil is suspended so that energy stored in the circuit decays over the course of said period;

taking one or more measures of such energy decay during said period and employing said one or more measures to measure said power drawn from the primary unit.

31. A method as claimed in any preceding claim, further comprising varying a field strength of said field in dependence upon the power required by the secondary device or, if there is more than one secondary device, the combined power required by the secondary devices.

32. An inductive power transfer system comprising:

a primary unit operable to generate an electromagnetic field;

at least one secondary device, separable from the primary unit, and adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

means for detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices; and

means operable, following such detection, to restrict or stop the inductive power supply from the primary unit.

33. A primary unit, for use in an inductive power transfer system that also has at least one secondary device separable from the primary unit, the primary unit comprising:

means for generating an electromagnetic field which couples with said at least one secondary device when it is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

means for detecting if there is a substantial difference between, on the one hand, a power drawn from the primary unit and, on the other hand, a power required by the secondary device or, if there is more than one secondary device, a combined power required by the secondary devices; and

means operable, following such detection, to restrict or stop the inductive power supply from the primary unit.

34. A secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising:

a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and

detecting means for detecting a synchronisation signal transmitted by the primary unit; and

control means, responsive to the detection of the synchronisation signal, to set the secondary device into a no-load state in which supply by the load connection means of any of the inductively-received power to said load is substantially prevented.

35. A secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising:

a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and

RFID communication means operable to supply to the primary unit, using an RFID communication method, information relating to a power requirement of the secondary device.

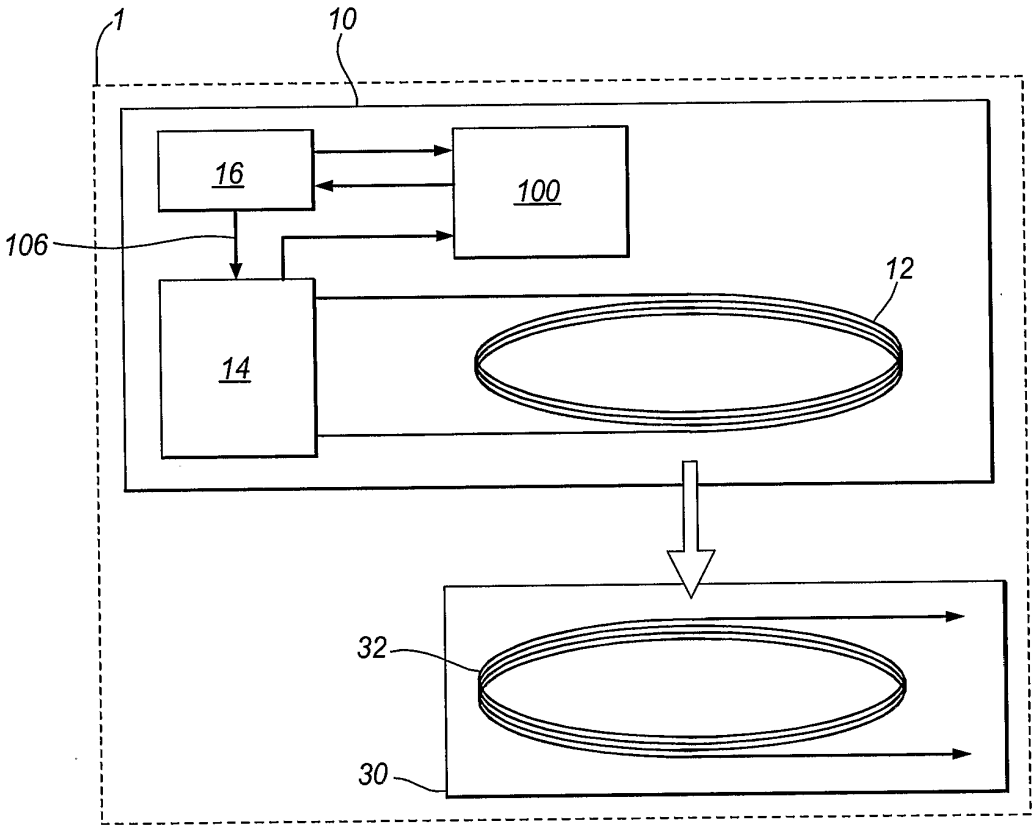


Fig.1

2/11

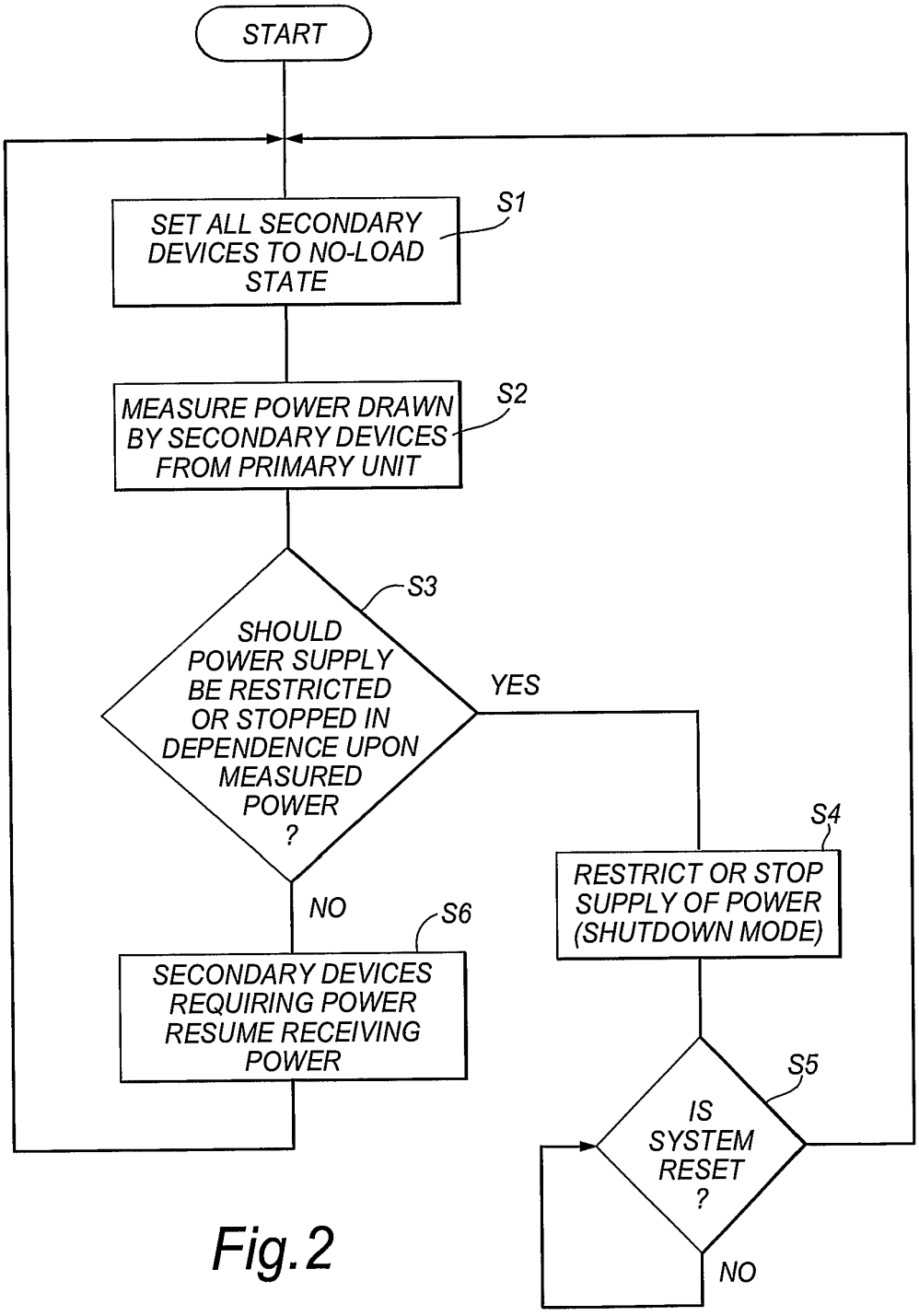

START
SET ALL SECONDARY DEVICES TO NO-LOAD STATE
S1
MEASURE POWER DRAWN BY SECONDARY DEVICES FROM PRIMARY UNIT
S2
SHOULD POWER SUPPLY BE RESTRICTED OR STOPPED IN DEPENDENCE UPON MEASURED POWER ?
S3
YES
NO
RESTRICT OR STOP SUPPLY OF POWER (SHUTDOWN MODE)
S4
SECONDARY DEVICES REQUIRING POWER RESUME RECEIVING POWER
S6
IS SYSTEM RESET ?
S5
NO

Fig.2

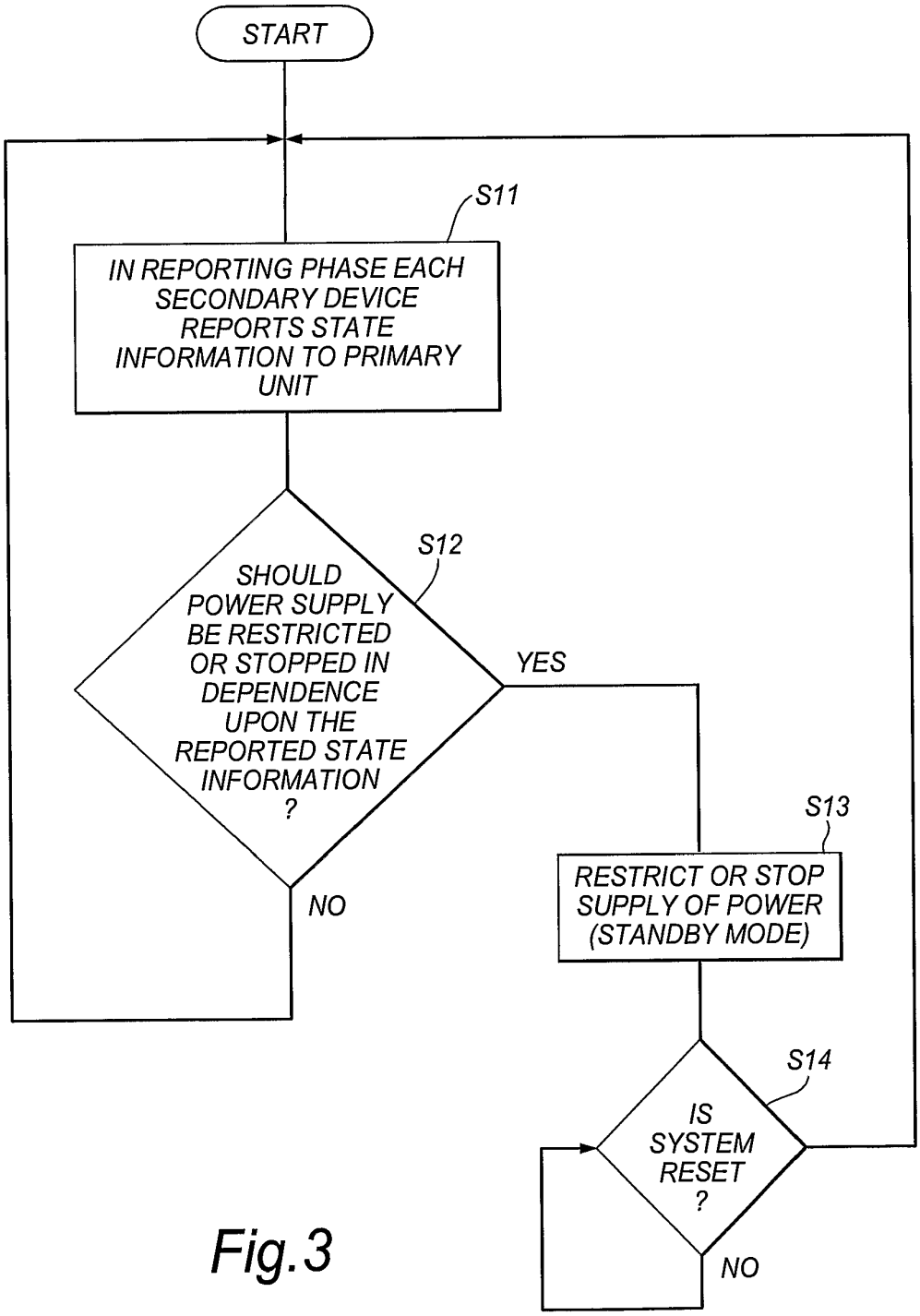

START
S11
IN REPORTING PHASE EACH SECONDARY DEVICE REPORTS STATE INFORMATION TO PRIMARY UNIT
S12
SHOULD POWER SUPPLY BE RESTRICTED OR STOPPED IN DEPENDENCE UPON THE REPORTED STATE INFORMATION ?
YES
NO
S13
RESTRICT OR STOP SUPPLY OF POWER (STANDBY MODE)
S14
IS SYSTEM RESET ?
NO

Fig.3

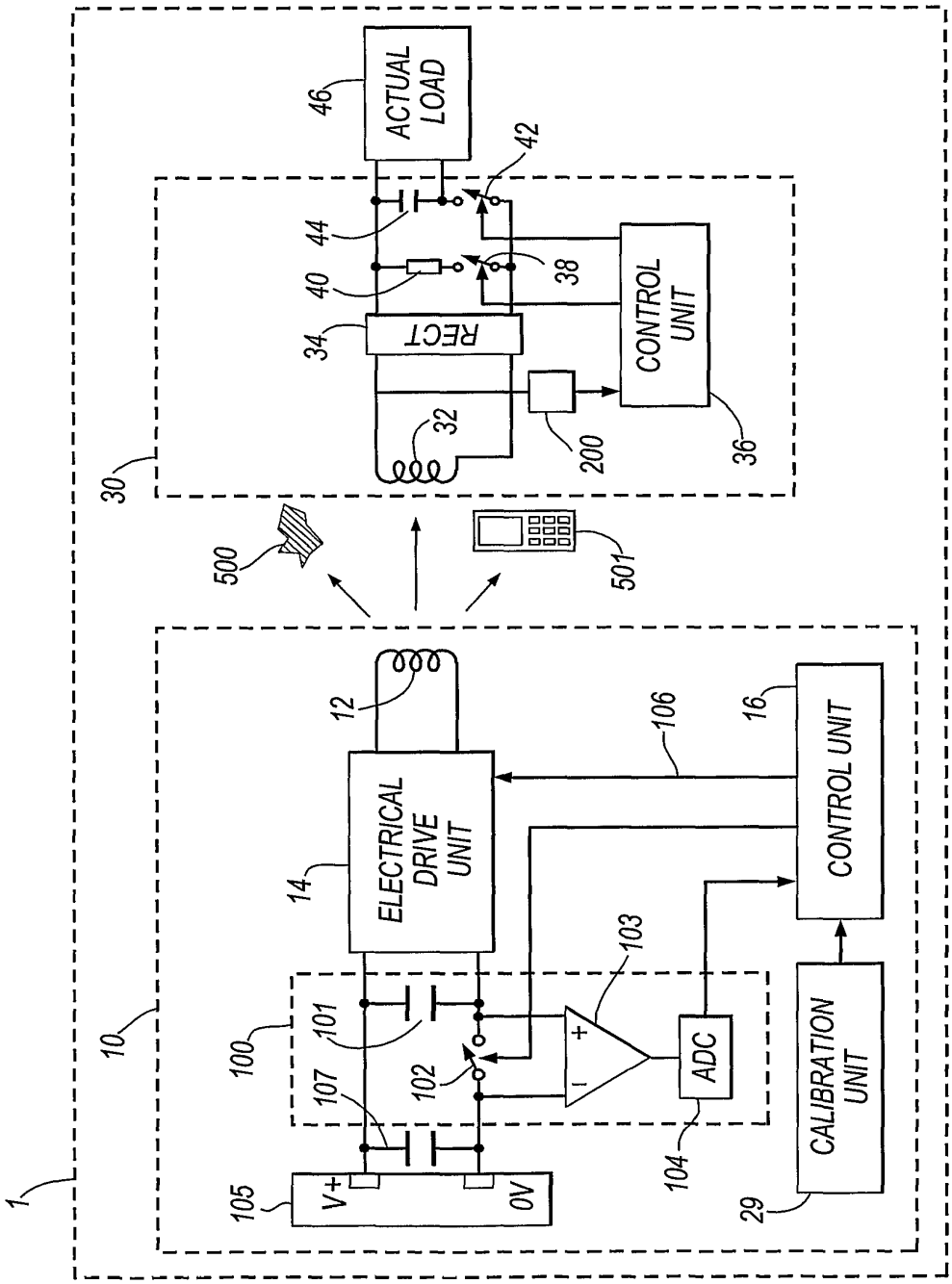

ACTUAL LOAD
46
42
44
40
38
CONTROL UNIT
34
REACT
32
200
36
30
500
501
12
106
16
CONTROL UNIT
ELECTRICAL DRIVE UNIT
14
103
10
100
101
102
107
ADC
CALIBRATION UNIT
104
29
105
V+
0V
1

Fig.4

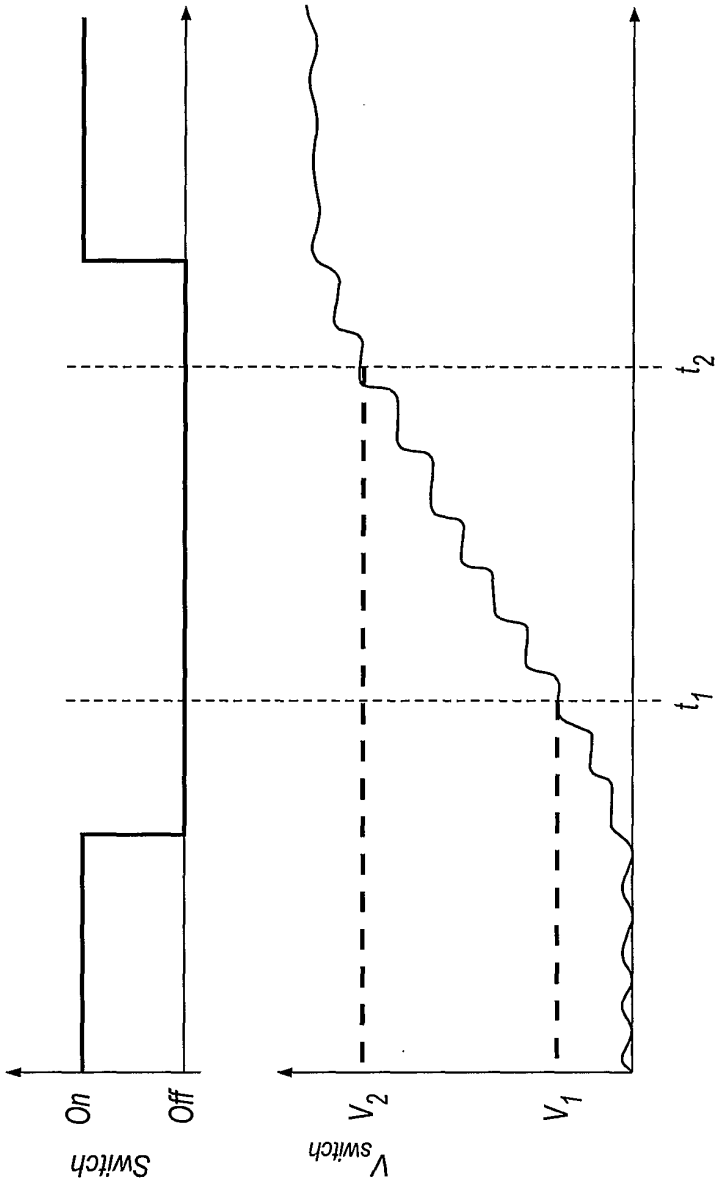
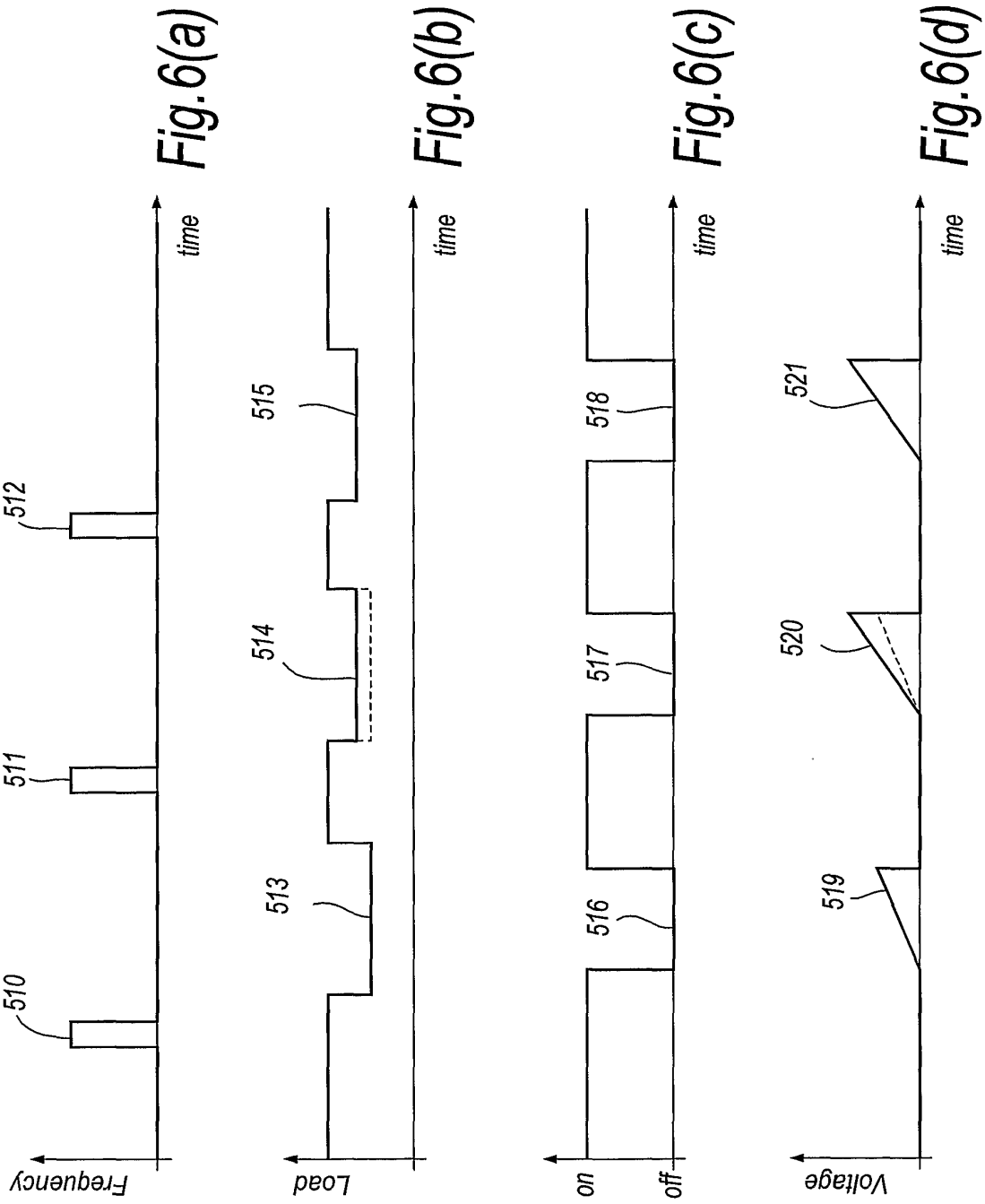


Fig.5


Fig.6(a)
time
Frequency
510
511
512
Fig.6(b)
time
Load
513
514
515
Fig.6(c)
time
on
off
516
517
518
Fig.6(d)
time
Voltage
519
520
521

7/11

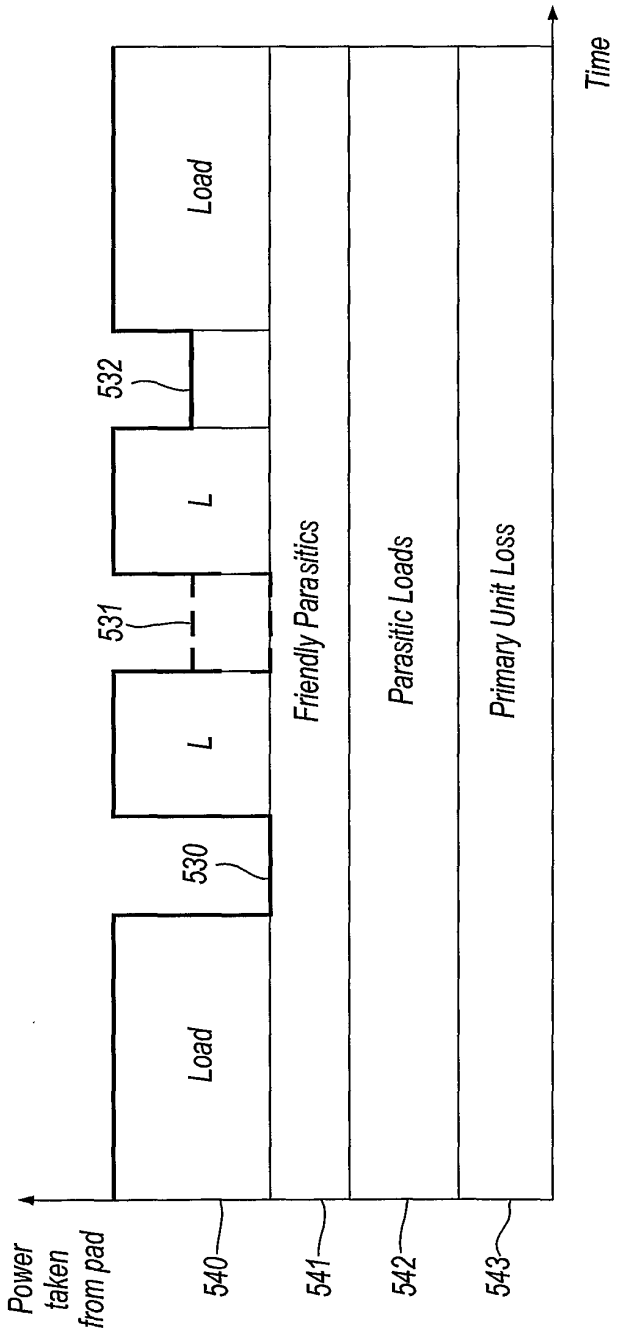

Time
Load
532
L
531
L
530
Load
Friendly Parasitics
Parasitic Loads
Primary Unit Loss
Power taken from pad
540
541
542
543

Fig.7

8/11

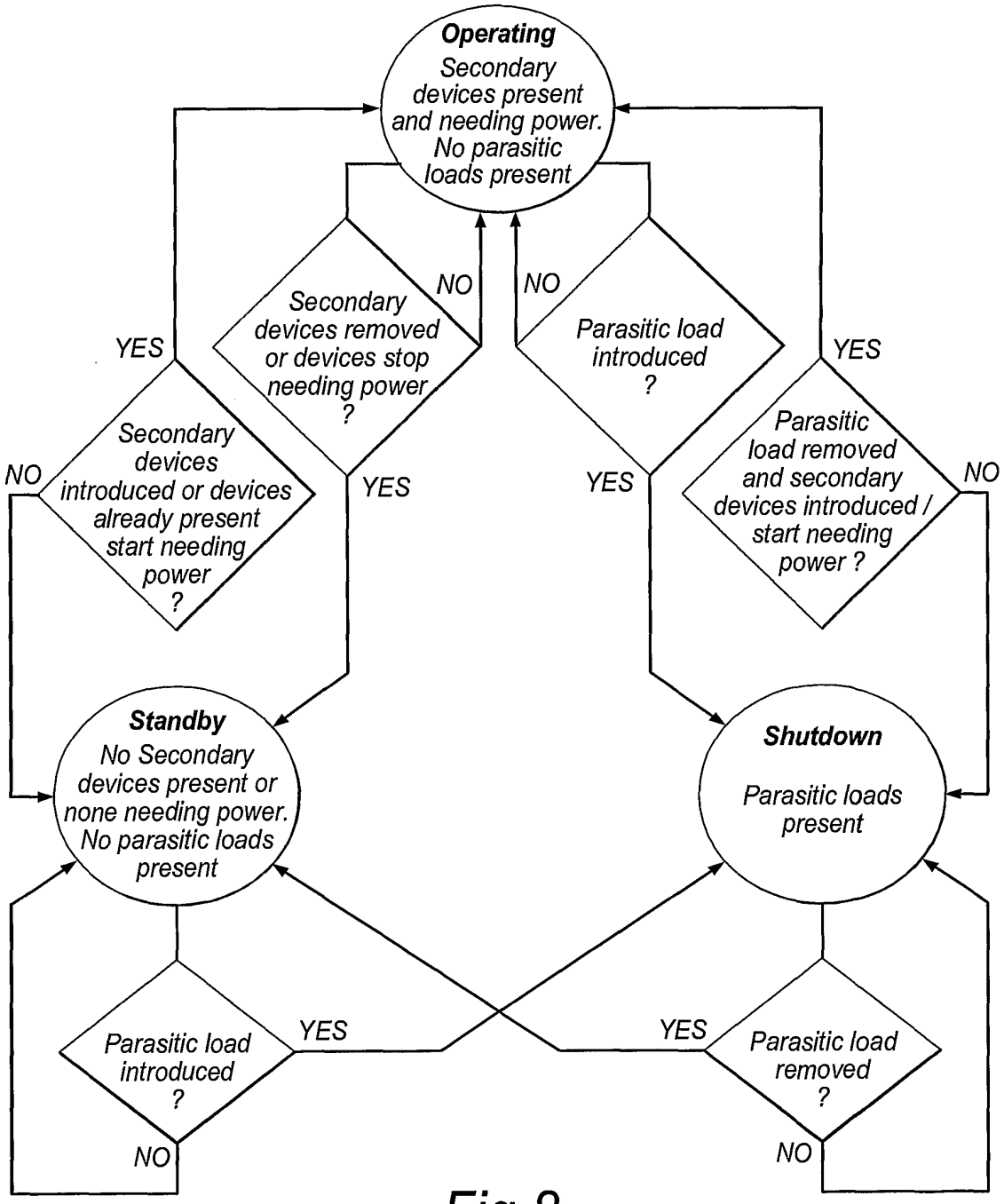

Operating
Secondary devices present and needing power. No parasitic loads present
Secondary devices removed or devices stop needing power ?
NO
YES
Parasitic load introduced ?
NO
YES
Secondary devices introduced or devices already present start needing power ?
NO
YES
Parasitic load removed and secondary devices introduced / start needing power ?
YES
NO
Standby
No Secondary devices present or none needing power. No parasitic loads present
Shutdown
Parasitic loads present
Parasitic load introduced ?
YES
NO
Parasitic load removed ?
YES
NO

Fig.8

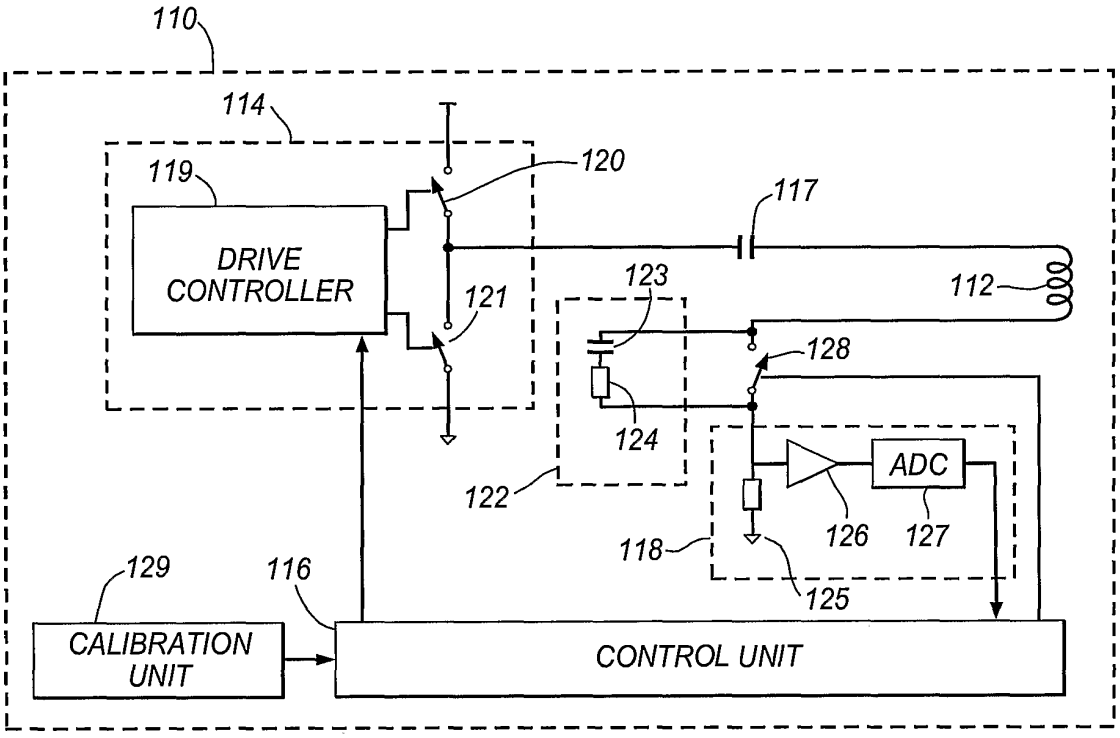

110
114
119
DRIVE CONTROLLER
120
121
117
112
123
124
128
122
ADC
126
127
118
125
129
116
CALIBRATION UNIT
CONTROL UNIT

Fig.9

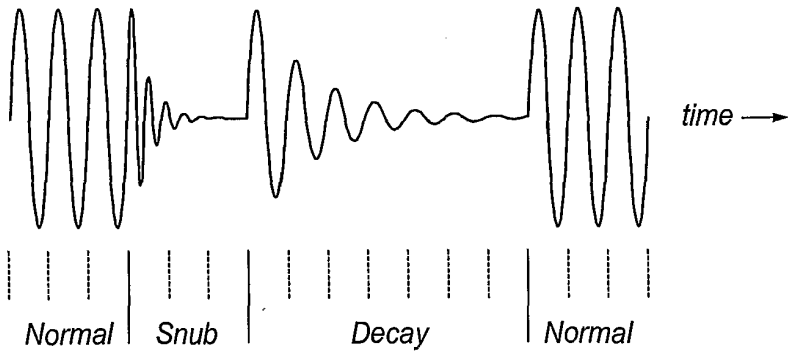

time
Normal
Snub
Decay
Normal

Fig.10

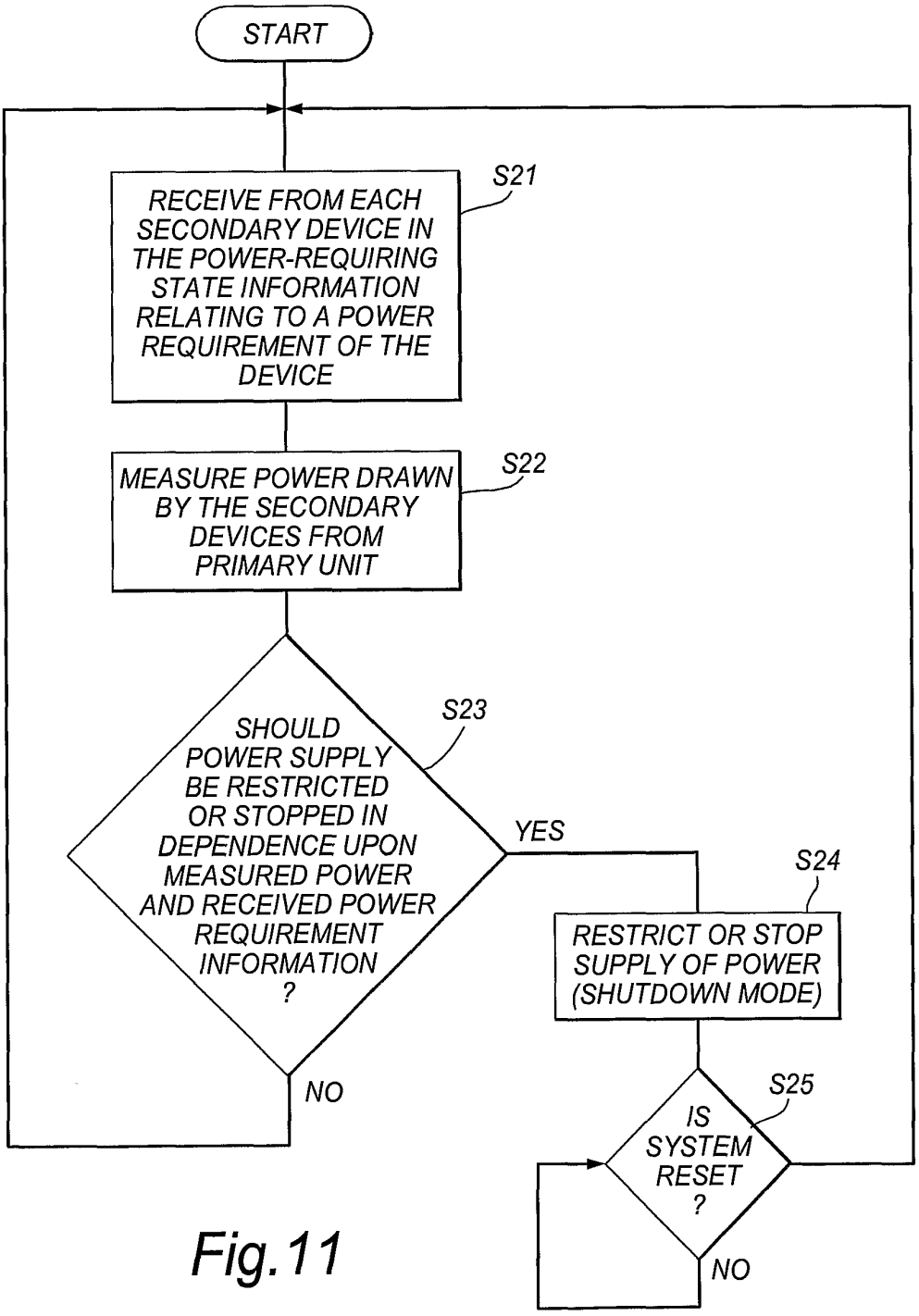

START
RECEIVE FROM EACH SECONDARY DEVICE IN THE POWER-REQUIRING STATE INFORMATION RELATING TO A POWER REQUIREMENT OF THE DEVICE
S21
MEASURE POWER DRAWN BY THE SECONDARY DEVICES FROM PRIMARY UNIT
S22
SHOULD POWER SUPPLY BE RESTRICTED OR STOPPED IN DEPENDENCE UPON MEASURED POWER AND RECEIVED POWER REQUIREMENT INFORMATION ?
S23
YES
NO
RESTRICT OR STOP SUPPLY OF POWER (SHUTDOWN MODE)
S24
IS SYSTEM RESET ?
S25
NO

Fig.11

11/11

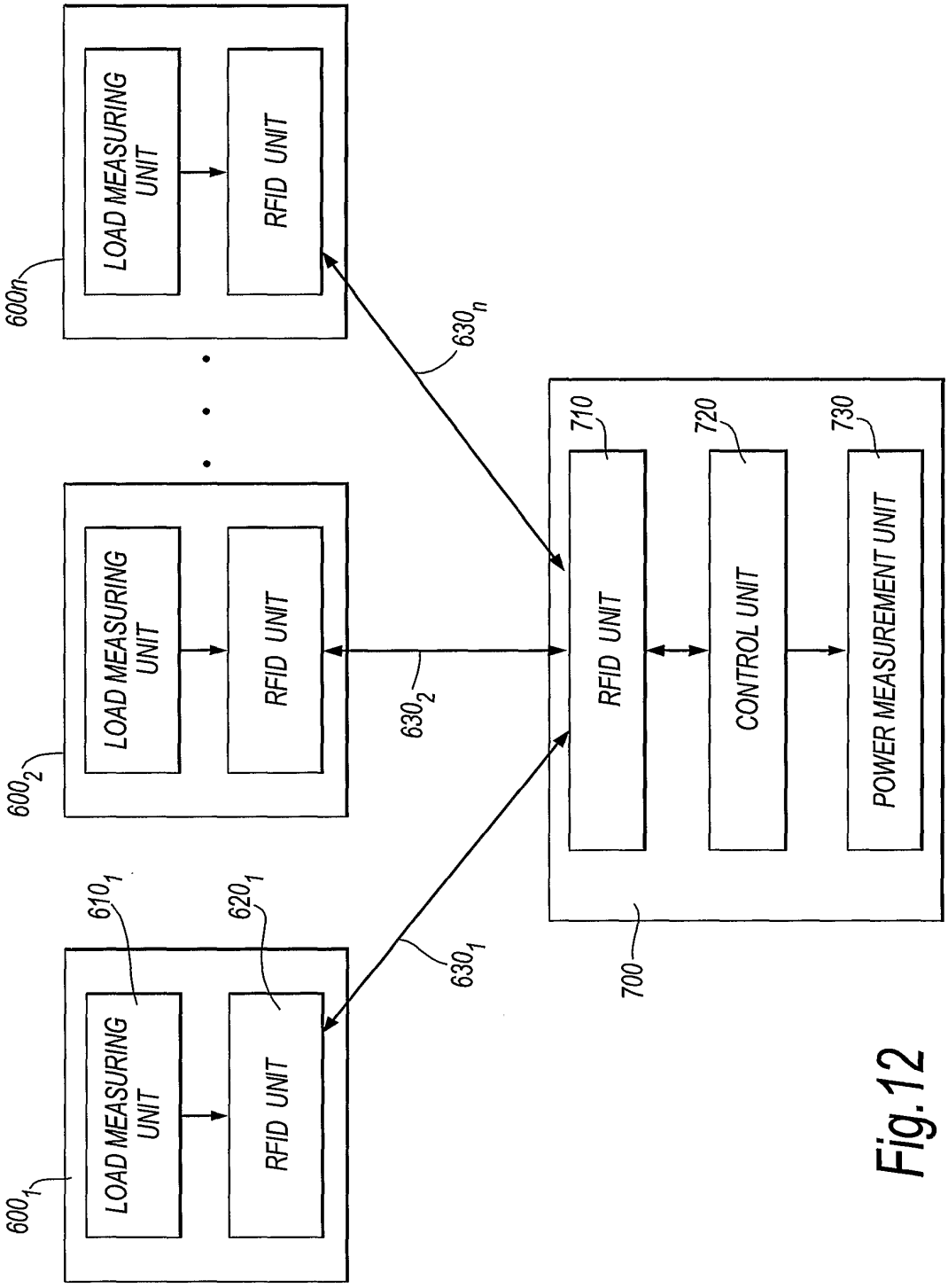

LOAD MEASURING UNIT
RFID UNIT
600n
630n
600 2
630 2
610 1
620 1
600 1
630 1
710
720
730
RFID UNIT
CONTROL UNIT
POWER MEASUREMENT UNIT
700

Fig.12

INTERNATIONAL SEARCH REPORT

Interi al Application No
PCT/GB2005/001824

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6 057 668 A (CHAO ET AL) 2 May 2000 (2000-05-02) column 3, paragraph 6; claim 1; figure 1	1,32,33 2-9,34, 35
Y	EP 0 533 247 A (ERICSSON RADIO SYSTEMS B.V) 24 March 1993 (1993-03-24) cited in the application claim 18	5-9,34
Y	US 2002/154518 A1 (ELFERICH REINHOLD ET AL) 24 October 2002 (2002-10-24) paragraph '0090!	8,9,35
Y A	WO 2004/015885 A (MOBILEWISE, INC; DAYAN, TAL; GOREN, OFER; KIKINIS, DAN; GOREN, YEHUDA) 19 February 2004 (2004-02-19) page 2 - page 5	5-7 12

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 August 2005	12/08/2005

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inter l Application No
PCI/GB2005/001824

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 118 249 A (BROCKMANN ET AL) 12 September 2000 (2000-09-12) cited in the application claims 1-4; figure 1	2-4

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

...rmation on patent family members

Inter ...al Application No
PCT/GB2005/001824

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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			DE	69207313 T2	15-05-1996
			EP	0533247 A1	24-03-1993
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			EP	1253695 A2	30-10-2002
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			WO	2004015885 A1	19-02-2004
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			EP	0982831 A2	01-03-2000

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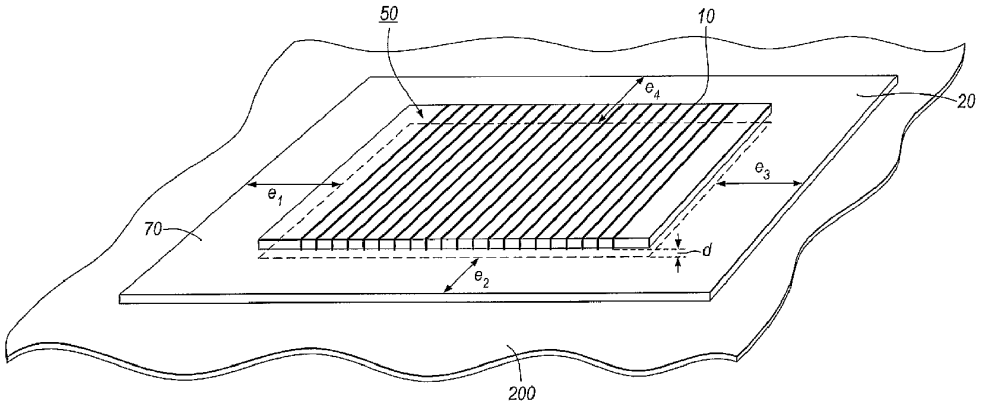
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Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: INDUCTIVE POWER TRANSFER UNITS HAVING FLUX SHIELDS



(57) Abstract: An inductive power transfer unit is adapted to be placed when in use on a support surface (200). A flux generating unit (50) extends in two dimensions over the support surface, and generates flux at or in proximity to a power transfer surface of the unit so that a secondary device placed on or in proximity to the power transfer surface can receive power inductively from the unit. A flux shield (70), made of electrically-conductive material, is interposed between the flux generating unit and the support surface, the shield extending outwardly (e_1 - e_4) beyond at least one edge of the flux generating unit. Alternatively, the flux shield may have one or more portions which extend over one or more side faces of the inductive power transfer unit or which extend between the side face(s) and the flux generating unit. The flux shield may be supplied as a removable accessory which attaches to the outside of the inductive power transfer unit.

WO 2005/024865 A2

INDUCTIVE POWER TRANSFER UNITS HAVING FLUX SHIELDS

This invention relates to inductive power transfer units having flux shields.

Inductive power transfer units, as described for example in the present applicant's published International patent publication no. WO-A-03/096512, the entire contents of which is hereby incorporated into the present application by reference, seek to provide a flat or curved power transfer surface over which a substantially horizontal alternating magnetic field flows. This field couples into any secondary devices placed upon the power transfer surface. In some variants this field may rotate in the plane of the surface to provide complete freedom of positioning for any secondary device placed on the surface to receive power. The secondary devices are, for example, built into portable electrical or electronic devices or rechargeable batteries which can be removed from the surface when not receiving power.

Depending on the design of the flux generating unit (magnetic assembly) of such power transfer units, they may also emit flux in directions other than desired horizontal surface field. For example a "squashed solenoid" design of flux generating unit emits flux symmetrically above and below it.

In Figure 1, a flux generating unit 50 comprises a coil 10 shaped into a flat solenoid wound around a former 20. The former 20 is in the form of a thin sheet of magnetic material. This results in a substantially horizontal field across the upper surface of the flux generating unit, but also an equal field across the lower surface. The field lines of both fields extend generally in parallel with one another over the respective surfaces, substantially perpendicularly to the coil windings. A secondary device 60 is shown in place over the upper surface.

Figure 2 shows a similar arrangement to that of Figure 1, but with an additional coil 11 wound, in an orthogonal direction to the winding direction of the coil 10, around the former 20. By driving the two coils 10 and 11 in a suitable manner, the flux generating unit may create a field which is substantially horizontal over the power

transfer surface (upper surface) and which rotates in the plane of that surface. In typical usage, the flux above the upper surface provides the functionality that the user desires (powering the secondary device 60), but the flux present at other surfaces may not be useful and can cause undesired effects.

Figure 3 shows a side view Finite Element analysis of the flux lines generated by the flux generating unit 50 in Figure 1 at an instant in time. The lines travel through the centre of the solenoid and then divide to return over and under it through the air. A secondary device 60 is shown placed on top of the unit 50.

One undesired effect occurs particularly when the primary unit is placed upon a ferrous metal surface, for example a mild steel desk or part of a vehicle chassis. The permeability of mild steel is sufficiently high that it provides a return path for the flux which is of considerably lower reluctance than the alternative path through air. Therefore the flux is "sucked" down into the metal desk. Figure 4 shows another Finite Element analysis view when a metal desk 200 is brought under the flux generating unit. The high permeability of the metal offers the flux lines a much lower-reluctance path than air to return from one end of the flux generating unit 50 to the other, and so they travel within the desk rather than through the air. This is undesirable for two reasons:

- A significant proportion of the flux generated by the inductive power transfer unit (primary unit) is flowing into the metal desk instead of flowing into any secondary devices on the upper surface of the unit, therefore the system becomes less efficient (consumes the more power) and the power received by the secondary device varies.
- The flux flowing through the metal desk causes core losses, for example via hysteresis and / or eddy current loss , which cause it to heat up.

It is known that when conductive materials, for example copper or aluminium, are placed into an alternating magnetic field, the field induces eddy-currents to circulate within them. The eddy currents then act to generate a second field which - in the limit of a perfect conductor - is equal and opposite to the imposed field, and cancels

it out at the surface of the conductor. Therefore these conductive materials can be seen as "flux-shields" – the lines of flux in any magnetic system are excluded from them. This may be used to shield one part of a system from a magnetic field and consequently concentrate the field in another part. GB-A-2389720, which is a document published after the priority date of the present application but having an earlier priority date, discloses a flux generating unit in the form of a printed circuit board having an array of spiral conductive tracks for generating flux above the upper surface of the unit. A ferrite sheet is placed under the board, and a conductive sheet is placed under the ferrite sheet, to provide a flux shield. The ferrite sheet and conductive sheet are of the same dimensions, parallel to the sheets, as the board.

According to a first aspect of the present invention there is provided an inductive power transfer unit, adapted to be placed when in use on a support surface, comprising: a flux generating means which, when the unit is placed on the support surface, extends in two dimensions over the support surface, said flux generating means being operable to generate flux at or in proximity to a power transfer surface of the unit so that a secondary device placed on or in proximity to the power transfer surface can receive power inductively from the unit; and a flux shield, made of electrically-conductive material, arranged so that when the unit is placed on the support surface, the shield is interposed between the flux generating means and the support surface, the shield extending outwardly beyond at least one edge of the flux generating means.

According to a second aspect of the present invention there is provided an inductive power transfer unit, adapted to be placed when in use on a support surface, comprising: a flux generating means which, when the unit is placed on the support surface, extends in two dimensions over the support surface, said flux generating means being operable to generate flux at or in proximity to a power transfer surface of the unit so that a secondary device placed on or in proximity to the power transfer surface can receive power inductively from the unit; and a flux shield, made of electrically-conductive material, having one or more portions which extend over one

or more side faces of the unit or which extend between said one or more side faces and said flux generating means.

In cases where the flux generating unit operates by creating a field which alternates back and forth in one linear dimension, the conductive shield will have induced in it an equal and opposite alternating linear field, which acts to cancel the field near the shield. In cases where the unit operates by creating a rotating field in the plane of its laminar surface, the conductive shield has induced in it a field which also rotates, again cancelling the field.

Such power transfer units are advantageous because they allow the flux to be concentrated in directions in which it is useful, improving the flux-efficiency of the unit, and to be shielded from directions where it can cause side-effects, for example by coupling into a metal desk under the unit.

In addition, the flux shield increases the coupling between the flux generating unit and the secondary device(s) by forcing most of the flux to go over the power transfer surface. Therefore less drive current is needed in the flux generating unit to create a given flux density in the secondary device(s). Accordingly, provided that losses in the flux shield are minimised, the system as a whole becomes more efficient.

To ensure that the apparatus runs cool and is power-efficient, I^2R losses (losses caused by circulating currents dissipating as heat) in the conductive shield must be kept small:

- The conductive shield is advantageously made of a highly conductive material, for example copper or aluminium sheet of sufficient thickness to ensure that the eddy-currents induced therein do not suffer from excessive resistance and therefore create heat. The flux density, and therefore the eddy currents, may vary across different parts of the apparatus, and therefore the necessary thickness, or material, may also vary.
- The spacing between the shield and the electrically-driven conductors of the flux generating unit can be optimised. The larger it is (i.e. the greater the

spacing between it and the electrically-driven conductors), the lower the current-density induced in the conductive shield, and therefore the lower the heating. However this must be traded-off against the larger the overall dimensions necessary, which may be less ergonomic.

In addition, the conductive shield must not itself be substantially ferrous, otherwise it may provide a low-reluctance path which "shorts" the intended flux path.

In one embodiment of the present invention, the conductive shield extends in a substantially continuous sheet substantially over all but one face of the flux generating unit, such that only the face substantially exposed is the laminar surface intended for power delivery to secondary devices. For example, if the generating unit is a substantially flat rectangular shape, the shield may extend to cover the bottom and four sides of the unit. As another example, if the flux generating unit is a substantially flat cylinder, the shield may extend to cover the bottom and cylindrical side of the unit. The advantage of such an arrangement is that it increases still further, compared to a flat sheet, the path that flux would have to travel in order to travel through a metal object underneath the flux generating unit.

In another embodiment of the present invention, the conductive shield may enclose all but a part of one or more faces of the flux generating unit. For example, if the flux generating unit is a substantially flat rectangular shape, the shield may cover the bottom, sides and outer part of the top of the flux generating unit. This may be advantageous in controlling the flux pattern at the edge of the top of the flux generating unit.

The conductive shield may form part of an enclosure of the inductive power transfer unit, for example a formed or cast aluminium or magnesium casing. This may be advantageous in reducing cost.

According to a third aspect of the present invention there is provided an inductive power transfer unit comprising: a power transfer surface on or in proximity to which

a secondary device can be placed to receive power inductively from the unit; flux generating means arranged to generate flux at or in proximity to said power transfer surface; and flux shield attachment means arranged for attaching a flux shield to the unit such that the attached shield is arranged at one or more external surfaces of the unit other than said power transfer surface, or is arranged between said one or more external surfaces and said flux generating means, so that the shield serves to shield objects outside the unit, adjacent to said one or more external surfaces, from flux generated by the flux generating means.

According to a fourth aspect of the present invention there is provided an accessory, adapted to be attached to the outside of an inductive power transfer unit, the unit having a power transfer surface on or in proximity to which a secondary device can be placed to receive power inductively from the unit and also having flux generating means arranged to generate flux at or in proximity to the power transfer surface, and the accessory comprising: means which co-operate with the unit to attach the accessory to the outside of the unit in a predetermined working disposition; and a flux shield, made of electrically-conductive material, which, when the accessory is in its said working disposition, extends at or in proximity to one or more external surfaces of the unit other than said power transfer surface so as to shield objects outside the unit, adjacent to said one or more external surfaces, from flux generated by the flux generating means.

In the third and fourth aspects of the invention the conductive shield is supplied to the user as a separate accessory to be placed under or around the power transfer unit. Optionally it may be provided as a retainable accessory, for example a clip-on cover. This is advantageous as it allows the bill of materials for the power transfer unit to be kept to an absolute minimum, yet allows users to purchase the accessory if the unit is to be used in a location where it may be necessary to constrain its field, for example on a ferrous metal desk.

In one embodiment the flux generating unit comprises at least one means for generating an electromagnetic field, the means being distributed in two dimensions

across a predetermined area in or parallel to the power transfer surface so as to define at least one power transfer area of the power transfer surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the power transfer-surface. Preferably the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the power transfer area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the power transfer surface in proximity thereto and are distributed in two dimensions thereover. Preferably the means has a height measured substantially perpendicular to the power transfer area that is less than either of the width or the length of the power transfer area. The height is more preferably less than one fifth, or less than one tenth, of either the width or height, so that the inductive power transfer unit as a whole is in the form of a flat bed or platform. When a secondary device, including at least one electrical conductor, is placed on or in proximity to a power transfer area of the inductive power transfer unit, the electromagnetic field lines couple with the at least one conductor of the secondary device and induce a current to flow therein. The conductive sheet or shield is arranged on or in the power transfer unit at a location other than the side on which the power transfer area is located.

In the context of the present application, the word "laminar" defines a geometry in the form of a thin sheet or lamina. The thin sheet or lamina may be substantially flat, or may be curved.

It is to be appreciated that the conductive sheet or shield may be generally laminar, or may include one or more edge portions that are directed towards the power transfer surface.

The conductive sheet or shield may be exposed on the side of the power transfer unit opposed to the power transfer surface, or may be covered with a layer of dielectric or other material, for example by part of a casing of the unit.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made, by way of example, to the accompanying drawings, in which:

FIGURE 1 is a perspective view showing an example of a flux generating unit suitable for use in embodiments of the present invention.

FIGURE 2 is a perspective view showing another example of a flux generating unit suitable for use in embodiments of the present invention.

FIGURE 3 shows a side view of the flux generating unit of Figure 1 for illustrating flux lines generated thereby.

FIGURE 4 is a view corresponding to Figure 3 but illustrating flux lines generated when a metal desk is present under the arrangement.

FIGURE 5 is a perspective view showing parts of an inductive power transfer unit according to a first embodiment of the present invention.

FIGURE 6 shows a side view of the unit of Figure 5 for illustrating flux lines generated thereby when the unit is placed on a metal desk.

FIGURE 7 is a perspective view showing parts of an inductive power transfer unit according to a second embodiment of the present invention.

FIGURE 8 shows a side view of the unit of Figure 7 for illustrating flux lines generated thereby when the unit is placed on a metal desk.

FIGURE 9 is a side view of an inductive power transfer unit and an accessory therefor according to a third embodiment of the present invention.

Figure 5 shows parts of an inductive power transfer unit according to a first embodiment of the present invention. In this embodiment, a flux generating unit 50 has the same general construction as the flux generating unit described in the introduction with reference to Figure 1. Of course a flux generating unit 50' as shown in Figure 2 can be used in this (and other) embodiments of the invention, instead. Similarly, any of the flux generating units described in WO-A-03/096512 can be used in embodiments of the present invention.

The flux generating unit 50 comprises a coil 10 wound around a former 20. The former 20 is in the form of a thin sheet of magnetic material. When the inductive power transfer unit is placed on a support surface 200, the flux generating unit 50 extends in two dimensions over the support surface.

A flux shield 70, made of electrically-conductive material such as copper, is interposed between the flux generating unit 50 and the support surface 200. As shown in Figure 5, the shield 70 extends outwardly by distances e_1 to e_4 beyond each edge of the flux generating unit 50. The distance e_1 is for example 50mm. The distance e_2 is for example 50mm. The distance e_3 is for example 50mm. The distance e_4 is for example 50mm.

In this embodiment, the flux shield 70 is in the form of a flat sheet which extends generally in parallel with the support surface. There is a gap of size d between the sheet and the electrical conductors of the coil 10 extending over the lower surface of the former 20. d is 4mm, for example.

Figure 6 shows a Finite Element analysis view of the unit of Figure 5. The support surface 200 is assumed to be a metal desk. The shield 70 forces any flux lines flowing through the metal desk to travel around the shield, increasing the path length and thus the effective reluctance of the "desk" path. As a result, the presence of the desk has less effect, since more flux lines travel over the unit instead of going through the desk.

Although the flux shield 70 has extensions beyond all edges of the unit 50 in the Figure 5 example, it will be appreciated that a worthwhile flux-shielding effect can also be obtained even if the flux shield extends beyond one edge or only extends beyond a pair of opposite edges.

Figure 7 shows parts of an inductive power transfer unit according to a second embodiment of the present invention. In this embodiment a flux shield 80 having 5 sides (base 82 and side walls 84, 86, 88 and 90) is provided. The base 82 of the flux shield 80 extends between the lower surface of the flux generating unit 50 and the support surface 200. Because the flux shield 80 has side walls in this embodiment, the base 82 need not extend out beyond the edges of the flux generating unit 50 by as far as the distances e_1 to e_4 in the Figure 5 embodiment. For example, e_1 to e_4 may each be 4mm. This can enable the overall dimensions of the power transfer unit to be reduced while keeping the effective reluctance of the desk path high. The height of the side walls 84, 86, 88 and 90 is exaggerated in Figure 7 for clarity. In practice, the side walls need not extend above the upper surface of the flux generating unit 50.

The flux shield 80 may be formed from a flat sheet of conductive material which is cut and folded up at the edges to form a tray-form member.

Figure 8 shows a finite element analysis view of the unit of Figure 7.

Figure 9 shows parts of an inductive power transfer unit 400 according to a third embodiment of the present invention. In this embodiment a flux generating unit 50, similar to the flux generating units described with reference to the first and second embodiments, is contained in a casing 410 of the unit 400. An upper surface of the casing 410 provides the power transfer surface in this embodiment, and a secondary device 60 is placed directly on the surface to receive power inductively from the flux generating unit 50.

In each of the four side walls of the casing 410 a small circular recess 420 is formed.

In this embodiment the flux shield 90 is an accessory which is adapted to be attached to the outside of the inductive power transfer unit 400. The flux shield 90, which is similar in form to the flux shield 80 shown in Figure 7, has circular projections 95 formed on the inner surfaces of the upstanding side walls of the flux shield 90. The projections 95 engage respectively with the recesses 420 in the casing of the inductive power transfer unit 400. In this way, the unit 400 can be inserted into the flux shield 90 due to the resilience of the materials of the flux shield 90 and/or casing 410. The projections and recesses serve to hold the flux shield 90 on the outside of the unit 400 in such a way that the flux shield shields objects outside the unit, adjacent to the external surfaces of the unit, from flux generated by the flux generating unit 50.

The provision of a removable flux shield has several advantages. In some applications, the flux shield is unnecessary. For example, the shield is unnecessary if the support surface on which the unit will be placed is non-metallic. In this way, the unit can be made as small as possible and at the lowest possible cost. Any user who intends to use the unit on a metallic support surface can purchase the flux shield as an optional accessory.

When the flux shield is in the form of a removable accessory, it is not necessary for the flux shield to have the form of the first embodiment or second embodiment described above. For example, the flux shield need not extend outwardly beyond the edges of the flux generating unit 50; it could be coterminous with the planar area of the flux generating unit 50 or even smaller than the planar area thereof. For example, a flat sheet-form conductive shield could be built into the base of a tray-form plastics housing of the accessory.

Any suitable way of attaching the flux shield to the outside of the inductive power transfer unit may be used. Although snap-fitting is particularly convenient, the flux shield may be attached to the unit using screws or Velcro ®. Equally, there could simply be a tight fit between the flux shield and the casing of the unit.

By way of example only, there now follows a set of test results for embodiments of this invention. In the test set up the flux generating unit 50 measured approximately 175x125x9mm. The flux shield 70 or 80 was made from a 0.6mm thick sheet of copper. The metal desk 200 was a sheet of metal 500mm x 500mm x 0.6mm thick (magnetically, this is effectively an infinite plane).

The current through the flux generating unit 50 was adjusted so that the power delivered to a secondary device 60 was the same at the start of each test. A control loop then held the current constant during the rest of each test.

The power received by the secondary device was monitored and the extra power drawn from the charger was monitored.

The results were as follows:

Test Condition	Power seen by secondary device	Extra power needed from charger
1a. No flux shield	100%	0W
1b. As 1a with steel under	*123%*	*11W*
2a. Flux shield sheet (Figure 5) immediately under magnetic assembly	100%	1.5W
2b. Flux shield moved 4mm from assembly	100%	0.7W
2c. As 2b with steel under	*110%*	*4.6W*
3a. Flux shield box (Figure 7)around bottom and edges (4mm gap)	100%	1.5W
3b. As 3a with steel under	*108%*	*2.2W*

Test 1 shows the case without any flux shield. The flux lines will initially be approximately as shown in Figure 3. Introducing a metal sheet under the assembly causes the flux to travel down and through the sheet, in preference to travelling up and over the top, as shown in Figure 4. The control loop in the generator is forced to expend 11W to keep its coil current constant, which is not optimal since it is inefficient and will cause the metal to warm up. In addition, the secondary device sees a rise in the power it receives to 123%, because eddy currents in the metal desk do act as a poor flux excluder even as they consume large amounts of generator

power – and this is not optimal either.

Test 2 shows the case with a flat flux shielding sheet underneath as in the first embodiment. A large (190mm x 140mm x 0.6mm) copper sheet flux shield immediately under the magnetic assembly (test 2a) causes the generator to have to supply an additional 1.5W, presumably because it starts to short the coil turns in the assembly. Moving this 4mm away from the assembly (i.e. d = 4mm in Figure 5) reduces this drain to 0.7W (test 2b). Now introducing a metal sheet only causes the generator to have to supply 4.6W (i.e. an additional 3.9W), and the power into the secondary device now only changes to 110% (test 2c). This is shown in Figure 6. So the flux shield has reduced each of the two side-effects by more than half.

Test 3 shows the case where the edges of the flux shield are brought up around the edges of the magnetic assembly, as in the second embodiment shown in Figure 7. The shield is kept 4mm away from the magnetic assembly on all sides (test 3a) to avoid the phenomenon seen in Test 2a. The generator must supply an additional 1.5W to overcome the losses of the eddy currents in the shield. Now introducing a metal sheet (test 3b) only causes the generator to have to supply an extra 2.2W (i.e. an additional 0.7W), and the power seen by the secondary device now only changes to 108%.

In conclusion, these test results clearly demonstrate the two key advantages of a flux shield in reducing the side effects of metal objects: less power delivered into the steel by the generator, and less variation in the power seen by the secondary device.

A shield extending completely around the magnetic assembly, except over the desired power transfer surface, can reduce the effect of metal desks on the generator by more than an order of magnitude, and on the secondary device by more than half. In the example shown the price to pay for this advantage is an extra 1.54W of quiescent power delivered by the generator, to overcome losses in the eddy-currents in the flux shield.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS

1. An inductive power transfer unit, adapted to be placed when in use on a support surface, comprising:

a flux generating means which, when the unit is placed on the support surface, extends in two dimensions over the support surface, said flux generating means being operable to generate flux at or in proximity to a power transfer surface of the unit so that a secondary device placed on or in proximity to the power transfer surface can receive power inductively from the unit; and

a flux shield, made of electrically-conductive material, arranged so that when the unit is placed on the support surface, the shield is interposed between the flux generating means and the support surface, the shield extending outwardly beyond at least one edge of the flux generating means.

2. A unit as claimed in claim 1, wherein said flux shield is in the form of a flat sheet which extends generally in parallel with the support surface.

3. A unit as claimed in claim 1 or 2; wherein said flux shield extends outwardly beyond each edge of the flux generating means.

4. An inductive power transfer unit, adapted to be placed when in use on a support surface, comprising:

a flux generating means which, when the unit is placed on the support surface, extends in two dimensions over the support surface, said flux generating means being operable to generate flux at or in proximity to a power transfer surface of the unit so that a secondary device placed on or in proximity to the power transfer surface can receive power inductively from the unit; and

a flux shield, made of electrically-conductive material, having one or more portions which extend over one or more side faces of the unit or which extend between said one or more side faces and said flux generating means.

5. A unit as claimed in any preceding claim, wherein said flux shield also extends over an outer peripheral portion of said power transfer surface or between said outer peripheral portion and said flux generating means.

6. A unit as claimed in any preceding claim, wherein said flux shield extends substantially continuously around said flux generating means except for a part thereof adjacent to said power transfer surface.

7. A unit as claimed in any preceding claim, wherein said flux shield provides at least part of a casing of the unit.

8. A unit as claimed in any preceding claim, wherein at least part of an outer surface of the flux shield is covered with a dielectric or other material.

9. A unit as claimed in any preceding claim, wherein a gap between said flux shield and electrical conductors of said flux generating means is set so that flux shielding is achieved without the flux shield unduly increasing power consumption of the flux generating means.

10. A unit as claimed in any preceding claim, wherein said flux shield varies in thickness from one part to another.

11. A unit as claimed in any preceding claim, wherein different parts of the flux shield are made from different respective materials.

12. A unit as claimed in any preceding claim, wherein the flux shield is attached removably to the unit.

13. An inductive power transfer unit comprising:

a power transfer surface on or in proximity to which a secondary device can be placed to receive power inductively from the unit;

flux generating means arranged to generate flux at or in proximity to said power transfer surface; and

flux shield attachment means arranged for attaching a flux shield to the unit such that the attached shield is arranged at one or more external surfaces of the unit other than said power transfer surface, or is arranged between said one or more external surfaces and said flux generating means, so that the shield serves to shield objects outside the unit, adjacent to said one or more external surfaces, from flux generated by the flux generating means.

14. An accessory, adapted to be attached to the outside of an inductive power transfer unit, the unit having a power transfer surface on or in proximity to which a secondary device can be placed to receive power inductively from the unit and also having flux generating means arranged to generate flux at or in proximity to the power transfer surface, and the accessory comprising:

means which co-operate with the unit to attach the accessory to the outside of the unit in a predetermined working disposition; and

a flux shield, made of electrically-conductive material, which, when the accessory is in its said working disposition, extends at or in proximity to one or more external surfaces of the unit other than said power transfer surface so as to shield objects outside the unit, adjacent to said one or more external surfaces, from flux generated by the flux generating means.

15. An accessory as claimed in claim 14, adapted to be attached removably to the outside of the unit.

16. An accessory as claimed in claim 14 or 15, being a clip-on cover for the unit.

17. An accessory as claimed in any one of claims 14 to 16, wherein, when the accessory is attached to the unit in its working disposition and the accessory is placed on a support surface, the flux generating means of the unit extend in two dimensions over the support surface with the flux shield of the accessory interposed between the

flux generating means and the support surface, and the flux shield extends outwardly beyond at least one edge of the flux generating means.

18. An accessory as claimed in claim 17, wherein said flux shield is in the form of a flat sheet which extends generally in parallel with the support surface.

19. An accessory as claimed in claim 17 or 18, wherein said flux shield extends outwardly beyond each edge of the flux generating means.

20. An accessory as claimed in any one of claims 14 to 19, wherein when said accessory is attached to the unit in its said working disposition said flux shield also extends over one or more side faces of the unit.

21. An accessory as claimed in any one of claims 14 to 20, wherein when said accessory is attached to the unit in its said working disposition said flux shield also extends over an outer peripheral portion of said power transfer surface of the unit.

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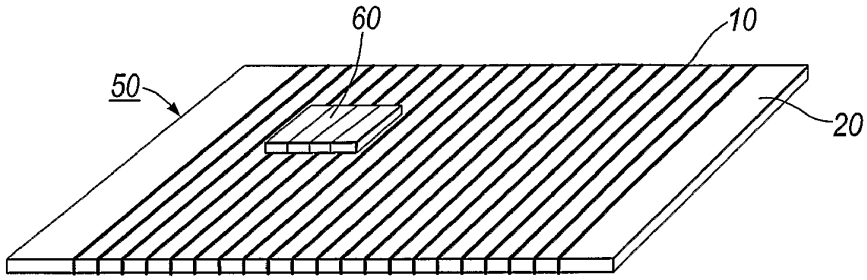


Fig.1

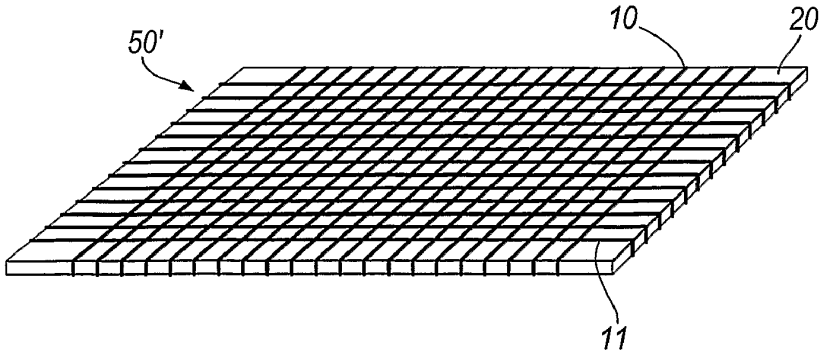


Fig.2

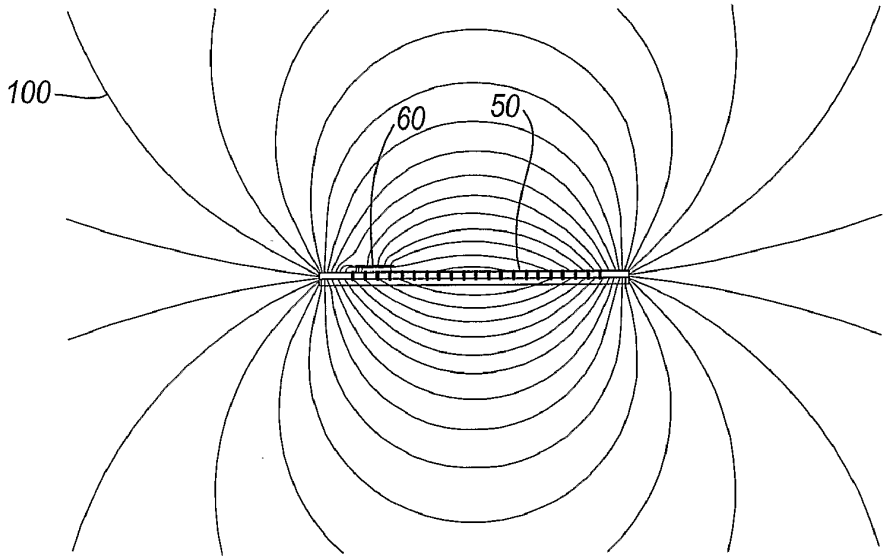


Fig.3

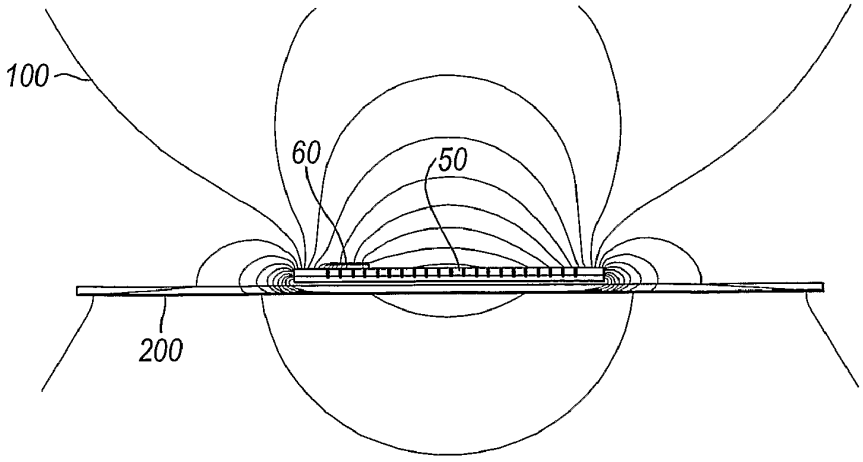


Fig.4

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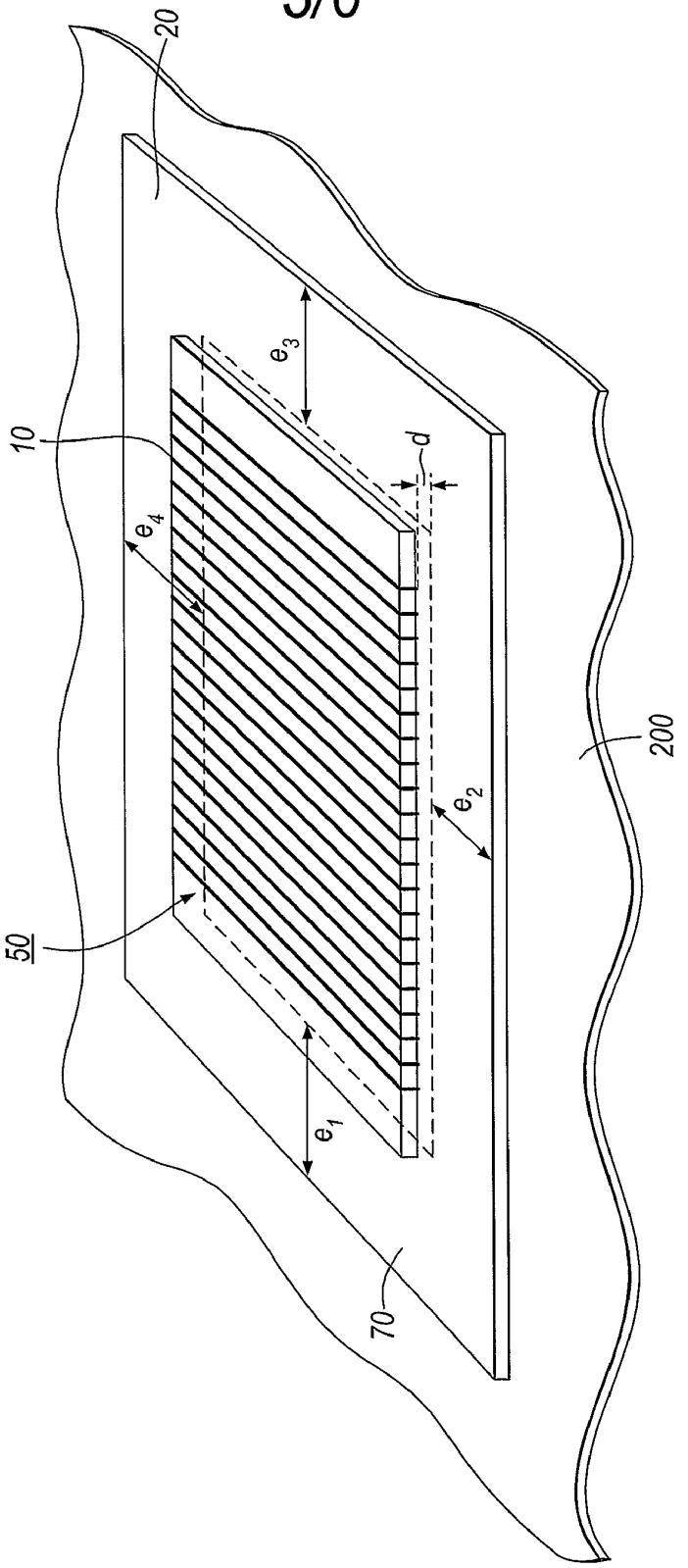


Fig.5

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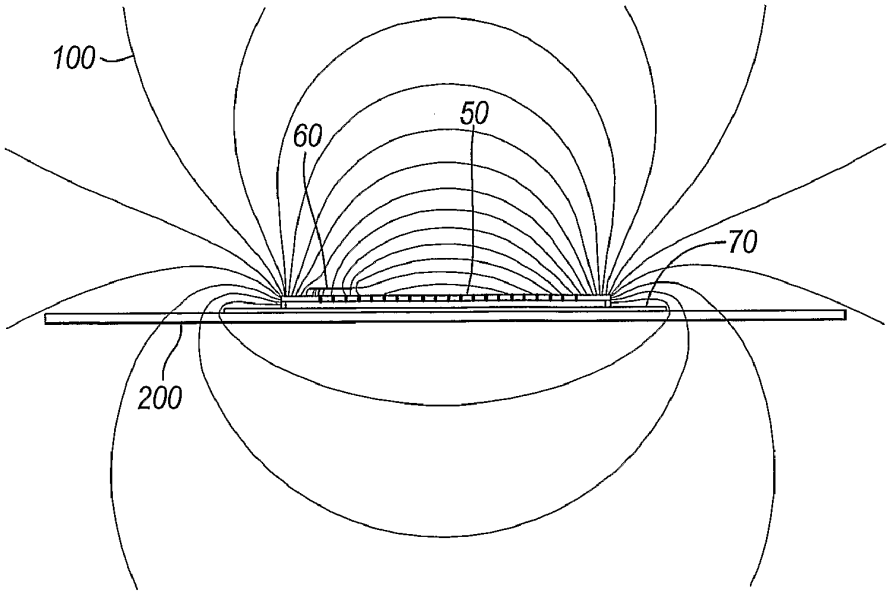


Fig.6

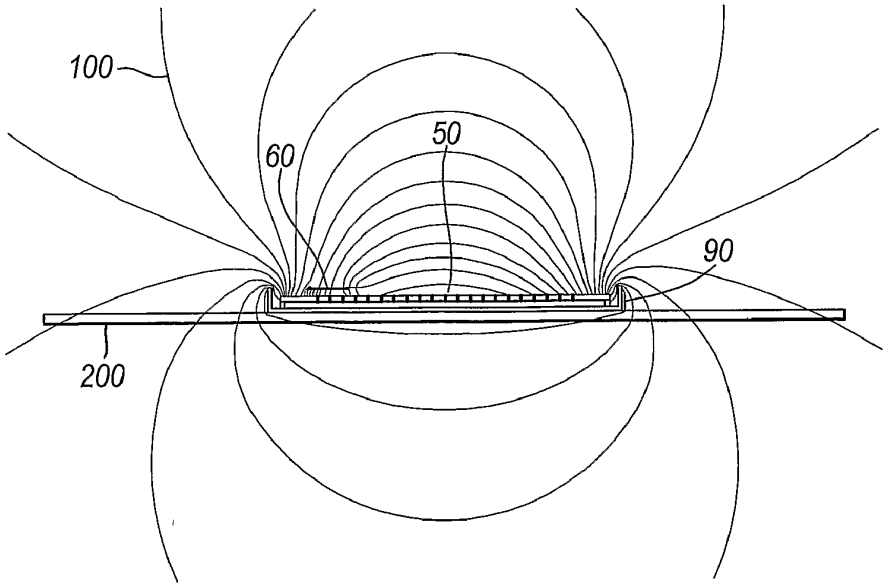


Fig.8

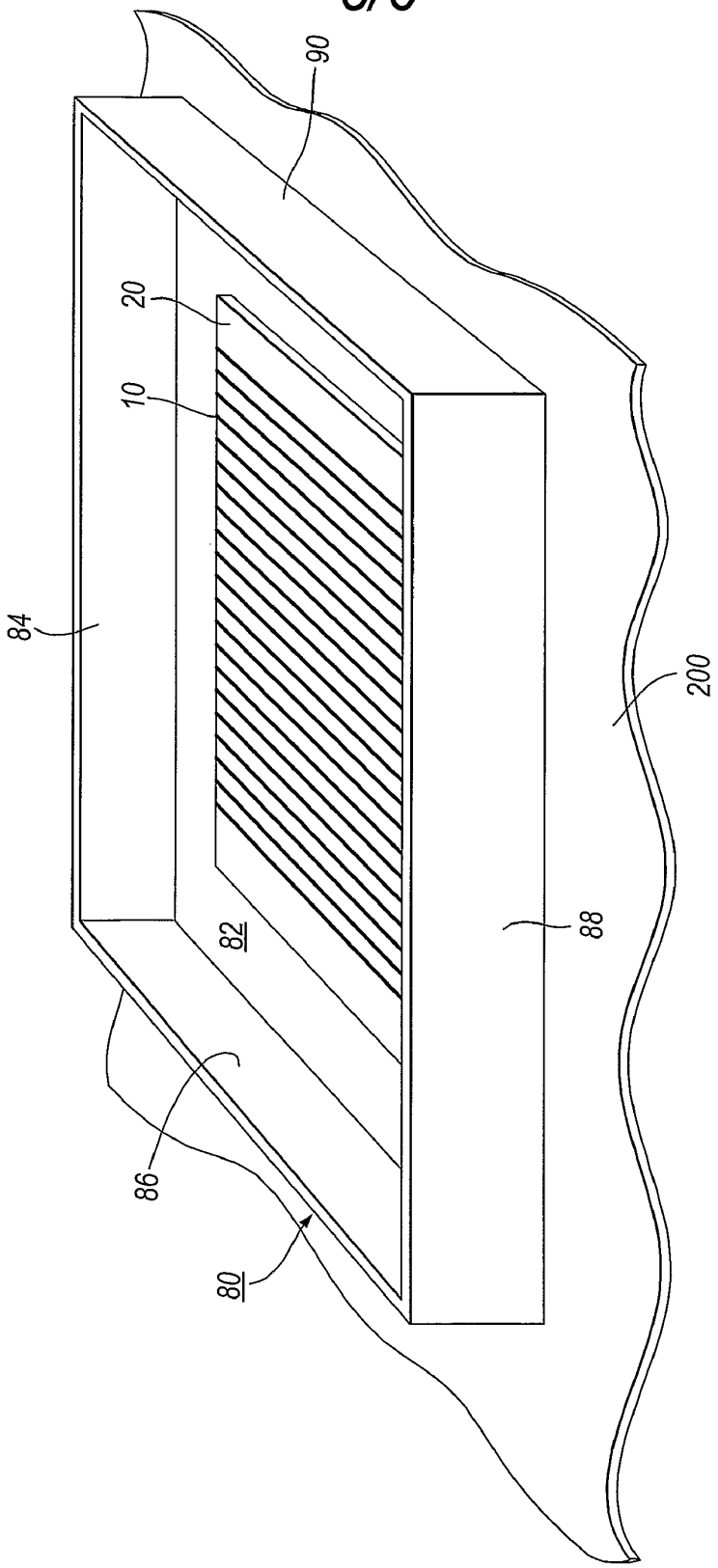


Fig.7

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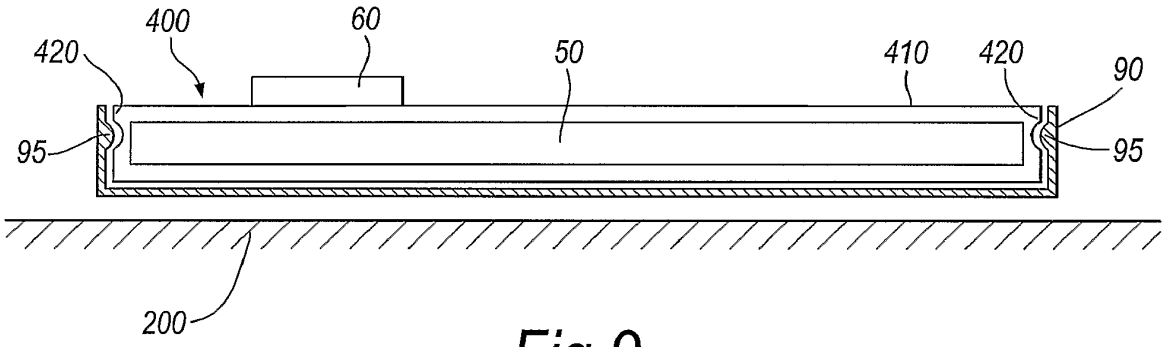


Fig.9

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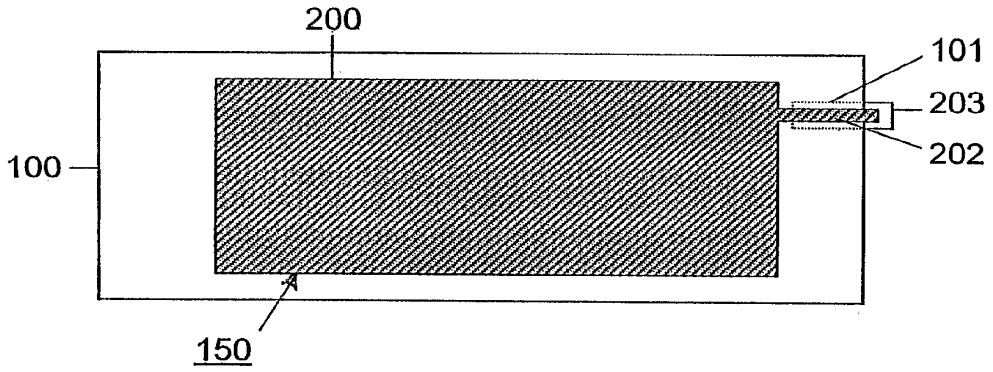
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(54) Title: ADAPTING PORTABLE ELECTRICAL DEVICES TO RECEIVE POWER WIRELESSLY



(57) Abstract: Wireless power receiving apparatus (150) is retrofitted to a portable electrical device (100) to enable the device to receive power wirelessly. The apparatus comprises a power-receiving element (200) adapted to be attached to the device, e.g. by adhesive (201), and also being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another. One or more power connectors (203) are connected electrically to the power-receiving element and are adapted to be connected, when the apparatus is in use, to one or more corresponding power connectors (101) of the portable electrical device to deliver power received by the element to the device. The power-receiving element may be in the form of a sticker or may be carried by or incorporated in a replacement cover portion for the portable electrical device.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ADAPTING PORTABLE ELECTRICAL DEVICES TO RECEIVE POWER WIRELESSLY

The present invention relates to adapting portable electrical devices to receive power wirelessly.

Many of today's portable devices contain an internal secondary cell or battery which may be recharged by temporarily attaching an external adaptor to the power connector of the device. However this is something of a nuisance for users because it requires manual dexterity, requires both hands, and, especially, because different manufacturers use incompatible connectors, so the right adaptor must be located for each device.

Various means have been proposed for charging devices without the need to attach an external adaptor. These include:

- A surface providing power by presenting an array of contacts which then mate with receiving contacts on the device. Examples include:
  - In academia, the "Networked Surfaces" research conducted by James Scott and Frank Hoffman of the Laboratory for Communications Engineering, Engineering Department, University Of Cambridge, U.K.
  - In business, the wire-free electricity base proposed by MobileWise Inc., U.S.A.
- A surface providing power to devices by induction, without any contacts, for example as disclosed in patent publication no. WO-A-03/96512. In this system, the device incorporates a substantially flat element for receiving power inductively, conditioning it and then providing it to the device's battery and electronics.

These solutions typically require a device design to be modified, typically by the Original Equipment Manufacturer, in order to incorporate the power-receiving

element during manufacture. However there are a very large number of existing portable devices which are not already enabled. It would therefore be convenient to have a solution whereby the user could enable an existing device by simply retrofitting a power-receiving element to it.

According to a first aspect of the present invention, there is provided wireless power receiving apparatus for use with a portable electrical device to enable the device to receive power wirelessly, the apparatus comprising: a power-receiving element adapted to be attached to the device, and also being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and one or more power connectors which, when the apparatus is in use, are connected electrically to the power-receiving element and are adapted to be connected to one or more corresponding power connectors of the portable electrical device to deliver power received by the element to the device.

The benefit of the invention is that it enables users to add wireless power transfer capability to their existing portable devices easily.

In use, the user simply attaches the power-receiving element to the portable device and then connects the power connector(s) to the corresponding power connector(s) (power-input) of the portable device, thus enabling the device to receive power without wires from a transmitter of power (e.g. an external charger) for example by way of electromagnetic induction.

The means of attaching the power-receiving element to the device might be an adhesive, or might be some mechanical means such as a clip. The power receiving element could alternatively snap-fit on the device or slide on to it. The element may be removable or permanently attached once applied.

Yet another way of attaching the power-receiving element to the portable electrical device is to have a rigid connection between the power-receiving element and at least one of the power connectors. In this case, connection of that power connector or

those power connectors to the corresponding power connector(s) on the portable electrical device serves to attach the power-receiving element mechanically to the device without the need for any separate attaching means such as adhesive or a clip.

Another way of attaching the power-receiving element to the portable electrical device is to form the power-receiving element as part of a replacement cover portion of the portable electrical device. Some devices, such as mobile phones, have replaceable cover portions so that the user can change the appearance or "skin" of the device.

Optionally, the power-connector(s) may be attached to the power-receiving element by a flexible connecting member, allowing the power-connector(s) to be inserted and removed from the device's power-input while the power-receiving element remains attached for convenient future use. Preferably, the flexible connecting member also serves to connect the one or more power connectors electrically to the power-receiving element.

In one embodiment the electrical connections (e.g. wires) extending between the power-receiving element and power connectors are detachable from the power-receiving element and/or from the power connectors when the apparatus is not in use. This can enable the electrical connections and the power connectors to be removed to protect them from possible damage whilst still leaving the power-receiving element attached.

By having the electrical connections detachable it is also possible to offer a single design of power-receiving element but several different designs of power connector (or power connector plus electrical connection such as a flying lead) for use with different portable electrical devices.

Optionally, the power-connector may itself incorporate a contact means similar to the power-receiving input of the device, so that even when it is connected to the device,

the device may still be plugged in to a conventional adaptor in a "pass-through" fashion.

The portable electrical device may have first connector means adapted to connect to corresponding second connector means of external equipment. The first connector means provide the one or more corresponding power connectors of the portable electrical device, possibly together with one or more further connectors for other purposes such as signal or data input/output. In this case, the apparatus preferably further comprises: third connector means adapted to connect to the device's first connector means, the third connector means providing the power connector(s) of the apparatus; fourth connector means adapted to connect to the external equipment's second connector means; and a pass-through connection arrangement interconnecting at least one connector of the third connector means and a corresponding connector of said fourth connector means.

The third and fourth connector means may be on opposite faces of a power connector unit or block so that the unit or block can be sandwiched between the external equipment (e.g. a car hands-free cradle for a mobile phone) and the portable electrical device. It is not necessary for the pass-through connection arrangement to interconnect the power connectors of the third and fourth connector means, although this is preferable to enable power to be supplied from the external equipment when available. The pass-through connection arrangement could serve just to interconnect signal or data connectors of the third and fourth connector means.

If the power received by the power-receiving means must be power-conditioned before being passed to the device, the power-conditioning circuitry may optionally be incorporated into the power-receiving element or the power-connector.

Optionally, all parts of the invention, especially the adhesive, may be substantially waterproof.

Optionally, the power-receiving element may be coloured and textured such that, when adhered to the device, it appears to be a part of the device. Alternatively, or additionally, the power-receiving means may carry text or pictures, for example a logo or advertising.

Optionally, the power-receiving element may include a substantially transparent pocket into which pictures and the like may be slid.

In another embodiment, a part of the power-receiving element which must be placed in proximity with the transmitter is marked or coloured or labelled distinctively. In this way, the user can be informed of how to position or orient the power-receiving element (attached to the portable electrical device) relative to the transmitter so that power is transferred efficiently from the transmitter to the power-receiving element.

Optionally, a power indicator may be provided, optionally in the power-receiving element or the power-connector, to indicate when power is being received and/or being passed to the device. The indicator may produce light (perhaps an LED or electroluminescent panel), sound or vibration.

Optionally, the power-receiving element may be applied inside the device instead of outside, for example to the rear of the battery compartment.

Optionally, the power-connector may connect to internal power contacts within the device, possibly to its batteries and/or battery contacts.

Preferably, the power-receiving element is substantially flat. Alternatively, but preferably in addition, the power-receiving element is flexible. These features make it easy to attach the power-receiving element to the portable electrical device at a suitable internal or external surface portion thereof. When the surface portion is an internal one, having the power-receiving element substantially flat and/or flexible makes it possible to fit the element conveniently even in confined spaces such as battery compartments. When the surface portion is external, these features make it

possible to attach the power-receiving element without significantly affecting the overall shape and/or ergonomics of the portable electrical device.

According to a second aspect of the present invention, there is provided in combination a portable electrical device and wireless power receiving apparatus embodying the aforesaid first aspect of the present invention.

The following non-exhaustive list illustrates some examples of devices that can be enabled using the present invention. Possibilities are not limited to those described below:

- A mobile communication device, for example a radio, mobile telephone or walkie-talkie;
- A portable computing device, for example a personal digital assistant or palmtop or laptop computer;
- Portable entertainment devices, for example a music player, game console or toy;
- Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
- A portable imaging device, for example video recorder or camera;
- Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
- Consumer devices, for example torches, clocks and fans;
- A battery-pack for insertion into any of the above;
- A standard-sized battery cell;

In the case of unintelligent secondary devices such as a battery cell, some sophisticated charge-control means may also be necessary to meter inductive power to the cell and to deal with situations where multiple cells in a device have different charge states. Furthermore, it becomes more important for the transmitter of power to be able to indicate a "charged" condition, since the secondary cell or battery may not be easily visible when located inside another electrical device.

According to a third aspect of the present invention there is provided a power-receiving element in the form of a sticker adapted to be attached adhesively to a surface portion of a portable electrical device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device.

By providing the power-receiving element in the form of a sticker the user can readily retrofit the power-receiving element to the portable electrical device.

For convenience of delivery and attachment, the sticker preferably has a removable backing sheet on its adhesive side which is removed at the time of attaching the element to the device.

The side of the sticker opposite its adhesive side may conform in appearance to surface portions of the portable electrical device that will be adjacent to that opposite side when the sticker is attached to the device. This can enable the sticker-form power-receiving element to be attached unobtrusively or invisibly to the outside of the portable electrical device.

In another embodiment the sticker has, on its side opposite its adhesive side, a substantially transparent pocket for carrying an insert. The insert may carry text or pictures, for example a logo or advertising.

According to a fourth aspect of the present invention, there is provided a replacement cover portion for a portable electrical device, the cover portion carrying or incorporating a power-receiving element adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device. Preferably, the replacement cover portion has substantially the same size and shape as the cover portion which it replaces. Alternatively, the replacement cover portion may be thicker than that which it

replaces, or extend over the side of the portable electrical device which houses the power connector, to allow the connection means to connect to the power connector.

In one embodiment the replacement cover portion has a power connector part carrying one or more power connectors arranged to connect, when the replacement cover portion is in place on the device, to one or more corresponding power connectors of the portable electrical device. Preferably, the power connector part is connected rigidly or semi-rigidly (e.g. resiliently) to the remaining parts of the replacement cover portion so that fitting the replacement cover portion automatically brings the one or more power connectors of the replacement cover portion into electrical connection with the one or more corresponding power connectors of the portable electrical device.

In another embodiment, the replacement cover portion covers a battery compartment of the portable electrical device and has one or more battery connectors adapted to connect to one or more corresponding battery connectors of the device and/or to terminals of one or more batteries installed in the device. For example, the one or more battery connectors of the cover portion may be adapted to be interposed between the battery terminals and the corresponding battery connectors of the device.

In another embodiment, the replacement cover portion covers a battery compartment of the portable electrical device, and the cover portion further carries or incorporates at least one rechargeable battery. When the replacement cover portion is in place on the device the battery is installed operatively in the battery compartment. The power-receiving element is connected operatively to the battery for charging the battery when power is received wirelessly from the transmitter.

The replacement cover portion is, for example, a replacement cover portion for a handset of a mobile communications network.

According to a fifth aspect of the present invention, there is provided a method of adapting a portable electrical device having no wireless power receiving capability to

have such a capability, the method comprising: attaching a power-receiving element to the device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and connecting one or more power connectors, which are connected electrically to the element, to one or more corresponding power connectors of the device so that power received by the element can be delivered to the device.

According to a still further aspect of the present invention, there is provided an attachable means for receiving power, the means comprising:

i) a substantially flat power-receiving means of sufficiently small dimensions that it can attach to an existing portable device without significantly altering its ergonomics;

ii) a power connector capable of attaching to the power input of an existing portable device; and

iii) a means of attaching part or all of the above to a portable device.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Figure 1a shows a schematic side view of a portable electrical device and a first example of wireless power receiving apparatus embodying the present invention;

Figure 1b is a schematic end view corresponding to Figure 1a;

Figure 1c is a plan view corresponding to Figure 1a;

Figures 2a to 2c are respective schematic side, end and plan views of a portable electrical device and a second example of wireless power receiving apparatus embodying the present invention;

Figures 3a and 3b are respective schematic plan and side views of a power-receiving

element embodying the present invention;

Figure 4 shows a circuit diagram of parts of circuitry included in apparatus according to one embodiment of the present invention;

Figure 5 shows a schematic cross-sectional view of a power connector of apparatus according to one embodiment of the present invention;

Figure 6 shows a schematic perspective view of a power-receiving element in the form of a sticker according to one embodiment of the present invention;

Figure 7 shows a schematic perspective view of a power-receiving element according to another embodiment of the present invention.

Figure 8 shows a schematic perspective view of parts of a handset for use in a mobile communications network, a battery pack therefor and a replacement cover portion for the handset according to one embodiment of the present invention;

Figure 9 shows a schematic perspective view of the handset and battery pack of Figure 8 and a replacement cover portion for the handset according to another embodiment of the present invention; and

Figure 10 shows a schematic perspective view of the handset of Figure 8 and a replacement cover portion for the handset according to yet another embodiment of the present invention.

FIGURE 1 shows parts of apparatus 150 according to a first embodiment of the present invention, and an example portable electrical device (mobile handset) 100 with which the apparatus is used. As originally manufactured the device has no wireless power receiving capability.

As shown in side view in Figure 1a the device 100 has a power-connector 101 which in this case is a socket. The apparatus 150 comprises a substantially flat power-receiving element 200, a layer of adhesive 201, a flexible connecting member (flexible wiring) 202 and a power-connector 203 capable of being plugged-in to the device's power-connector 101.

Figures 1b and 1c show end and plan views of the arrangement of Figure 1a. The rear face (underside) of the mobile device 100 is uppermost in Figure 1a, and it is to this face that the element 200 is attached.

Figures 2a to 2c shows corresponding views to those of Figures 1a to 1c but for apparatus 160 according to the second embodiment of the present invention. In this case the device power connections (first connector means) 111a,b are contact strips instead of a socket. These device power connections 111a,b are adapted to connect to corresponding mating strips (second connector means – not shown) of external equipment (not shown) such as a charger. A power connector unit 213 of the apparatus has corresponding mating strips (third connector means) 215a,b on an inner face 214 thereof which make electrical contact with the device's power connections 111a,b. In addition, further connectors (fourth connector means) 217a,b are provided on an outer face 216 of the power connector unit 213 so that other equipment, for example an in-car hands-free unit or charger, having the second connector means may still be connected. These further connectors 217a,b are connected electrically to the corresponding contacts 215a,b by a pass-through connection arrangement incorporated into the power connector unit 213. The connectors 215a,b and 217a,b may include connectors used for purposes other than power delivery, for example input/output of signals and data.

Figures 3a and 3b show plan and side views respectively of one example of a substantially flat power-receiving element 200 for use in embodiments of the present invention. A magnetic core consists of six strips of amorphous metal 400 each measuring 50x30x0.02mm, stacked. Around these is wound a coil 300, which could be for example of copper wire, tape, or a stamped or pressed metal. In this case, the

coil passes around the core 30 times, with a centre-tap, providing current to three connections 202 which connect to further circuitry described later with reference to Figure 4. The entire element is readily flexible, which is useful in making it conform to any non-flat part of the device to which it is applied, and also makes it less fragile, since the entire element can be less than 0.2mm thick.

Further information regarding the power-receiving element of the example shown in Figures 3a and 3b, and regarding further examples of suitable power-receiving element is given in our patent publications WO-A-03/096361 and WO-A-03/096512, the entire contents of which are incorporated herein by reference. Various designs of a transmitter of wireless power suitable for use with the power-receiving element are also disclosed in these patent publications.

Figure 4 shows circuitry 450 capable of converting the alternating current delivered by the power receiving element into power suitable for use in a portable electronic device. A parallel-resonating capacitor 501 tunes the coil, which allows increased power transfer. A value of 100's of nF is typical, depending on the exact core materials and coil construction, and therefore inductance. The alternating current is full-wave rectified by diodes 500. Schottky diodes with a forward voltage drop of 0.3V provide best performance. Capacitor 502 provides smoothing of the DC. The voltage at this point is unregulated, which may be sufficient to send to subsequent electronics within the portable device, if it is capable of taking such. Optional voltage regulator 503 limits the voltage for devices which are not capable of taking an unregulated supply. This regulator may be a linear or switch mode type, and may optionally also contain other protection and system management circuitry. Optional indicator 504 indicates that power is being received.

An alternative configuration to that shown in Figures 3a, 3b and 4 would be to use a full bridge rectifier instead of diodes 500, removing the need for the centre-tap, but increasing the total power loss. With this configuration, the tuning capacitor may be parallel-resonant or series-resonant.

Figure 5 shows a detail view of one implementation of a power connector 600. A barrel-shaped protrusion carries two conducting rings 601 and 602 which mate with contacts within the power input socket of the portable device. The circuitry 450 of Figure 4 is contained within the power connector, and the optional power indicator 504 is visible externally. Optionally the connector 600 is removable from an end 603 of the flexible wiring 202, allowing different power connectors to be fitted to suit the particular device, each with the appropriate circuitry (power electronics) 450.

Alternatively, one end of the flexible wiring 202 could be removable from the power-receiving element 200 and the other end attached permanently to the power connector 600. This would allow the power connector 600 and flexible wiring 202 to be sold as one unit, and the power-receiving element to be sold as another unit. Again, this would make it possible to offer different versions of the power connector plus flexible wiring to work with different portable electrical devices, whilst offering only a single design of power-receiving element. The removable connections between the flexible wiring and the power connector and/or power-receiving element can be made by any suitable electrical connection arrangement such as a plug and socket.

A preferred implementation of the present invention is illustrated schematically in Figure 6. In this implementation, the power-receiving element is in the form of a "sticker" 700. The element 700 has a layer of adhesive 702 on one surface 701 thereof. The element is supplied with a removable backing sheet 703 which protects the adhesive 702 prior to attachment of the element to the portable electrical device. The backing sheet 703 is peeled off by a user to expose the layer of adhesive 702 on surface 701. After peeling off the backing sheet 703 the user simply presses the power-receiving element on its adhesive side 702 to the portable electrical device.

Figure 7 shows a schematic perspective view of a power-receiving element in another embodiment of the present invention. In this embodiment the power-receiving element 800 has, on its side 801 which will be visible to a user when the element is attached to the device, a transparent pocket 802. An insert 803, for

example a slip of paper or card, is carried within the pocket 802. The insert may bear text or pictures, for example a logo or advertising.

Another preferred implementation of apparatus embodying the present invention is in the form of a replacement cover portion of the portable electrical device itself. There are several types of portable electrical device commercially available which have replaceable cover portions. Handsets for use in mobile communications networks made by several major manufacturers are one example. Replacement cover portions for such devices can advantageously carry or incorporate at least the power-receiving element of apparatus embodying the present invention.

Figure 8 shows a schematic perspective view of such a handset 900. The handset 900 has a battery compartment 902 for holding a removable battery pack 904. The removable battery pack 904 is, for example, a rechargeable battery pack. The battery pack 904 has terminals (not shown) which connect to corresponding battery connectors 906 of the handset 900 within the battery compartment 902 when the battery pack 904 is installed in the battery compartment. The handset 900 also has a power connector 908 at a bottom end 910 thereof.

A replacement cover portion 950 according to an embodiment of the present invention is adapted to be fitted to the handset 900. The replacement cover portion in this embodiment is a rear cover portion and covers the battery compartment 902 of the handset 900 as well as other parts thereof. The cover portion 950 has on its inner face or incorporated within it a power-receiving element 952. The element 952 may, for example, be the same as the power-receiving element 200 described hereinbefore. The cover portion 950 is designed to extend at one end 954 beyond the bottom end 910 of the handset 900. At the end 954 the cover portion 950 has a power connector part 956 carrying one or more power connectors 958. The power connector(s) is/are connected in some suitable way (not shown) to the power-receiving element 952, either directly or via power conditioning circuitry such as the circuitry 450 of Figure 4. The power connector(s) 958 is/are adapted to connect to the corresponding power connector(s) of the handset power connector 908. This arrangement is convenient in

that installation of the cover portion 950 on the handset 900 automatically makes the required electrical connections between the power-receiving element 952 and the power connector 908 of the handset. If necessary, the power connector part 956 of the cover portion 950 may be connected semi-rigidly (e.g. resiliently) instead of rigidly to the remaining parts of the cover portion 950. This can make it easier for the power connector(s) 958 of the cover portion to be connected to the corresponding power connector(s) of the handset 900 when the cover portion is being fitted to the handset.

Figure 9 shows another embodiment in which the power-receiving element is carried by or incorporated in a replacement cover portion. In Figure 9, a replacement cover portion 1000 does not have the extended end 954 or the power connector part 956 of the replacement cover portion 950 of Figure 8. Instead, an internal power connector part 1002 is connected, preferably via power conditioning circuitry such as the circuitry 450 of Figure 4, to the power-receiving element 952. The connection may be made using flexible wiring 1004. The power connector part 1002 is sufficiently thin to enable it to be interposed between the battery terminals of the battery pack 904 and the power connectors 906 formed within the battery compartment 902 of the handset 900. In a similar way to that described previously with reference to Figure 2, the power connector part 1002 has a set of contacts on both its main faces. The two sets of contacts are connected together by a pass-through connection arrangement. This enables the power from the battery pack 904 to be supplied to the power connectors 906 when the power-receiving element is not receiving power wirelessly from a transmitter.

Figure 10 shows yet another embodiment in which a replacement cover portion 1050 carries or incorporates a rechargeable battery pack 1054 in addition to a power-receiving element 952. The electrical connections between the power receiving element 952 and the battery pack 1054 are made by suitable means (not shown) incorporated in or carried by the cover portion 1050. The fitting of the replacement cover portion 1050 to the handset 900 brings the battery terminals of the battery pack 1054 into contact with the power connectors 906 of the handset 900.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. Wireless power receiving apparatus for use with a portable electrical device to enable the device to receive power wirelessly, the apparatus comprising:

a power-receiving element adapted to be attached to the device, and also being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and

one or more power connectors which, when the apparatus is in use, are connected electrically to the power-receiving element and are adapted to be connected to one or more corresponding power connectors of the portable electrical device to deliver power received by the element to the device.

2. Apparatus as claimed in claim 1, wherein said power-receiving element is adapted to be attached adhesively to the device when the apparatus is in use.

3. Apparatus as claimed in claim 1, further comprising mechanical attachment means adapted to attach the power-receiving element mechanically to the device when the apparatus is in use.

4. Apparatus as claimed in claim 1, wherein said power-receiving element forms part of a replacement cover portion of the portable electrical device.

5. Apparatus as claimed in claim 1, wherein said power-receiving element and at least one of said power connectors of the apparatus are connected rigidly together, whereby connection of said at least one power connector to its said corresponding power connector of the portable electrical device serves to attach the power-receiving element mechanically to the device.

6. Apparatus as claimed in any one of claims 1 to 4, further comprising a flexible connecting member connecting said one or more power connectors flexibly to said power-receiving element.

7. Apparatus as claimed in claim 6, wherein said flexible connecting member also serves to connect said one or more power connectors electrically to the power-receiving element.

8. Apparatus as claimed in any one of claims 1 to 5, having one or more electrical connections extending between said power-receiving element and said one or more power connectors, said one or more electrical connections being detachable

from said power-receiving element and/or from said one or more power connectors when the apparatus is not in use.

9. Apparatus as claimed in any preceding claim, wherein said portable electrical device has first connector means adapted to connect to corresponding second connector means of external equipment, said first connector means providing said one or more corresponding power connectors of the portable electrical device, and the apparatus further comprising:

third connector means adapted to connect to said first connector means of the portable electrical device, said third connector means providing said one or more power connectors of the apparatus;

fourth connector means adapted to connect to said second connector means of said external equipment; and

a pass-through connection arrangement interconnecting at least one connector of said third connector means and a corresponding connector of said fourth connector means.

10. Apparatus as claimed in claim 9, wherein said first to fourth connector means also provide connectors for purposes other than power delivery, and said pass-through connection arrangement serves to interconnect corresponding connectors of said third and fourth connector means used for said other purposes.

11. Apparatus as claimed in any preceding claim, further comprising:

power-conditioning circuitry operable to condition the power received by the power-receiving element prior to delivery to the portable electrical device.

12. Apparatus as claimed in any preceding claim, wherein said power-receiving element is small relative to said portable electrical device.

13. Apparatus as claimed in any preceding claim, wherein said power-receiving element is thin relative to said portable electrical device.

14. Apparatus as claimed in any preceding claim, wherein a volume occupied by said power-receiving element is small in comparison with a volume occupied by said portable electrical device.

15. Apparatus as claimed in any preceding claim, wherein said power-receiving element is of sufficiently small dimensions that, when attached to the portable electrical device, it does not substantially alter the ergonomics of the device.

16. Apparatus as claimed in any preceding claim, wherein parts of said power-receiving element that are visible to a user of the device when the element is attached to the device have an external appearance which conforms to an external appearance of adjacent parts of the device.

17. Apparatus as claimed in any preceding claim, wherein a part of said power-receiving element which must be placed in proximity with the transmitter is marked or coloured or labelled distinctively.

18. Apparatus as claimed in any preceding claim, wherein said power-receiving element has, at a surface thereof that is visible to a user of the portable electrical device when the element is attached to the device, a substantially transparent pocket for carrying an insert to be visible to the user.

19. Apparatus as claimed in any preceding claim further comprising an indicator which produces a predetermined indication of an operating state of the apparatus.

20. Apparatus as claimed in any preceding claim, wherein said power-receiving element is substantially flat.

21. Apparatus as claimed in any preceding claim, wherein said power-receiving element is flexible.

22. In combination a portable electrical device and wireless power receiving apparatus as claimed in any preceding claim.

23. The combination of claim 22, wherein said power-receiving element is attached to an external surface portion of the device.

24. The combination of claim 22, wherein said power-receiving element is attached to an internal surface portion of the device.

25. The combination of claim 24, wherein said internal surface portion is a surface portion of a battery compartment of the device.

26. The combination of any one of claims 22 to 25, wherein said one or more corresponding power connectors of the portable electrical device are internal power connectors.

27. The combination of any one of claims 22 to 26, wherein said one or more corresponding power connectors of the portable electrical device are battery connectors.

28. A power-receiving element in the form of a sticker adapted to be attached adhesively to a surface portion of a portable electrical device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device.

29. A power-receiving element as claimed in claim 28, wherein said sticker has a removable backing sheet on its adhesive side which is removed at the time of attaching the element to the device.

30. A power-receiving element as claimed in claim 28 or 29, wherein a side of said sticker opposite its adhesive side conforms in appearance to surface portions of the portable electrical device that will be adjacent to said opposite side when the sticker is attached to the device.

31. A power-receiving element as claimed in any one of claims 28 to 30, wherein said sticker has, on its side opposite its adhesive side, a substantially transparent pocket for carrying an insert.

32. A replacement cover portion for a portable electrical device, the cover portion carrying or incorporating a power-receiving element adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device.

33. A replacement cover portion as claimed in claim 32, having a power connector part carrying one or more power connectors connected operatively to the power-receiving element and arranged to connect, when the replacement cover portion is in place on the device, to one or more corresponding power connectors of the portable electrical device.

34. A replacement cover portion as claimed in claim 32 or 33, adapted to cover a battery compartment of the portable electrical device, and having one or more battery connectors adapted to connect to one or more corresponding battery connectors of the device and/or to terminals of one or more batteries installed in the device.

35. A replacement cover portion as claimed in claim 34, wherein said one or more battery connectors of the cover portion are adapted to be interposed between said battery terminals and said corresponding battery connectors of the device.

36. A replacement cover portion as claimed in claim 32 or 33, adapted to cover a battery compartment of the portable electrical device, and further carrying or incorporating at least one rechargeable battery such that, when the replacement cover portion is in place on a device, the battery is installed operatively in the battery compartment, the power-receiving element being connected operatively to the battery for charging the battery for charging the battery when power is received wirelessly from the transmitter.

37. A replacement cover portion as claimed in any one of claims 32 to 36, being a replacement cover portion for a handset of a mobile communications network.

38. A method of adapting a portable electrical device having no wireless power receiving capability to have such a capability, the method comprising:

attaching a power-receiving element to the device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and

connecting one or more power connectors, which are connected electrically to the element, to one or more corresponding power connectors of the device so that power received by the element can be delivered to the device.

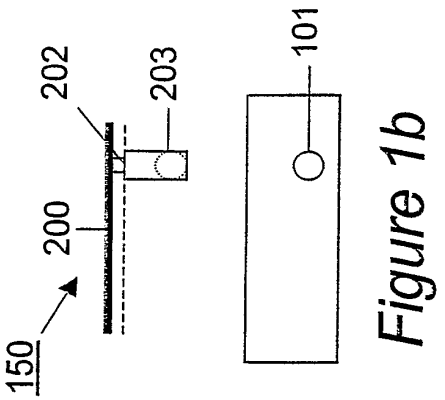


Figure 1b

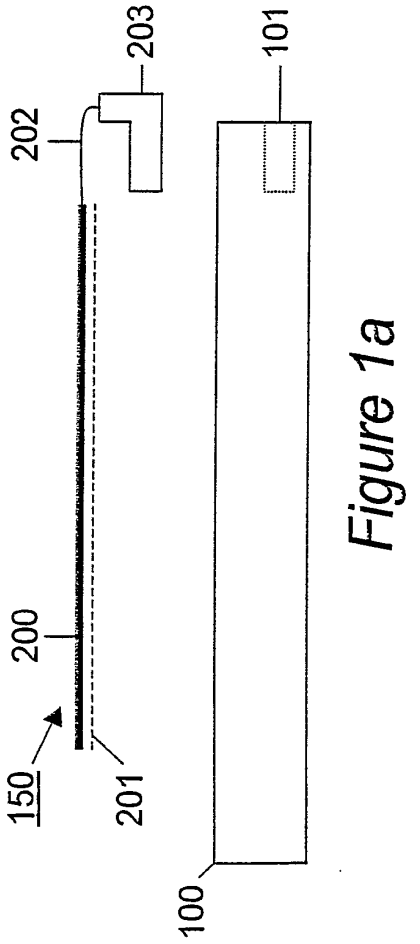


Figure 1a

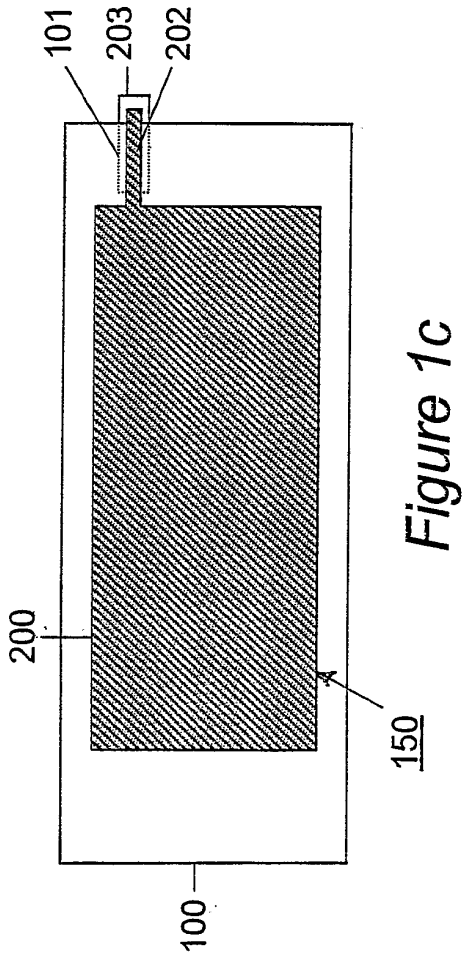


Figure 1c

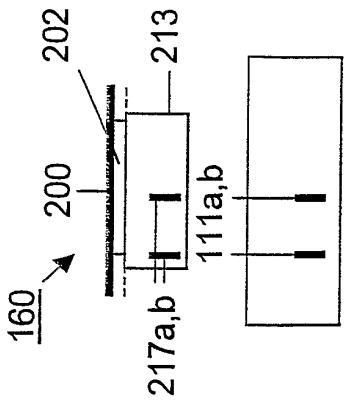


Figure 2b

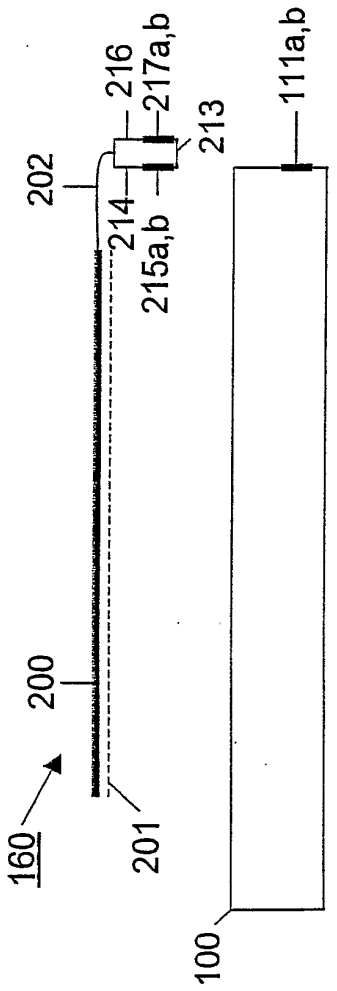


Figure 2a

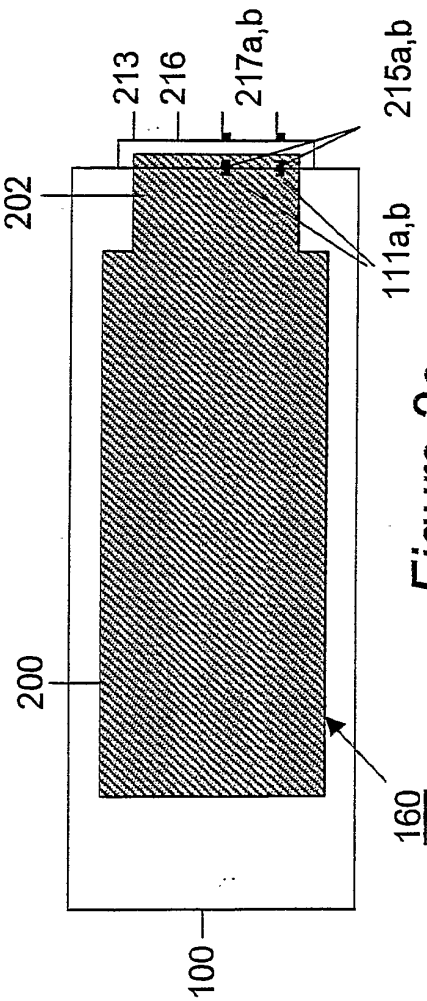


Figure 2c

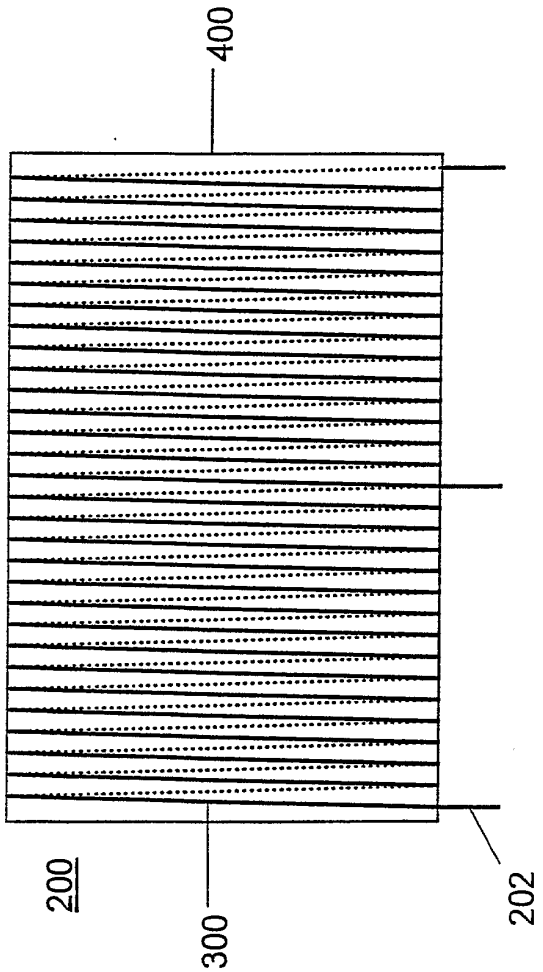


Figure 3a

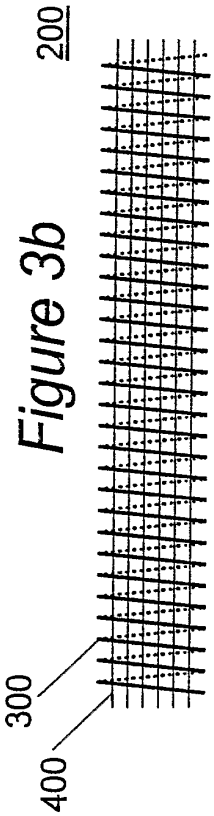
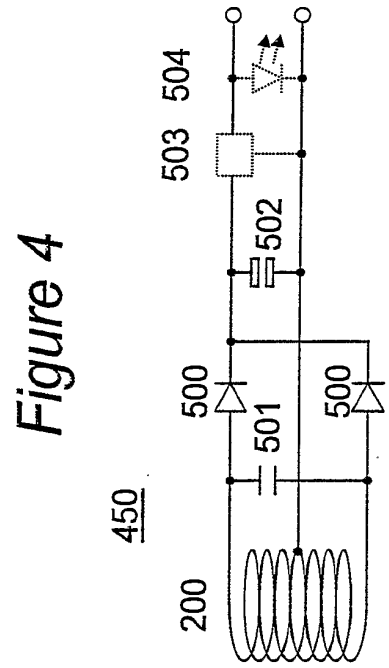


Figure 3b

Figure 4



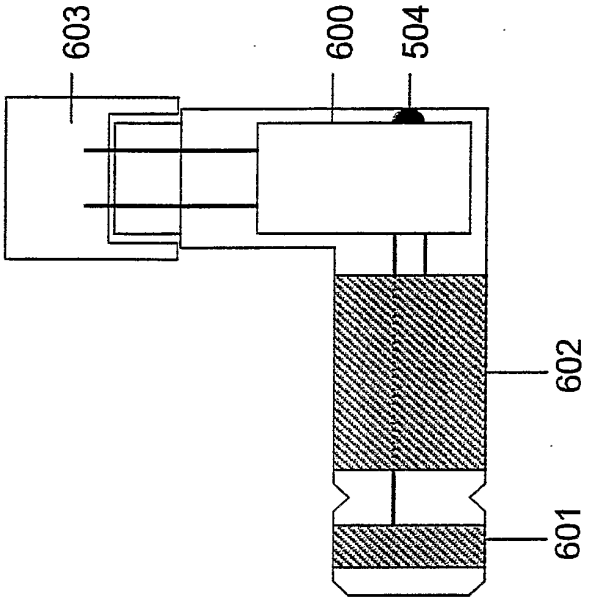


Figure 5

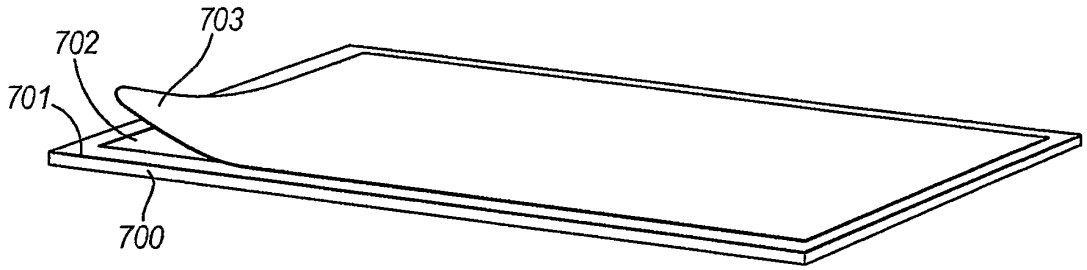


Fig.6

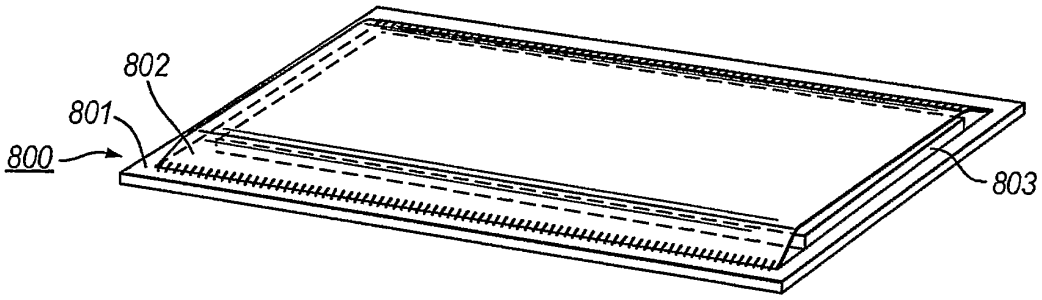


Fig.7

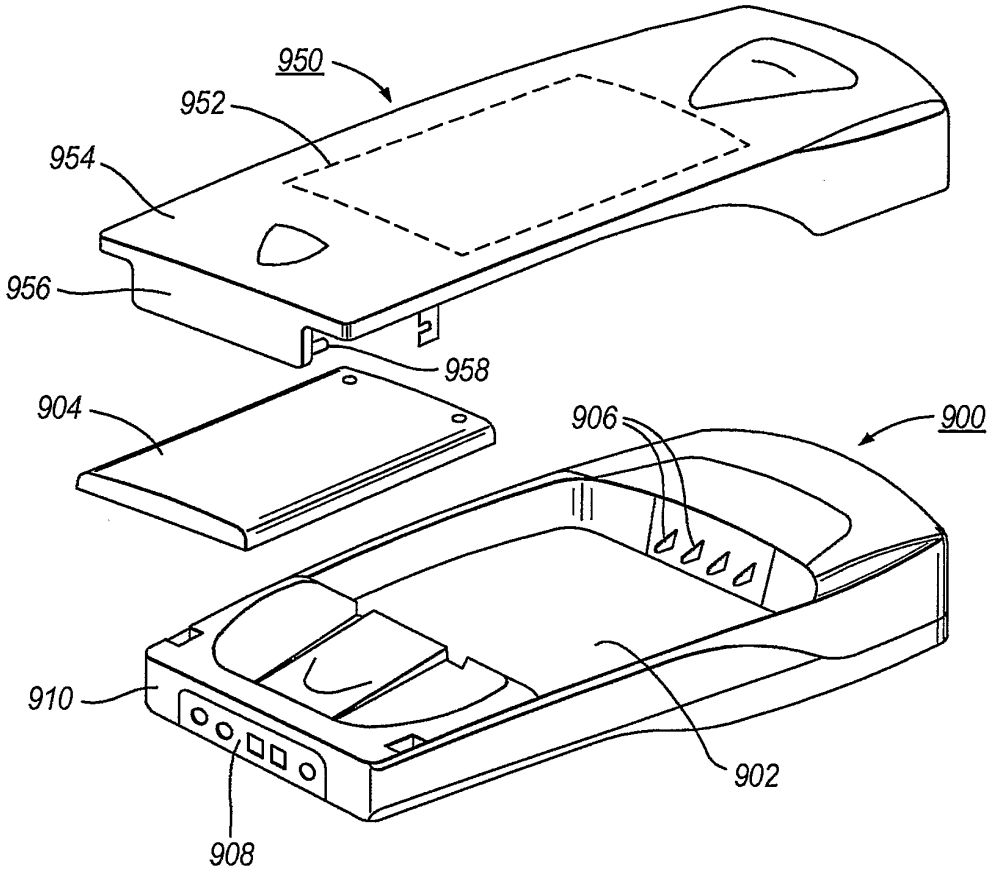


Fig.8

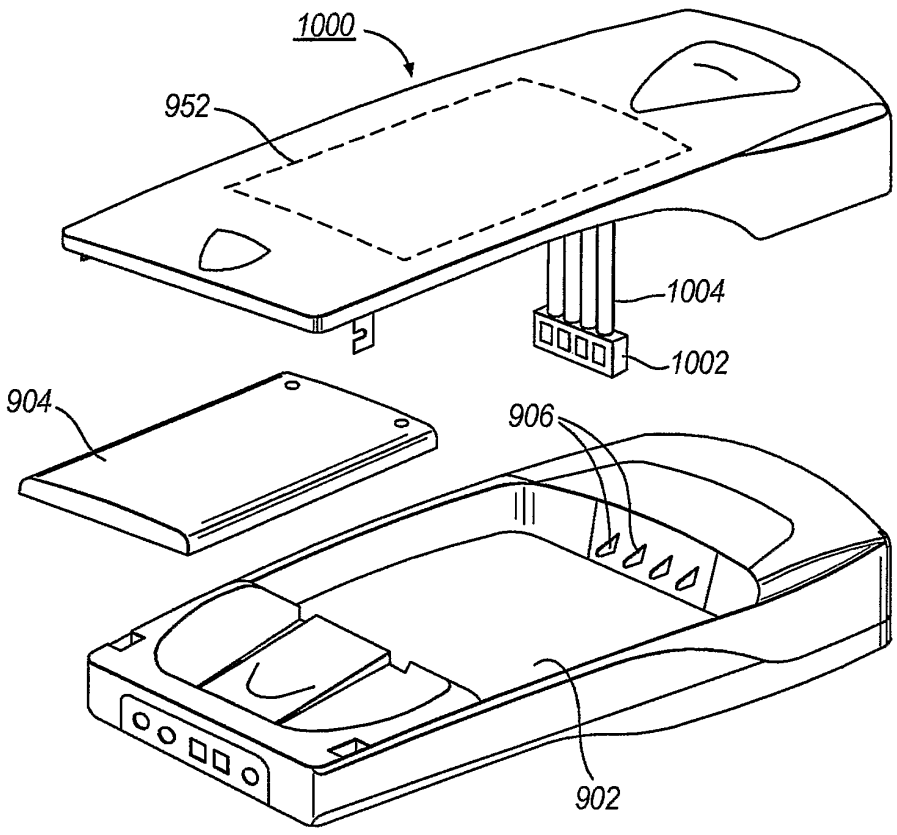


Fig.9

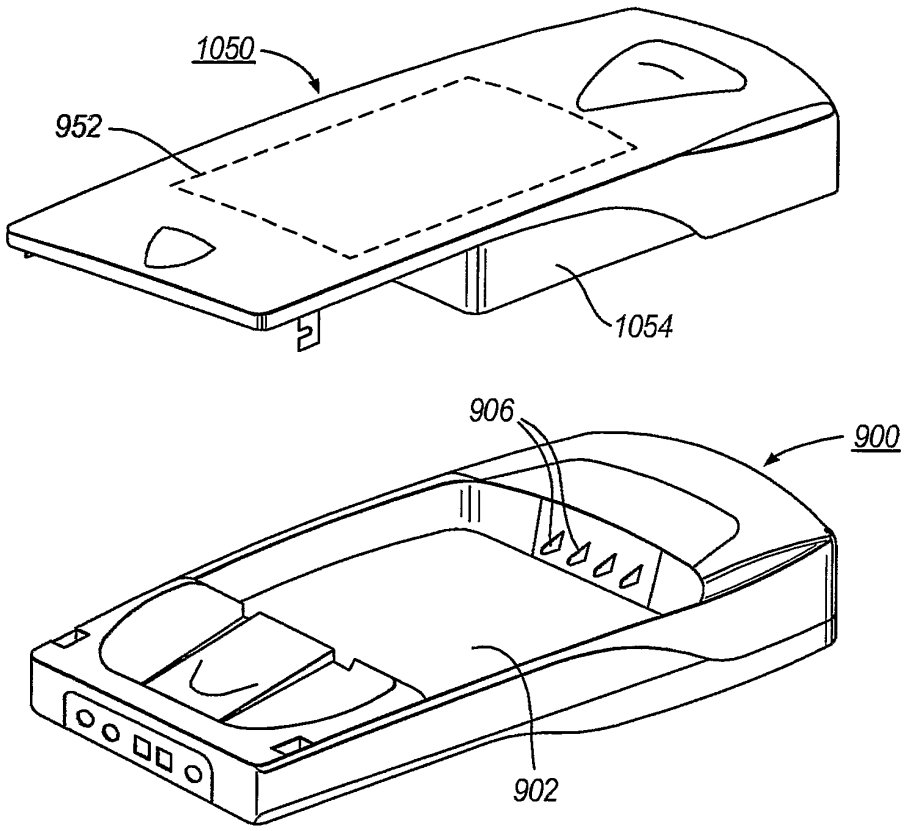


Fig.10

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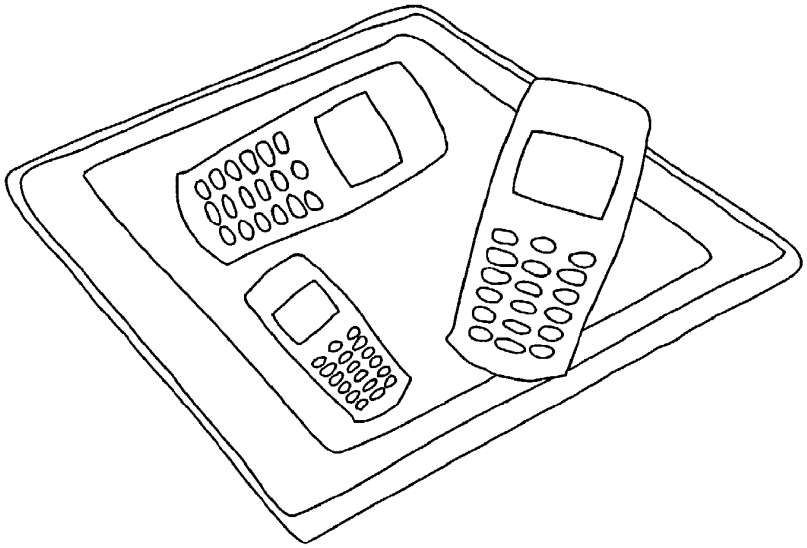
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[Continued on next page]

(54) Title: IMPROVEMENTS RELATING TO AUTOMATICALLY CONFIGURING RECHARGEABLE DEVICES



Wirelessly-rechargeable devices, recharged by being placed onto, or in proximity to, a recharging pad.

(57) Abstract: There is disclosed a system and method for causing portable electronic devices to take various actions or state changes when brought into proximity to a recharging station, and/or removed from proximity to a recharging station. Additionally, the actions or changes may vary depending on the relative position of the device on the recharging station.

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

IMPROVEMENTS RELATING TO AUTOMATICALLY CONFIGURING RECHARGEABLE DEVICES

This invention relates to a new system of managing portable rechargeable devices in relation to their recharging stations, and a method of managing portable rechargeable devices in relation to their recharging stations.

Portable rechargeable devices (instances of which are hereinafter referred to simply as a "device") are usually charged either by:

- attaching a wire from a recharger (Figure 1), or
- by dropping the device into some kind of receptive cradle connected to a recharger, or
- by dropping the device onto a surface connected to a recharger (Figure 2)

Charging is either by via electrical contacts or a non-contact means, e.g. magnetic induction or light-power.

Examples include:

- The Palm Pilot™ series of Personal Digital Assistants (PDAs), which sit in a recharging cradle.
- Mobile phones, which can be dropped into a cradle in a car for recharging and hands-free operation.

In some cases, devices charged by non-contact means may not need to be physically touching their rechargers – just placing a device close to a recharger may be sufficient to enable charging to take place. So hereinafter in this patent application, when the word "on" is used in the context of recharging a device on a recharger, it should be understood to mean that it may either touch its recharger, or be near enough to permit recharging to take place. Likewise the word "off" used in such a context should be understood to mean that it is being taken out of contact with its recharger, or far enough away that recharging is no longer possible.

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In some instances, today's wire-recharged devices are able to perform certain useful automatic actions when they:

- are removed from the recharging station and/or
- are replaced on the recharging station and/or
- remain on the recharging station

Examples include:

- Hagenuk™ DECT wireless cordless home phones, which if removed from the cradle while ringing automatically go "off-hook" (answer), and if off-hook automatically go "on-hook", terminating the call, as they are replaced onto the cradle.
- The Palm Pilot™, which is also able to synchronise data with a connected PC via its recharging cradle, on command from a manual pushbutton.
- Various mobile phones (e.g. Ericsson™ T68) which can detect when an external hands-free set is plugged in to them, and alter their "profile" setting accordingly. The "profile" is a collection of settings which affect the phone's behaviour, for example the volume setting and the answer mode. If the hands-free set functionality is incorporated in an in-car charging cradle, the combined unit has the functionality of automatically changing its profile when dropped into the cradle, and of automatically reverting to a previous profile when removed from the cradle.

Unrelated to the above, but of relevance to the present invention, there exist devices powered by an external inductive field, and capable of simultaneously exchanging data to and from the remote device generating that field. An example of such data modulation combined with an inductive power source is the passive "RFID" devices and smart labels, for example the Philips MIFARE™ smart tags, which are both powered and interrogated by an inductive field from a nearby reader.

Today more and more devices are capable of obtaining their data communications (e.g. voice data or computer data) wirelessly, for example by DECT or Bluetooth or 802.11 WiFi.

If such devices are also made capable of being recharged without wires (e.g. by induction-charging) then the devices become entirely wire-free, with obvious benefits of convenience for the user.

However in this case the mechanical contact connection which today serves to indicate to the device that it is in a cradle is not present in such inductively-charged devices. This removes a useful means of triggering automatic actions such as those described above.

According to a first aspect of the present invention there is provided:

- a recharging station ("recharger") and
- a portable rechargeable device ("device"),
- the device incorporating a means for receiving power from such a recharger without direct electrical contact ("receiver"),
- the receiver having a means for detecting when it is in proximity to the recharger, and signalling this information to the rest of the device ("control means"),
- the control means using this information to change the state of the device, or to take some predetermined action.

Such a system is advantageous because it provides the device with a means of altering its behaviour in some useful fashion as it is removed from and/or replaced on the recharger.

According to a second aspect of the present invention, there is provided a method of altering the settings, and/or triggering certain behaviour of a portable rechargeable device by means of a receiver capable of detecting that it is in proximity to a recharging station and informing the control software or electronics of the device electronics of this fact.

The receiver may receive power for example via an inductive loop or a photovoltaic cell. Typically it may incorporate some kind of power-conditioning circuit, for example a rectifier and a smoothing capacitor, and possibly a voltage regulator, which will then typically be connected both to the power-supply input of the device and to a rechargeable battery. There may be a separate charge-controller to control the recharging of the battery.

The control means may be dedicated analogue or digital electronics, or a microcontroller running a software program.

The communication from the receiver to the control means may be a simple hardware or software binary signal indicating whether or not the device is in proximity to the recharger, or it may be some more sophisticated hardware or software signal indicating for example the three conditions "far from recharger / close to recharger / on recharger".

The receiver may detect this condition for example simply by detecting that its received power has crossed a preset threshold. The detection may be conducted by component already mentioned, for example a regulator or charge-controller

It will be clear to those skilled in the art that the transition from one signal state to another (an "event") may be a useful trigger for causing actions to take place.

Optionally, a signal indicating that the device is being brought closer to the recharger may do any or all of the following:

- Cause the device to begin reception, transmission or synchronisation of its data with another device, for example a personal computer (PC). The data may be of any type, for example but not limited to calendar and contact data, photographic data, music data.
- Cause the device, if it is interacting with the user (for example a phone "off-hook", or a computer streaming live video from some expensive source) to cease the interaction (for example, the phone going "on-hook", or the

computer ceasing to stream the video). Indeed the device may simply turn-off, or appear to do so.

- Switch to a different mode of communication with other devices.

Optionally a signal indicating that the device is being taken further from the recharger may cause the device to do any or all of the following:

- Cause the device, if it is signalling for attention from the user (for example, a phone ringing or an alarm sounding) to change into a mode suitable for interaction with the user (for example, the phone going "off-hook" or the alarm silencing). Indeed the device may simply turn-on ready to be used, for example an electric shaver starting.
- "Finish-up" any ongoing data transfers in an ordered fashion, on the assumption that it may be about to go out of range, e.g. leave the house.
- Switch to a different mode of communication with other devices.
- Request a security verification from the user (for example, a PIN number or fingerprint). This would be useful in cases where a device is being recharged in a public place, to prevent thieves from find the device useful if they steal it.

Optionally, the location and/or orientation in which the device is placed relative to the recharger may be sensed by the device, the recharger or both, and made to control their behaviour or state. For example, placing a phone in a particular part of the recharger might mean "ring quietly" or "refuse calls". Moving a device relative to its charger might cause its light and/or a light on the recharger to illuminate, making it easier to pick-up in the dark.

Optionally, or additionally, to the control means detecting that it is close to a recharger via the power receiver (which indicates that it may be close-enough to actually charge), it may detect that it is in the region of a recharger by some other longer-range wireless interface. For example, both the recharger and the device may have bidirectional Bluetooth or 802.11 WiFi interfaces capable of interchanging information. This allows the control means to know when it is "close, but not close-enough to charge". If this is coupled with a means for detecting that the device needs

recharging, the recharger may for example light an indicator to indicate its useful presence.

Alternatively or additionally, the flow of power from the recharging means to the device may be modulated to encode data upon it. It may be modulated in either direction:

- by the recharger (e.g. by skipping power cycles) to send data to the device, and/or
- by the device (e.g. by shorting turns during power cycles) to send data to the recharger, and/or
- both of the above.

Such data may be a simple static identity number ("ID"), for example a unique ID or class ID. In the case of devices which also have another ID for different purposes (for example the phone number of a phone, or the Internet Protocol or Bluetooth address of a data device), the two IDs may be the same, thus communicating the other ID over the recharging link. The ID may even be the ID of a related item, for example the Social Security Number or email address of the owner of a device, or the IP address of a computer within wireless range of the recharging station.

Alternatively or additionally, such data may be a dynamic flow of novel information between devices, for example the data needed to synchronise a PDA with a PC.

Depending on the type of power transfer, the data transfer rate may be quite slow.

A device may set its internal state (e.g. the profile of a mobile phone) differently, and/or conduct certain actions (e.g. synchronisation) differently, dependant on the ID of the recharger on which it is placed. For example, a mobile phone may set its profile to ring more quietly when on a recharger with a "home" ID than on one with a "car" ID).

A recharger in a public place may read the phone number (or other ID) of a device so that it can bill the user for power received, or push adverts.

Once the power is exhausted on a device, it may refuse to work again until it is recharged on a recharger with a particular ID or class of ID's previously-defined.

It can be difficult for users of wireless devices to configure them such that they are able to communicate with to one another. Such devices tend to have long IDs which must somehow be exchanged in order for a link to be established, and this normally either has to be done by entering many numbers or letters, or by requesting a list of all devices within range and choosing one.

It will be seen that for such devices, for example a wireless PDA trying to synchronise with a PC, the simple reception or exchange of such an ID may be of great help in informing one device of the other's address automatically, so that it may establish a link on a separate communication means, possibly a wireless network with higher data-rate and greater-range.

The usable distance within which a device must be of a recharger in order to recharge is usually short and well-defined (compared to that of a typical wireless data system), and thus it is convenient for the user to point or wave the device at the recharger, to make it clear which device should be talking to which.

If, for example, a recharger has a separate wireless Access Point built-in, or attached to or nearby to it (for example one using the Bluetooth or 802.11 protocols), it can advertise the IP address of the Access Point to any devices placed on it. Without this, much button-pushing would be required of the user to configure the device to achieve a simple task, e.g. collecting email, at a new location such as a café or office, which may never be visited again.

As another example, imagine that an inductive recharger is placed on a mantelpiece in the living room of a home, and it is set to encode a unique "living room ID" onto its inductive field:

- If the user places a video-camera or digital camera on the recharger to recharge it, and the video camera has a wireless link on it, this ID mechanism can ensure that when "play" is pressed, the image is sent to the correct TV, and not to the one in the room next door.
- Likewise if the user places a music player (e.g. an MP3 player) with a wireless link, this ID mechanism can ensure that when "play" is pressed, the audio is sent to the correct loudspeaker music system, and not to the one in the room next door.

The same scenario could be imagined in a car – where a user may want to ensure that any device they place on an in-car recharger uses their own networks and not those e.g. of the car next door.

As another example, if every device remembers the ID of the last recharger it has encountered (including any recharger it may currently be on), then placing the device on the recharger, even momentarily, becomes a means of establishing a "rendezvous ID" which can be used to exchange data by some other wireless means between two devices.

If the recharger is capable of simultaneously recharging more than one device, the recharging station can even become a "proxy" – an area enabling devices to exchange data with each other.

The receiver may optionally have an alternative mode of operation where it is capable of generating power for transfer to another device, rather than receiving it. In such a case, two devices may exchange IDs or data as described above directly between them without the help of any recharger.

Any combination of all of the above may be possible.

For a better understanding of the present invention and to show it may be carried into effect, reference shall now be made, by way of example, to the accompanying drawing(s), in which:

FIGURE 3 shows an embodiment of the present invention.

Referring to Figure 3, a recharger uses an inductive coil to create an alternating magnetic field. This field is picked-up by a device in proximity. The device rectifies smoothes and regulates the power, before delivering it to the control means and, via a charge-controller, to the device battery. The area bordered by a dotted line may be considered to be the "receiver" in the present invention. So far, this is a description typical of any inductively-charged electronic device.

What makes it novel is the signal line (heavy dotted line) from the regulator to the control means. In this embodiment, the regulator is measuring the power received, and setting the signal line high if the power received is above a threshold, and low otherwise. The control means uses this information to change certain behaviour, for example to set Profile A when the signal line is high and to set Profile B when the signal line is low.

In a more sophisticated embodiment, the recharger modulates the transmitted power with an ID number which is the ID of a local wireless access point. The receiver now decodes this ID data from the incoming power and passes it to the control means which makes more sophisticated use of it, for example to use it to access the Internet.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and

"comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A system for recharging portable devices comprising:
   - a recharging station ("recharger") and
   - a portable rechargeable device ("device"),
   - the device incorporating a means for receiving power from such a recharger without direct electrical contact ("receiver"),
   - the receiver having a means for detecting when it is in proximity to the recharger, and signalling this information to the rest of the device ("control means"),
   - the control means using this information to change the state of the device, or to take some predetermined action.

2. A system as claimed in claim 1, wherein the device includes a memory containing data, and wherein, when the control means detects increased proximity to the charger, the control means triggers the device to begin transmission, reception or synchronisation of the data to, from or with another computer.

3. A system as claimed in claim 1 or 2, wherein, when the control means detects increased proximity to the charger, the control means triggers the device to cease any ongoing interaction with a user of the device.

4. A system as claimed in any preceding claim, wherein, when the control means detects decreased proximity from the charger, the control means triggers the device to begin interacting with a user of the device.

5. A system as claimed in any preceding claim, wherein, when the control means detects decreased proximity from the charger, the control means triggers the device to finish any ongoing wireless communications.

6. A system as claimed in any preceding claim, wherein the device has a user interface and wherein, when the control means detects decreased proximity from the charger, the control means triggers the device to lock its user interface.

7. A system as claimed in any preceding claim, wherein a behaviour or operation of the control means changes dependant on where and/or in what rotation the device is placed on the recharger.

8. A system as in any preceding claim, wherein a flow of power from the recharger to the device is modulated to encode data upon it, either by the recharger, the device or both.

9. A system as claimed in claim 8, wherein the encoded data is a static identification number.

10. A system as in claim 9, wherein the number is a wireless network address of the recharger or device.

11. A method of altering the settings, and/or triggering certain behaviour of a portable rechargeable device by means of a receiver capable of detecting that it is in proximity to a recharging station and informing the control software or electronics of the device electronics of this fact.

12. A system for recharging portable devices, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

13. A method of altering the settings, and/or triggering certain behaviour of a portable rechargeable device, substantially as hereinbefore described with reference to or as shown in Figures 2 and 3 of the accompanying drawings.

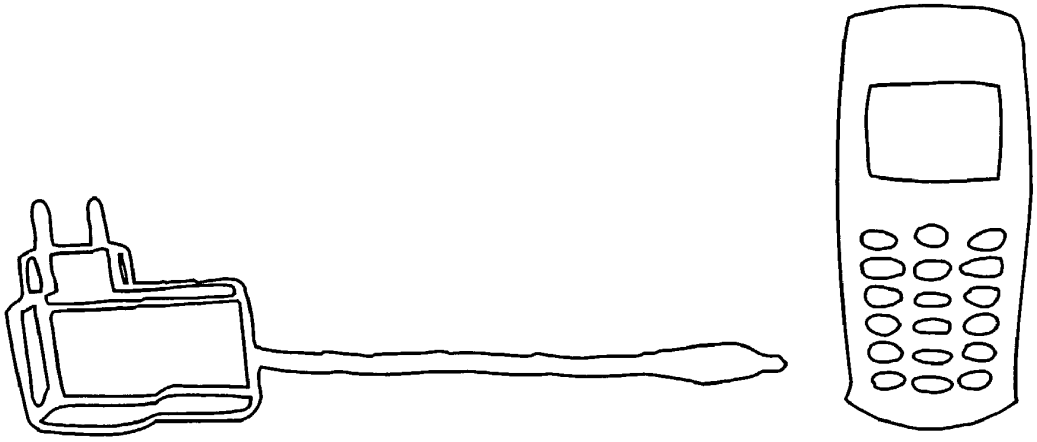


Figure 1 – Conventional "flying lead" charger, which plugs into a mobile device to charge it

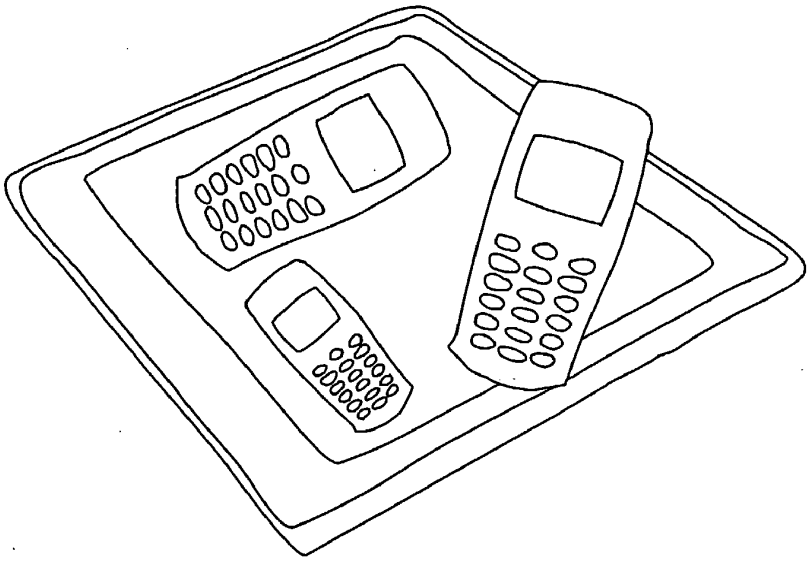


Figure 2 – Wirelessly-rechargeable devices, recharged by being placed onto, or in proximity to, a recharging pad.

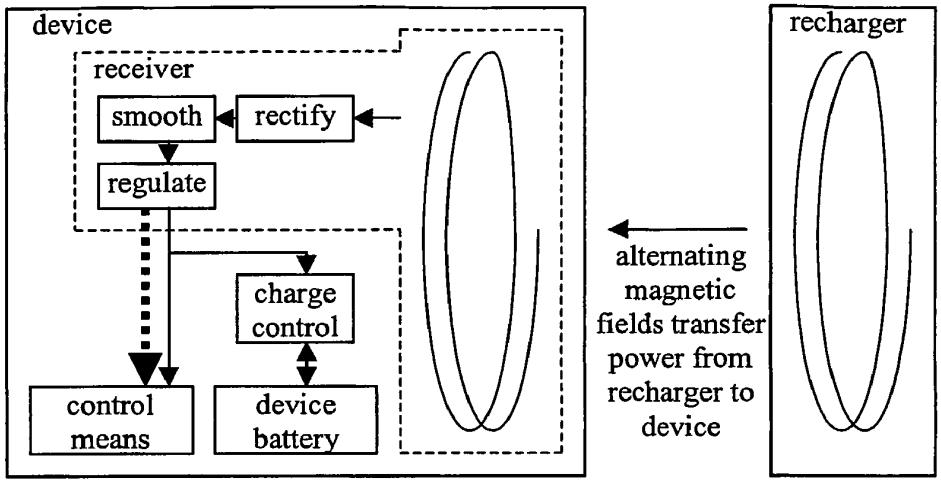


Figure 3 – Example configuration for informing control means of the proximity of the device to a recharger

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB 03/04642

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J5/00 H02J17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 455 466 A (PARKS TERRY J ET AL) 3 October 1995 (1995-10-03) abstract; figure 2 column 2, line 5 - line 65 column 3, line 26 -column 4, line 56	1,2,5-8, 11
Y	---	9,10
X	EP 0 533 247 A (ERICSSON RADIO SYSTEMS BV) 24 March 1993 (1993-03-24) abstract column 1, line 36 - line 45 column 1, line 53 -column 8, line 14; figures 1,2 column 15, line 56 -column 16, line 27	1,8-11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 February 2004	01/03/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lorenzo Feijoo, S

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 127 799 A (KRISHNAN RAJESH) 3 October 2000 (2000-10-03) abstract column 1, line 50 -column 2, line 52	1,2,8,11
X	EP 1 096 641 A (SEIKO EPSON CORP) 2 May 2001 (2001-05-02) abstract paragraph '0006! - paragraph '0014!	1,2,8,11
X	EP 0 558 316 A (G2 DESIGN LTD) 1 September 1993 (1993-09-01) abstract; claims 1,2,13,21 column 1, line 53 -column 2, line 44	1,11
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A	US 6 429 622 B1 (SVENSSON LARS) 6 August 2002 (2002-08-06) abstract; figures 3,5	1,9-11
A	US 5 982 764 A (BUTLER NEAL R ET AL) 9 November 1999 (1999-11-09) abstract column 2, line 32 - line 48 column 5, line 36 -column 6, line 38	1,8,11
A	US 2002/082059 A1 (HASHIZUME HIROSHI ET AL) 27 June 2002 (2002-06-27) abstract; claims 1-3	2-5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 03/04642

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 12-13
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 12-13

Claims 12-13 have not been searched as they are not allowable under Rule 6.2 (a) PCT

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB 03/04642

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International Bureau

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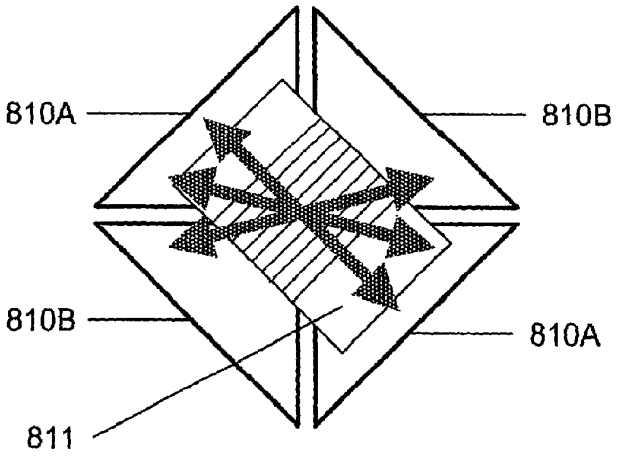
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

[Continued on next page]

(54) Title: IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER



(57) Abstract: A unit (701) for transferring power in an inductive manner to at least one power-receiving device, and a system comprising such a unit and such a device. The unit (701) includes at least one coil structure (702, 703, 704) configured to allow various degrees of translational and rotational freedom of movement of the power-receiving device relative thereto. This provides increased ease of use, since it is not necessary for a user to place the power-receiving device in mechanical or other registration with the unit (701).

WO 2004/038888 A2

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER

This invention relates to a new device for transferring power in a contact-less fashion, for example electromagnetic induction.

Today's inductively-chargeable portable devices, for example the Braun Oral B Plak Control power toothbrush, must typically be precisely aligned with their charger in order to charge them. This precision is necessary so that the coil in the device is correctly aligned with the coil in the charger – the coils being, in effect, the two halves of a conventional power transformer.

Some examples of typical prior art are shown in Figure 1. In Figure 1a, the primary coil of the charger is aligned with the secondary coil of the device. In Figure 1b, a horseshoe electromagnet on the charger is aligned with a similar electromagnet on the device. Figure 1c operates in a very similar way to Figure 1b: the field is created by two coils operating in antiphase (with the lower return circuit being an air gap), and the secondary coil is a flat wound coil. Prior art such as US4873677 works in such a fashion. Note in all cases the precise alignment that is required in order to achieve good coupling between the primary and secondary coils.

Referring now to Figure 2 which explains some terminology used in the present application: Figure 2a shows some charger 201 with a surface 203, the charger 201 emitting a field, and some device 202 charging from the charger 201 (and appreciating that in this figure the shapes of both are irrelevant). Figure 2b shows that the device 202 may move about on ("be translated relative to") the surface 203 of the charger 201 in two directions, depicted X and Y, which are at right angles to one another. The device 202 may also move nearer to and further from the charger 201 in direction Z, but as this will eventually take it out of the charging field, and this is therefore not considered here.

Figure 2c shows that in addition to the above translations, the device 202 may rotate around the X axis (rX), the Y axis (rY) and the Z axis (rZ). In the present application,

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only rotations about rZ, and not those around rX or rY, shall be considered. Each of these six translations and rotations is independent from (also known as "orthogonal to") the others, and is known as a "degree of freedom".

Figure 2d shows an alternative translation co-ordinate system. Instead of orthogonal (X,Y) movement, the position of the device 202 is determined by the radius (r) and the angle (θ) from some centre point. Even though θ involves rotation, it is still a translational degree of freedom, since the device 202 itself need not rotate about its own axis.

For maximum user convenience a system should allow up to five degrees of freedom - translation in the Z axis not being of practical use - so that a device 202 can be placed without regard to its position or orientation on the charger 201.

But today's toothbrush chargers and the like are typically much more constrained. Systems employing the transformer configuration shown in Figure 1a offer one degree of freedom (rotation in the plane of the coils), and those shown in Figure 1b and Figure 1c offer zero degrees of freedom, since if the device is to continue to receive adequate power it cannot be either rotated nor translated relative to the charger. Having zero - or only a few - degrees of freedom requires precise alignment which may be inconvenient to the user because it requires a degree of care and manual dexterity in placing the device 202 on the charger 201.

In addition, systems lacking the translational (X and Y) degrees of freedom cannot charge multiple devices simultaneously, because of course not more than one device can occupy the required (X,Y) position at once.

In addition, such systems requiring precise primary:secondary alignment are also not a universal inductive charging solution – one able to charge devices with very different power requirements – because the different coil sizes mandated by the power needs of different types of devices will not be a good match for any single size of charger coil – see Figure 3.

Various means of increasing the number of degrees of freedom have been proposed.

One simple method is to have a large coil in the charger, emitting a large field, allowing the device to pick-up sufficient power even if it is not perfectly aligned. Figure 4, for example, shows such a charger coil 401 and device coil 402. This is the method adopted by various RFID devices. However the coupling between the coils 401 and 402 will be poor and highly variable dependent on position, so this solution is inefficient and limits the power that can be transferred while still complying with emission legislation. Therefore this solution is far from ideal in charging applications, where efficiency is typically an important criterion.

A solution which improves upon the efficiency of such "large coil" systems, while still offering several degrees of freedom, is to use multiple coils in the charger, enabled as appropriate, ensuring that there is always a reasonable match between nearby charger coils and the device coil. See Figure 5, showing multiple charger coils 501 and single device coil 502. Prior art includes:

- A system is described in the Journal of the Magnetics Society of Japan titled "Coil Shape in a Desk-type Contactless Power Station System" (29th Nov 2001)

An alternative solution is the present applicant's UK patent application number 0210886.8 of 13 May 2002, which discloses a system generating a horizontal field across the surface of the charger, in contrast to conventional solutions which generate a vertical field out of the surface of the charger. A copy of equivalent International patent application no PCT/GB2003/002030 is being filed with the present application so as to form part of the file thereof, and the full contents of PCT/GB2003/002030 are hereby incorporated into the present application by reference. This offers the same two translational degrees of freedom (X and Y) as the above multiple-coil approach, but with better field uniformity and therefore worst-case efficiency. Optionally, the horizontal field may be rotated in the plane of the charger, offering an additional one degree of rotational freedom (rZ). See Figure 6 which shows a laminar

charger 601 generating a magnetic field in the plane of the charger 602 and a device 610 capable of receiving power from such a field when it is in a certain alignment 611. If the field generated by the charger is made to rotate, as shown, then there is no requirement to align the device in any particular orientation.

According to a first aspect of the present invention, there is provided a unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with at least one electrical coil, and the power-receiving device being capable of receiving power when placed in more than one position or rotation on the unit.

The unit may include a pad in which the coils are disposed, the pad serving as a surface upon which power-receiving devices may be placed in order to effect power transfer. The unit may incorporate a power supply or be connectable to a power supply. The pad is preferably a laminar pad, i.e. has a configuration of a lamina. In other words, the pad is preferably generally flat, and may be substantially planar, it being understood that the pad may take a curved form or be made conformal to a curved surface such as the inside of a glove compartment in an automobile. This may apply also to the further aspects of the invention set out hereinbelow.

According to a second aspect of the present invention, there is provided a unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with a plurality of electrical coils, the electrical coils not all being of the same shape.

The coils may be simple conductive loops, or may comprise a more complex arrangement of conductors. Where a more complex arrangement of conductors is provided, for example as disclosed in the present applicant's co-pending UK patent applications numbers 0210886.8 of 13th May 2002 and 0213024.3 of 7th June 2002 (the full disclosures of which are hereby incorporated into the present application by reference), the term "coil" in the context of the present application is intended to denote each separate arrangement of conductors that defines a given charging region

or active area on the primary unit and on which a secondary device is placed in order to effect charging.

The plurality of electrical coils preferably in this aspect may also not all be of the same size and/or not all enclose the same dimensional area.

According to a third aspect of the present invention, there is provided a unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with a plurality of electrical coils, the electrical coils not all being of the same size and/or not all enclosing the same dimensional area.

In some embodiments, all the coils may be of mutually different shapes and/or sizes and/or dimensional areas. In other embodiments, two or more of the plurality of coils may have the same shape and/or size and/or dimensional area, with the remaining coils having one or more different shapes and/or sizes and/or dimensional areas, or all having the same different shape and/or size and/or dimensional area.

The coils may be spatially separated from each other such that no coil is enclosed in or overlaps with any other coil. Alternatively, one or more smaller coils may be contained within a boundary of one or more larger coils. Where one or more smaller coils are contained within a boundary of a larger coil, the coils may be substantially concentric, or may have some other arrangement. For example, a plurality of smaller coils may be contained within a boundary of a larger coil in such a way that the smaller coils are not contained within each other or overlap with each other. Some smaller coils may be nested within each other within the boundary of a larger coil, with some other smaller coils not being nested within each other within the same outer boundary.

The coils may take various shapes, including circular, elliptical, generally ovate, triangular, rectangular, parallelogram, trapezoidal, star-shaped, regular polygonal, irregular polygonal or amorphous.

According to a fourth aspect of the present invention, there is provided a unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with at least one plurality of nested electrical coils and also with means for selectively activating one or more of the nested electrical coils so as to be adaptable to provide efficient power transfer to power-receiving devices of different sizes and/or power requirements and/or positions/rotations.

The means for selectively activating one or more of the nested coils may be adapted automatically to sense an appropriate size and/or power requirement and/or position/rotation determinant of the power-receiving unit (for example, a size or sizes of secondary power-receiving coils in the power-receiving device).

The nested coils may be substantially circular, or may take any other appropriate shape as outlined above.

In a particularly preferred embodiment, there are provided four nested sets of electrical coils, each having a substantially right-angled triangular shape, and arranged such that the right-angles of the four sets of coils all point towards a single origin point such that the four sets of nested coils have an overall substantially square or rectangular configuration. Preferably, adjacent sets of coils are driven in antiphase so as to cause rotation of a resultant electromagnetic field about the origin point, thereby providing a degree of rotational freedom in the positioning of a power-receiving device on the pad.

According to a fifth aspect of the present invention, there is provided a unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with an even number of electrical coils each having corner portion, the coils being arranged such that the corner portions all point towards an origin point, and wherein, in operation, adjacent coils are driven in antiphase so as to cause rotation of a resulting electromagnetic field about the origin point.

There is preferably provided four coils, which may each have a substantially right-angled triangle shape, a quarter circular shape or any other appropriate shape. Where more than four coils are provided, they may each have a generally triangular shape or take the shape of a sector of a circle.

Any of the first to fourth aspects of the present invention may be combined with at least one power-receiving unit so as to form a system for contact-less power transfer.

According to a sixth aspect of the present invention, there is provided a system for contact-less power transfer, the system comprising a power-transmitting unit provided with a primary coil and at least one power-receiving device incorporating a secondary coil, wherein the primary coil is generally elongate along an x-axis with respect to an orthogonal y-axis, and wherein the secondary coil is sized so as to be sufficiently similar in size to the primary coil with respect to the y-axis so as to provide efficient power transfer, but smaller in size with respect to the x-axis so as to provide a translational degree of freedom of movement along the x-axis.

In this way, several power-receiving devices may be simultaneously provided with power by the primary coil by placing the devices adjacent each other along the x-axis.

The primary coil may be generally rectangular, or any other appropriate shape, including elliptical or generally ovate. The secondary coil preferably has a corresponding rectangular (possibly square) or elliptical or ovate or other configuration, subject to the constraints that the extent of the primary coil along the y-axis is substantially similar to that of the secondary coil along the y-axis, and that the extent of the primary coil along the x-axis is greater than that of the secondary coil along the x-axis. Preferably, the extent of the primary coil along the x-axis is at least twice, advantageously at least three or four times, that of the secondary coil along the x-axis.

According to a seventh aspect of the present invention, there is provided a system for contact-less power transfer, the system comprising a power-transmitting unit provided with at least one primary coil having a boundary portion and at least one power-receiving device incorporating a secondary coil, wherein power transfer takes place by way of coupling of near-field flux flowing about the boundary portion of the at least one primary coil with windings of the secondary coil.

There may be provided just a single primary coil of appropriate configuration, or a plurality of adjacent primary coils which will enable a plurality of power-receiving devices to receive power simultaneously.

The at least one primary coil may be generally rectangular in shape, in which case there is one linear degree of freedom of movement of the secondary coil.

Alternatively, the at least one primary coil may be substantially circular or elliptical or the like, in which case a rotational degree of freedom of movement is provided.

According to an eighth aspect of the present invention, there is provided a system for contact-less power transfer, the system comprising a power-transmitting unit provided with first and second substantially concentric primary coils, the first being larger than the second, and at least one power-receiving device incorporating at least one secondary coil dimensioned so as to correspond to a distance between the first and second primary coils, wherein power transfer takes place by way of coupling of near-field flux flowing about the boundaries of the first and second primary coils with generally opposed edges of the secondary coil.

The first and second primary coils in this aspect are supplied with currents flowing in opposite directions. The coils may be generally circular, or may take any other appropriate shape as hereinbefore described.

Summarising the above, the table below lists the desirable characteristics of any inductive charging system, and illustrates how those of the present invention compare with prior art:

	Today's chargers	**Present invention**	**UK 0210886.8**
Simple *(therefore cheap to make)*	Y	Y	Y
Efficient and uniform field *(high-power within regulations)*	Y	Y	Y
Simultaneous *(more than one device at a time)*	N	Y	Y
Universal *(many types of devices)*	N	Y	Y
Degrees of freedom *(convenience)*	0 or 1 (rZ)	0..2 of (X,Y,rZ)	2 (X,Y) 3 (X,Y, rZ)

Embodiments of the present invention may therefore provide greater simplicity (and thus reduced cost) by offering a number of degrees of freedom which is less than that of GB 0210886.8, but greater than that of today's "toothbrush" chargers, while still preserving many of the benefits of GB 0210886.8 (Simplicity, Efficiency, Simultaneity and Universality).

Additionally, this may optionally be achieved while still retaining forward compatibility with devices and chargers of the type described in GB 0210886.8.

There shall now be described various embodiments of the present invention that fit into the following three categories:

1. No degrees of freedom – the charger has different positions for different types of device (Figure 7)
2. Only the rZ rotational degree of freedom, so the device has to be placed in the correct position on the charger. The charger has a single location with an effective coil size that alters with device needs (Figure 8 and Figure 9)

3. Only one translational degree of freedom (Figure 10), either:
    a. Linear translational
    b. Circular translational, and rotational

Addressing each of these categories in turn:

1. No degrees of freedom

Figures 7a,7b,7c show three different types of charger configuration 701 which each have several sizes or shapes of coil 702,703,704. Each coil could be, for example, a multiply-wound coil of a type similar to that in Figure 1a. The coils may all be driven simultaneously, or only when a device is sensed.

The location and/or rotation and/or type of each coil is made clear by some indicator, allowing the user to place their device onto the coil which best couples to it, and in the correct orientation if such is necessary.

In Figure 7a, the coils are spatially separate (allowing multiple devices to be charged simultaneously), in Figure 7b they are concentric, and in Figure 7c they are a mixture of the two.

The coils can of course be of any shape to suit the device, and some examples are shown in Figure 7d.

2. Only the one rZ rotational degree of freedom

Figures 1a and 8a show a prior art system with a single rotational degree of freedom – a coil on the primary 800 couples to a corresponding coil on the device 801 in the manner of a simple transformer.

Figure 8b shows an alternative method of achieving the same rotational degree of freedom for a device 811 which expects a field in the manner of Figure 1c. An antiphase field is driven into sets of coils 810A and 810B such that the field rotates from being aligned in the 810A axis to being aligned in the 810B axis and back to

810A. Thus over time the device receives a significant amount of power no matter what its orientation.

Figure 9 extends these two means of generating a rotational degree of freedom by adding universality. A charger 901 consists of a number of such coils, arranged concentrically, each of which can be driven independently. The charger behaves differently depending on which type of device is present 902.

- In Figure 9a no device is present, and so no charger coils are driven.
- In Figure 9b a physically small device with correspondingly small power requirements is present, and so only a few of the inner coils are driven.
- In Figure 9c a physically large device with correspondingly large power requirements is present, and so many of the coils are driven.

Figures 9d,9e,9f show a charger with a coil configuration 903 of the type shown in Figure 8b, but again arranged concentrically as above, with similar benefits.

3a. One linear translational degree of freedom

Figure 10 shows various configurations in which the primary charger coil is larger than the secondary device coil, but constrained in its dimensions such that it offers a reasonably efficiency with a single translational degree of freedom in the X axis, and therefore the option of simultaneous charging of multiple devices.

In Figure 10a a rectangular charger coil 1001 drives a smaller device coil 1002 by generating a field in the Z axis. By being similar in size to the device coil in the Y dimension, reasonable efficiency is obtained. By being significantly larger than the device coil in the X dimension, one degree of translational freedom is achieved.

Of course the coils could be any type of shape (for example ellipsoidal) rather than rectangular as shown – an important point is the aspect ratio.

Figures 10b and 10c achieve a similar result for devices of the Figure 1c type, 1003. In Figure 10b, a charger coil identical to Figure 10a is used. In Figure 10a it was be

considered to be generating a net flux out from the centre of the coil in the Z dimension, but it can equally be viewed "up close" to the edge of the coil as generating a flux which is rotating around the wire(s), as shown in Figure 10b. Therefore if a device of Figure 1c is placed across any edge of the coil, it will receive the flux.

In Figure 10c a second coil is placed below the first 1004. If placed along the boundary between the two, as shown, the device coil will receive power from each coil. Of course this concept can be extended indefinitely in the Y dimension, as shown with a dotted line, to produce any number of lines along which a device may receive power.

3b. One circular translational degree of freedom

Figure 11a shows a large coil 1101 with a small coil 1102 inside it. The coils carry current in opposite directions, and so will generate a net flux flowing in the Z axis (out of the page). If a device with a coil 1103 is placed anywhere within the annulus formed between the coils, it will receive this flux with reasonable efficiency. Thus the device has a circular translational degree of freedom, and multiple devices can be placed on the charger.

Figure 11b shows a similar scheme working with a device of Figure 1c type. The device straddles the outer coil 1101 to couple with it. This could be seen as a variant of Figure 10b.

It will be appreciated that the coils do not have to be circular.

In each of the above cases, the charger may sense if any device is present on any particular coil, and if so what its power needs are. Possible means for doing this include but are not limited to:

- Sensing the resonance ("Q") or other characteristics of the driven coils
- Communication by modulation of data signals onto the magnetic field (e.g. "back-scatter", as used by RFID devices).

In all embodiments of this present application, the user has limited degrees of freedom when placing devices. Therefore it may be advantageous to indicate these constraints to the user.

Such indications may be done in a variety of ways, for example:

- For chargers with placement restrictions, indicating the correct device position by means of:
  - Outlining of the coil area
  - Filling, or patterning, the active coil area.
- For chargers with rotational restrictions, indicating the correct device rotation by means of:
  - A line or arrow, or set of such.

The indications may be rendered in any number of media, for example:

- Printing ink, perhaps of a particular colour
- Raising or lowering the charger surface.
- Overall shape of the charger, or part of it.

The device may include corresponding indications.

Some examples of possible indications are shown in Figure 12, which:

- Figure 12a shows a printed or raised outline of two devices, for chargers which have no degrees of freedom.
- Figure 12b shows a printed or raised arrow on both the charger and the device, for chargers with 2 translational but not rotational degrees of freedom.
- Figure 12c shows similar to 12b, but with striped indication instead of arrows.
- Figure 12d shows a "target" of concentric circles on both charger and device, for chargers with only a rotational degree of freedom.
- Figure 12e shows a charger with one circular translational degree of freedom, designed such that the active area of the charger is obvious from its form.

Prior art such as US5952814 [Philips phone charger with interlock] describes how the casing of charger may be made to match the internal shape of the charger thus allowing for accurate alignment of the primary and secondary coils.

It will be appreciated that in the case of a device coil designed to receive power by picking-up flux travelling substantially in the plane of the charger, as opposed to orthogonal to it, numerous possible designs of core are possible, for example but not limited to:

- a rod of permeable material with wire coiled around it (Figure 13a) or
- a flat piece of permeable material with a wire coiled flat around it (Figure 13b), as in Figure 1c.

It will also be appreciated that in any of the above, the precise shape of any coils in the device and/or charger will have an effect on the efficiency and other characteristics. For example, replacing any square coil with a circular coil may reduce efficiency somewhat, but, thanks to the rotational symmetry of a circle, allows the device to have a rotational degree of freedom.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with a plurality of electrical coils, the electrical coils not all being of the same shape.

2. A unit as claimed in claim 1, wherein the electrical coils are not all of the same size and/or do not all enclose the same dimensional area.

3. A unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with a plurality of electrical coils, the electrical coils not all being of the same size and/or not all enclosing the same dimensional area.

4. A unit as claimed in claim 3, wherein the electrical coils are not all of the same shape.

5. A unit as claimed in any preceding claim, wherein at least one of the electrical coils comprises a simple conductive loop.

6. A unit as claimed in any preceding claim, wherein at least one of the electrical coils comprises a complex arrangement of conductors defining a charging region on which a power-receiving device may be placed.

7. A unit as claimed in any preceding claim, wherein all of the electrical coils have mutually different shapes and/or sizes and/or enclose mutually different dimensional areas.

8. A unit as claimed in any one of claims 1 to 6, wherein two or more of the electrical coils have the same size and/or shape and/or enclose the same dimensional area.

9. A unit as claimed in claim 8, wherein one or more of the remaining coils have one or more different shapes and/or sizes and/or enclose different dimensional areas than the said two or more of the electrical coils.

10. A unit as claimed in any preceding claim, wherein the electrical coils are spatially separated from each other such that no coil is enclosed within or overlaps any other coil.

11. A unit as claimed in any one of claims 1 to 9, wherein one or more smaller coils are contained within a boundary of one or more larger coils.

12. A unit as claimed in any one of claims 1 to 9 and 11, wherein one or more coils overlap with one or more other coils.

13. A unit as claimed in claim 11, wherein the smaller coils contained within a boundary of at least one larger coil are arranged in a substantially concentric or nested configuration.

14. A unit as claimed in claim 11, wherein the smaller coils contained within the boundary of at least one larger coil are arranged such that the smaller coils do not overlap each other or are not contained within each other.

15. A unit as claimed in claim 11, wherein some of the smaller coils contained within the boundary of at least one larger coil have a nested configuration, and wherein some other of the said smaller coils are do not have a nested configuration within the same boundary.

16. A unit as claimed in any preceding claim, wherein the unit is provided with means for selectively activating one or more of the electrical coils in order to provide efficient power transfer to power-receiving devices of different sizes and/or power requirements and/or positions or rotations.

17. A unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with at least one plurality of nested electrical coils and also with means for selectively activating one or more of the nested electrical coils so as to be adaptable to provide efficient power transfer to power-receiving devices of different sizes and/or power requirements and/or positions/rotations.

18. A unit as claimed in claim 17, wherein at least one of the electrical coils comprises a simple conductive loop.

19. A unit as claimed in any claim 17 or 18, wherein at least one of the electrical coils comprises a complex arrangement of conductors defining a charging region on which a power-receiving device may be placed.

20. A unit as claimed in claim 17, wherein there is provided four nested sets of electrical coils, each having a substantially right-angled triangular shape, and arranged such that the right-angles of the four sets of coils all point towards a single origin point such that the four sets of nested coils have an overall substantially square or rectangular configuration.

21. A unit as claimed in claim 20, wherein, in operation, adjacent sets of coils are driven in antiphase so as to cause rotation of a resulting electromagnetic field about the origin point.

22. A unit for transferring power in an inductive manner to at least one power-receiving device, the unit being provided with an even number of electrical coils each having a corner portion, the coils being arranged such that the corner portions all point towards an origin point, and wherein, in operation, adjacent coils are driven in antiphase so as to cause rotation of a resulting electromagnetic field about the origin point.

23. A unit as claimed in claim 22, the unit being provided with four coils.

24. A unit as claimed in claim 22 or 23, wherein each coil has a substantially right-angled triangle shape or a quarter circular shape.

25. A system for contact-less power transfer, comprising a unit as claimed in any one of claims 1 to 25 and a discrete power-receiving device including a secondary coil for coupling inductively with the least one coil of the unit.

26. A system for contact-less power transfer, the system comprising a power-transmitting unit provided with a primary coil and at least one power-receiving device incorporating a secondary coil, wherein the primary coil is generally elongate along an x-axis with respect to an orthogonal y-axis, and wherein the secondary coil is sized so as to be sufficiently similar in size to the primary coil with respect to the y-axis so as to provide efficient power transfer, but smaller in size with respect to the x-axis so as to provide a translational degree of freedom of movement along the x-axis.

27. A system as claimed in claim 26, wherein an extent of the primary coil along the x-axis is at least twice, advantageously at least three or four times, that of the secondary coil along the x-axis.

28. A system for contact-less power transfer, the system comprising a power-transmitting unit provided with at least one primary coil having a boundary portion and at least one power-receiving device incorporating a secondary coil, wherein power transfer takes place by way of coupling of near-field flux flowing about the boundary portion of the at least one primary coil with windings of the secondary coil.

29. A system as claimed in claim 28, comprising a plurality of adjacent primary coils enabling a plurality of power-receiving devices to receive power simultaneously.

30. A system as claimed in claim 28 or 29, wherein the at least one primary coil is generally rectangular in shape, so as to provide is one linear degree of freedom of movement of the secondary coil.

31. A system as claimed in claim 28 or 29, wherein the at least one primary coil is substantially circular or elliptical or the like, so as to provide a rotational degree of freedom of movement of the secondary coil.

32. A system for contact-less power transfer, the system comprising a power-transmitting unit provided with first and second substantially concentric primary coils, the first being larger than the second, and at least one power-receiving device incorporating at least one secondary coil dimensioned so as to correspond to a distance between the first and second primary coils, wherein power transfer takes place by way of coupling of near-field flux flowing about the boundaries of the first and second primary coils with generally opposed edges of the secondary coil.

33. A system as claimed in claim 32, wherein the first and second primary coils, in operation, are supplied with currents flowing in opposite directions.

34. A system as claimed in claim 32 or 33, wherein the primary coils are generally circular or elliptical or the like.

35. A unit as claimed in any one of claims 1 to 24, wherein the at least one coil is incorporated in a laminar charging pad upon which a power-receiving device may be placed.

36. A unit as claimed in claim 35, wherein the charging pad is substantially planar.

37. A system as claimed in any one of claims 25 to 34, wherein the at least one coil is incorporated in a laminar charging pad upon which the power-receiving device may be placed.

38. A system as claimed in claim 37, wherein the charging pad is substantially planar.

39. A unit for transferring power in an inductive manner to at least one power-receiving device, substantially as hereinbefore described with reference to or as shown in Figures 7 to 13 of the accompanying drawings.

40. A system for contact-less power transfer, substantially as hereinbefore described with reference to or as shown in Figures 7 to 13 of the accompanying drawings.

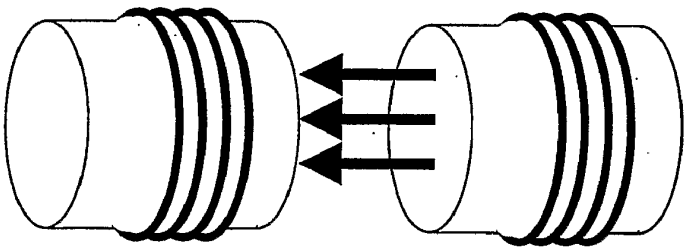


Figure 1a
(Prior Art)

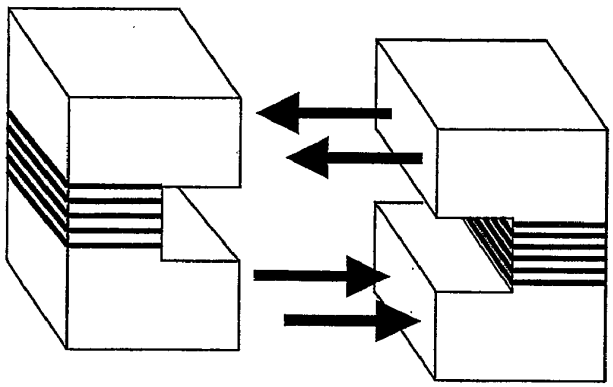


Figure 1b
(Prior Art)

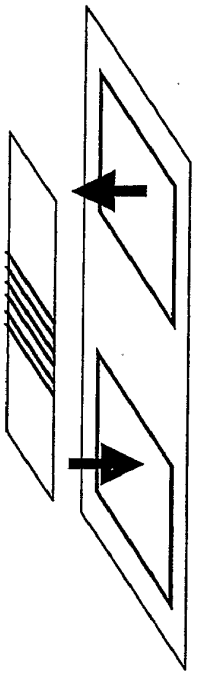


Figure 1c
(Prior Art)

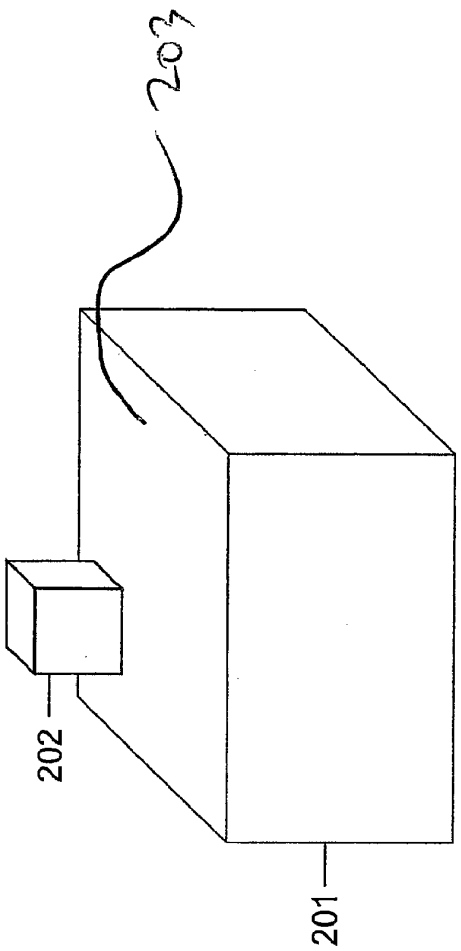


Figure 2a

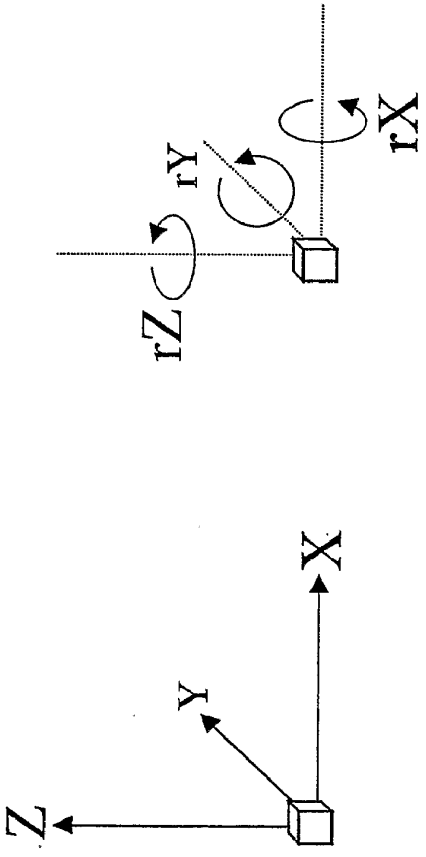


Figure 2b

Figure 2c

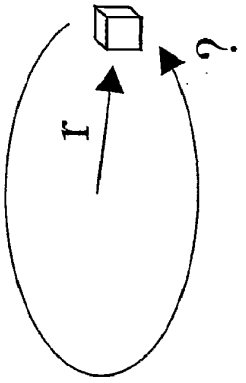


Figure 2d

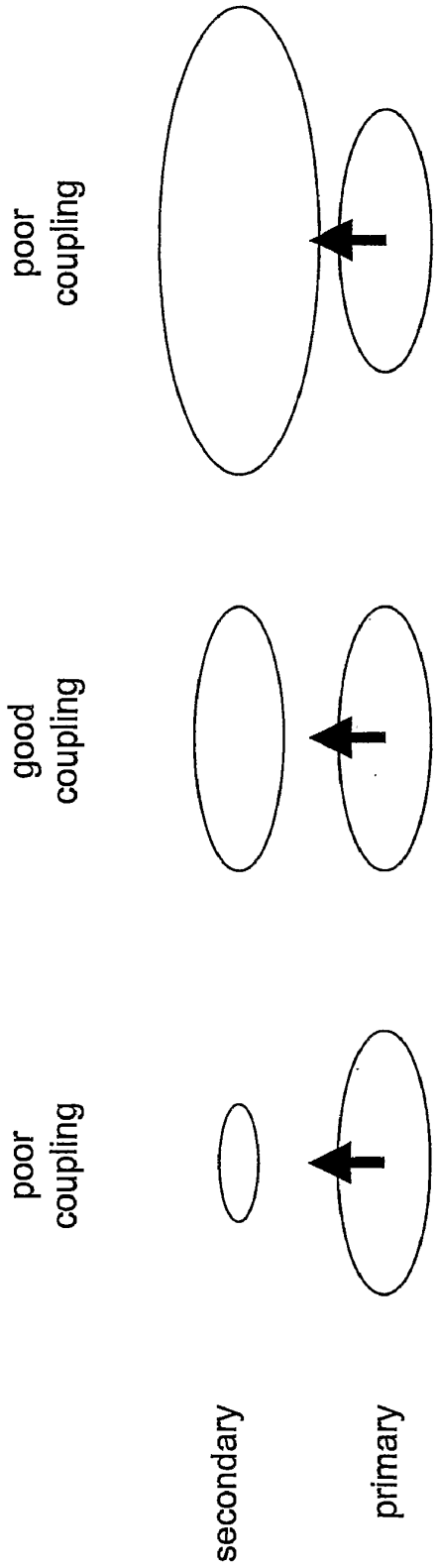

poor coupling
good coupling
poor coupling
secondary
primary

Figure 3

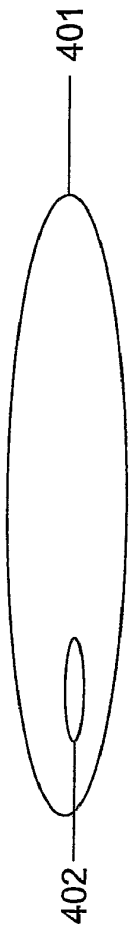


Figure 4 (Prior Art)

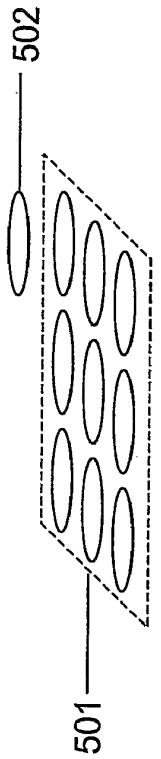


Figure 5
(Prior Art)

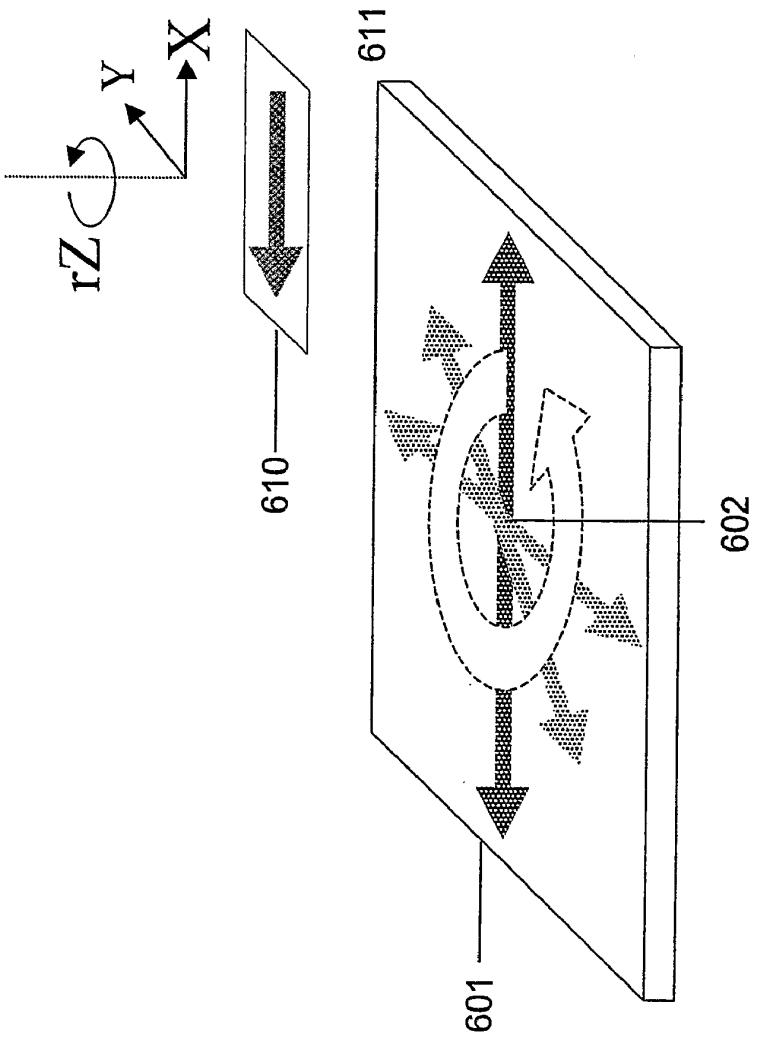


Figure 6 (Prior Art)

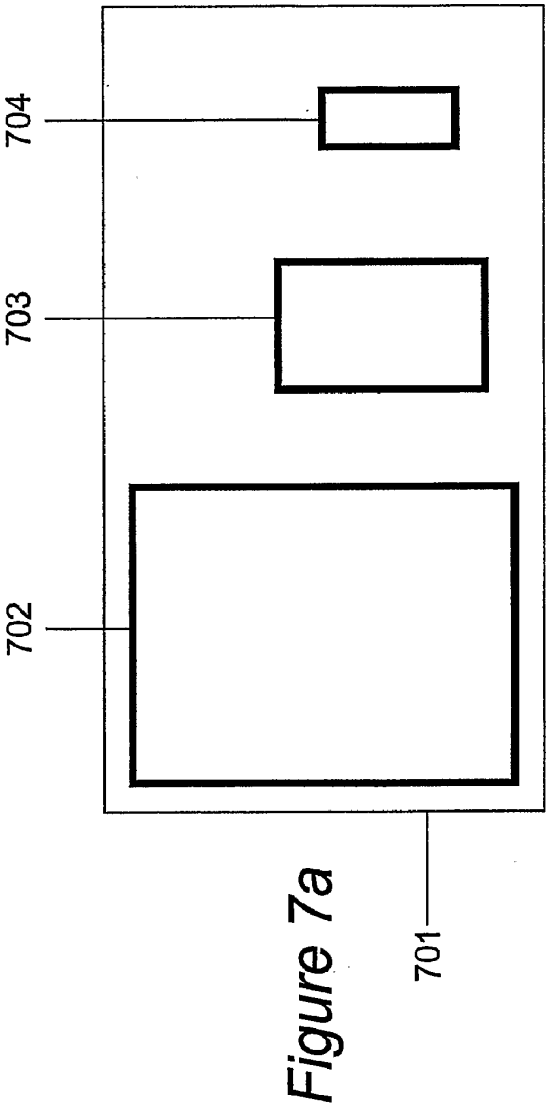


Figure 7a

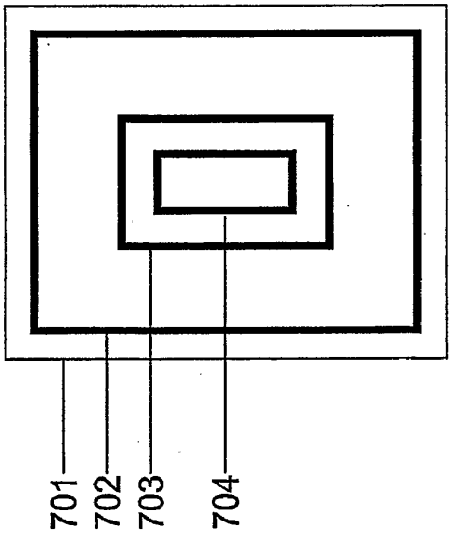


Figure 7b

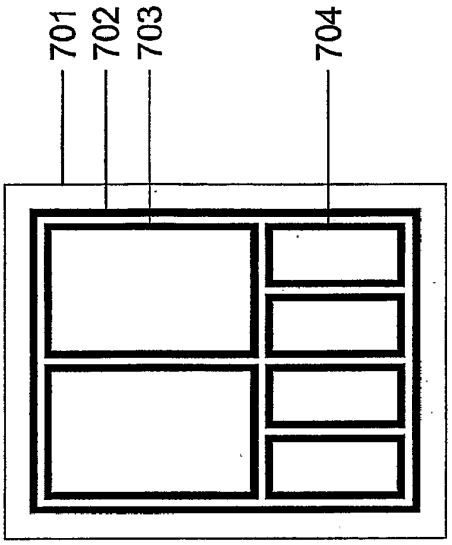


Figure 7c

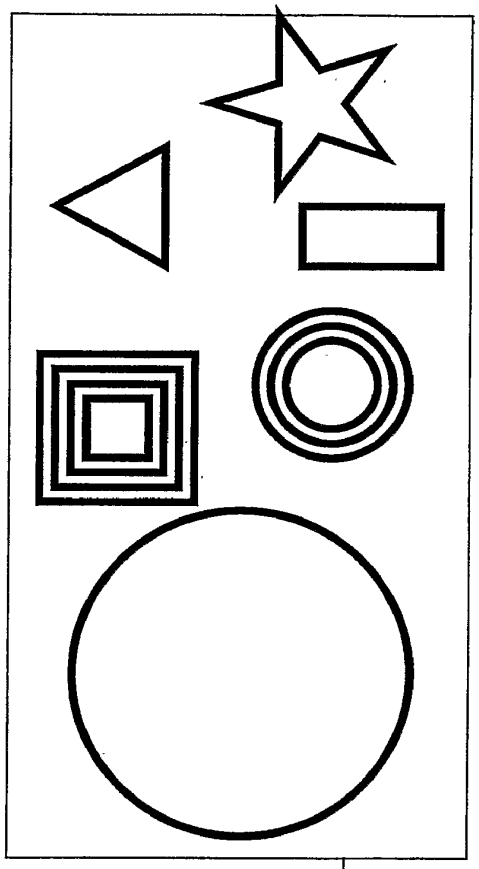


Figure 7d

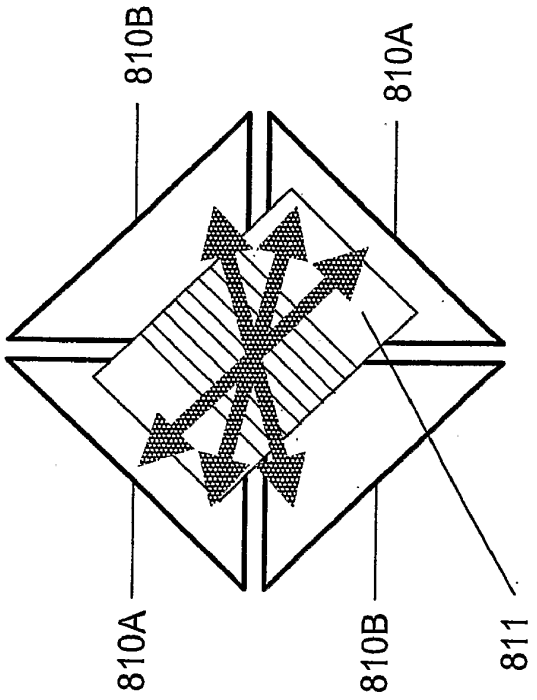


Figure 8b

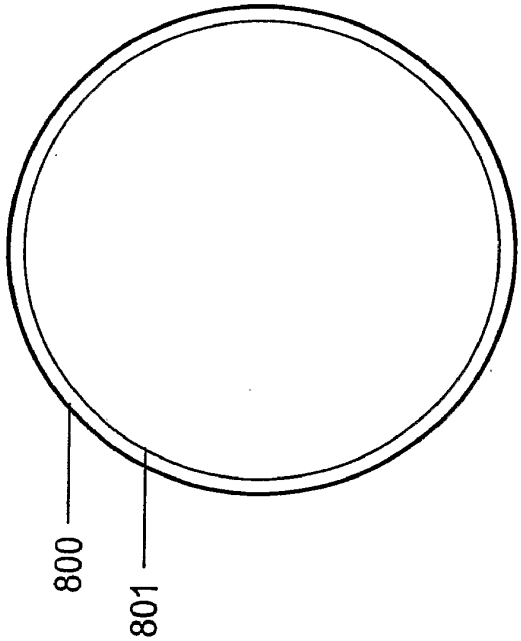


Figure 8a
(Prior Art)

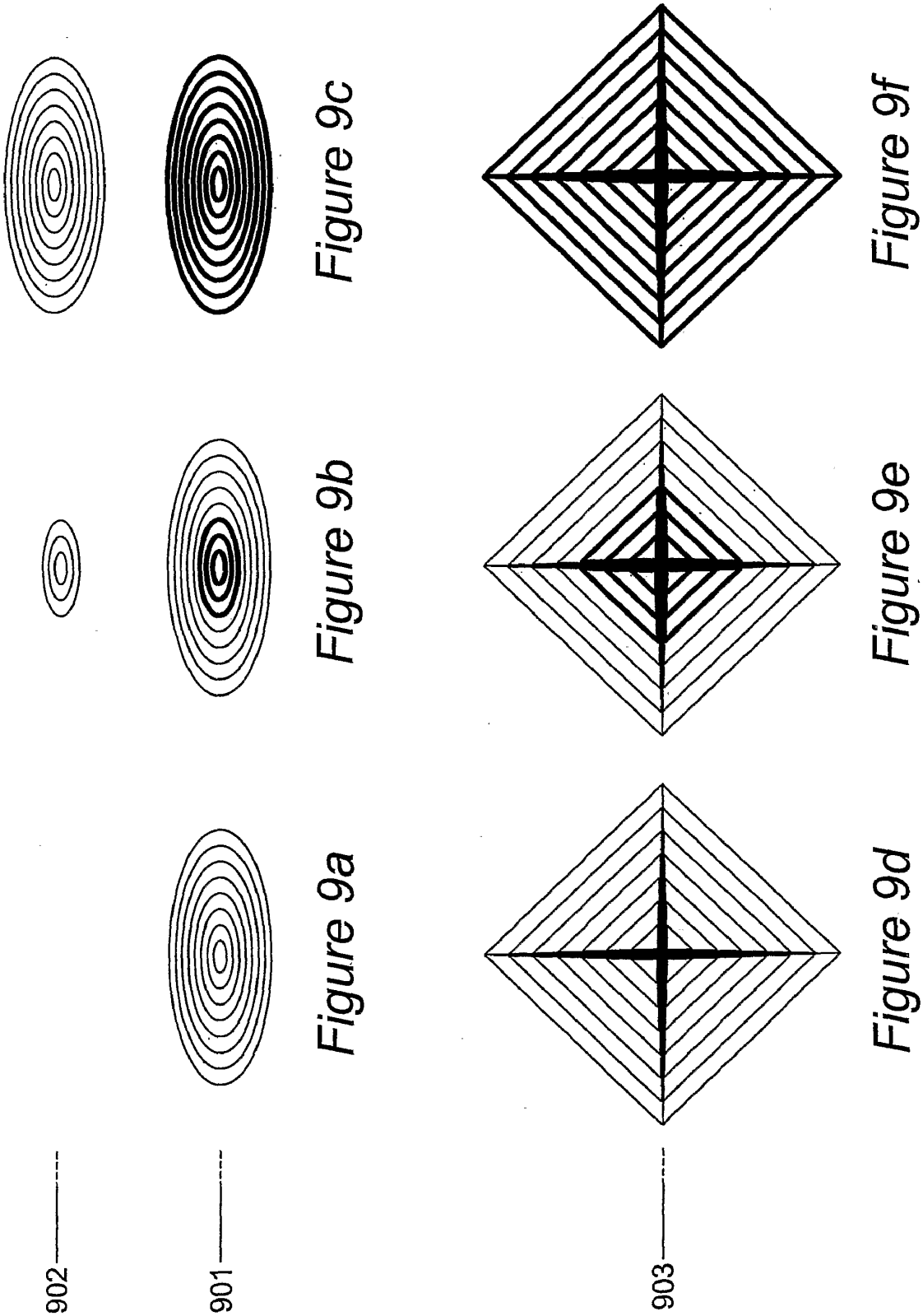


Figure 9a Figure 9b Figure 9c

Figure 9d Figure 9e Figure 9f

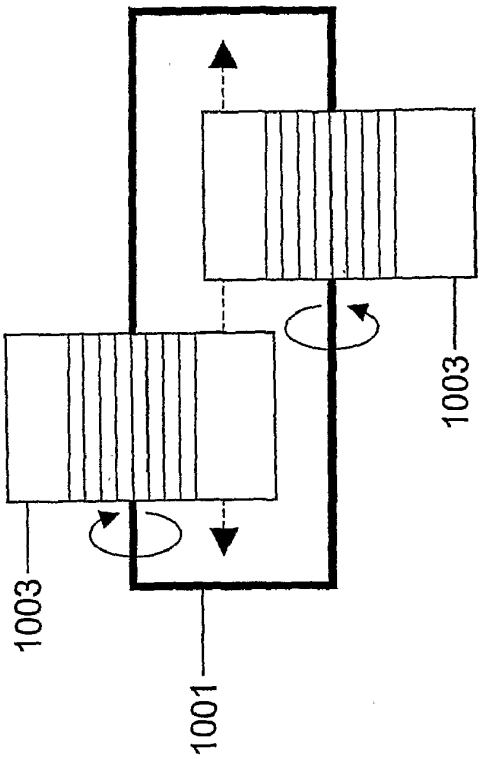


Figure 10b

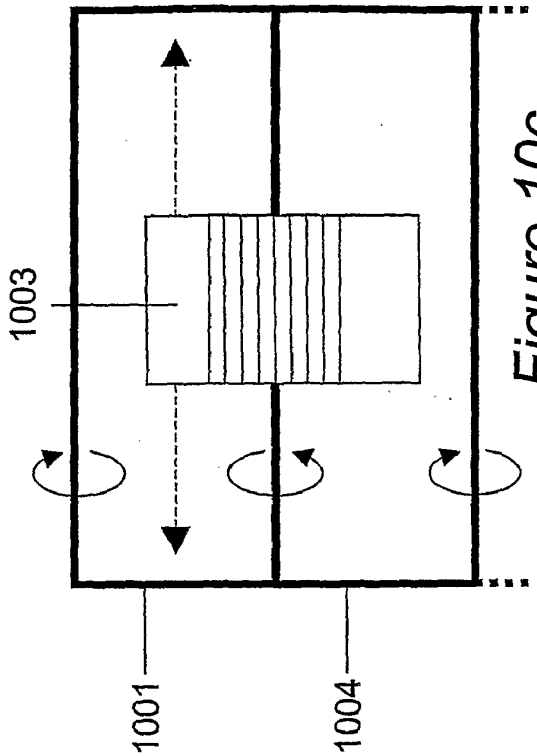


Figure 10c

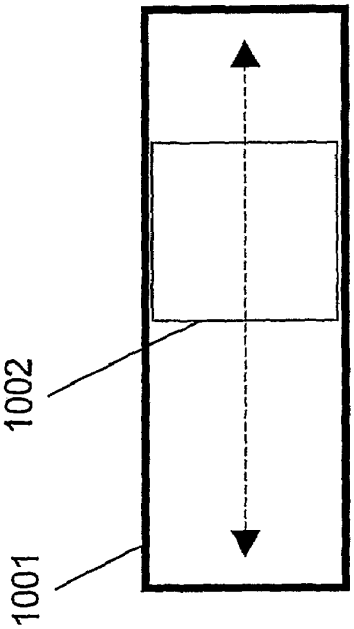
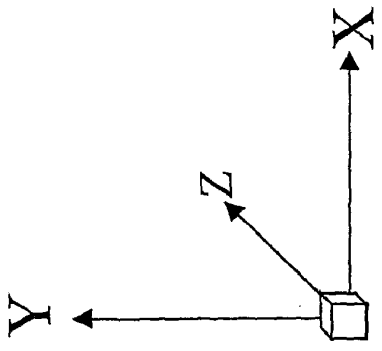


Figure 10a



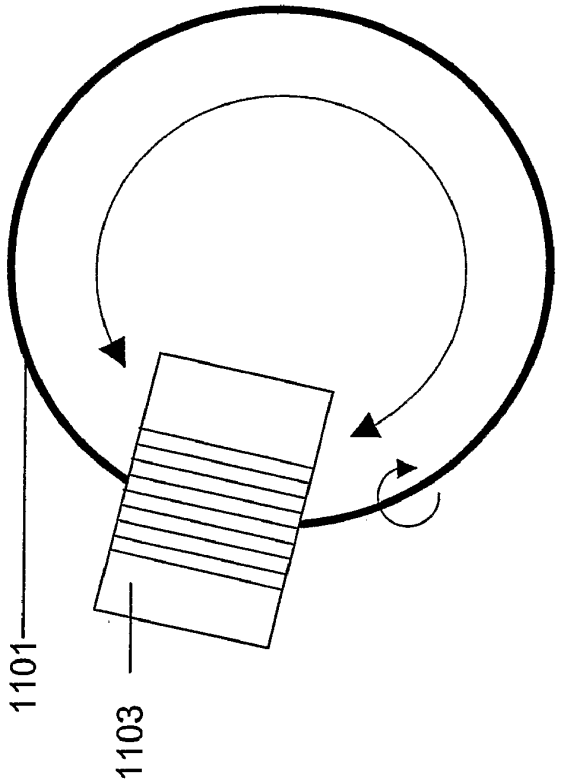


Figure 11b

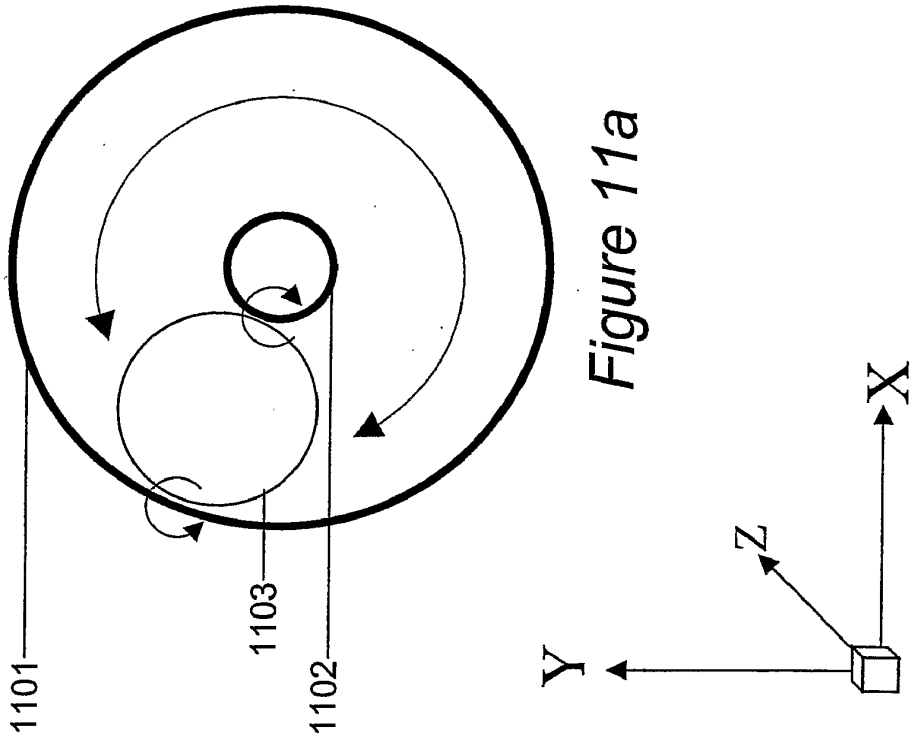


Figure 11a

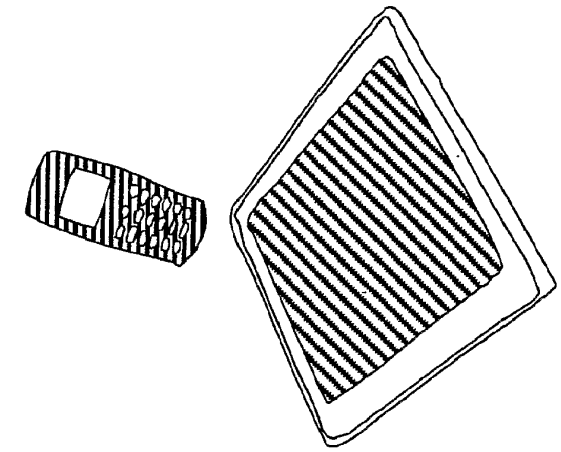


Figure 12c

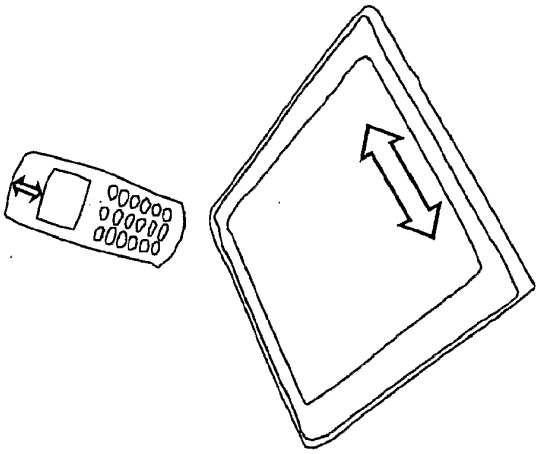


Figure 12b

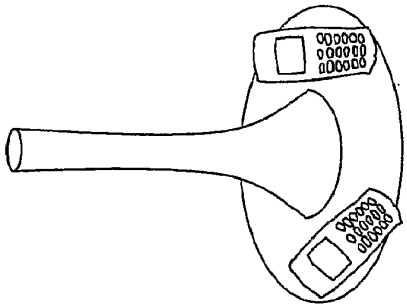


Figure 12e

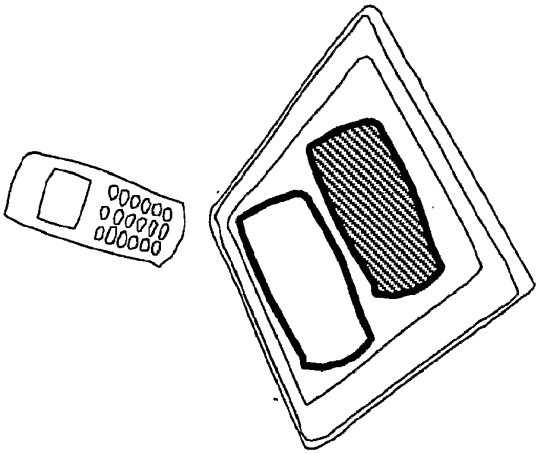


Figure 12a

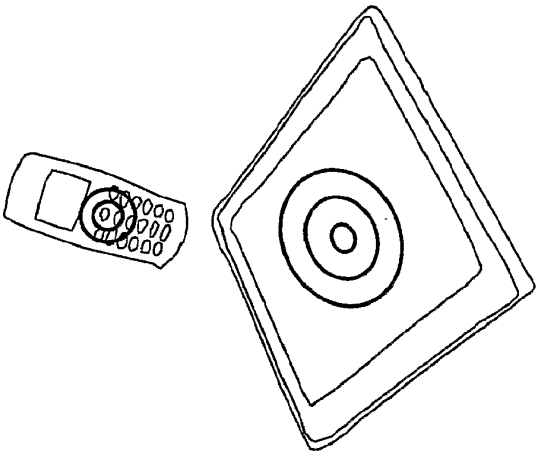


Figure 12d

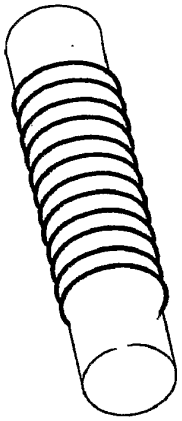


Figure 13a

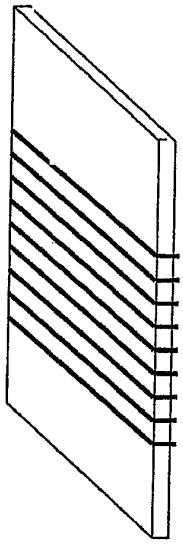


Figure 13b

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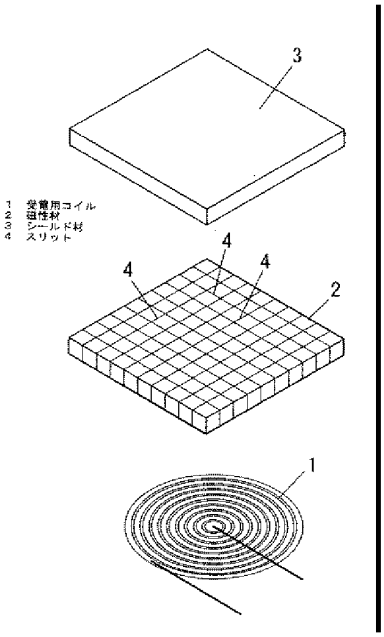
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(54)【発明の名称】非接触電力伝送機器

(57)【要約】
【課題】磁性材での渦電流の発生を抑制して電力伝送効率を高める。
【解決手段】一次側送電用コイルからの電力を受けるための二次側受電用のコイル１を備え、該コイル１の少なくとも片面に磁性材２が配設されている。上記磁性材２は上記両コイルの対向面と平行な面にスリット４が形成されている。電力伝送効率の向上のための磁性材に設けたスリットは、磁束が磁性材を通ることによって発生する渦電流を抑制するために、熱損失を低減する。
【選択図】図１



【特許請求の範囲】
【請求項1】
一次側送電用コイルからの電力を受けるための二次側受電用のコイルを備えた非接触電力伝送機器であって、上記二次側受電用コイルの少なくとも片面に磁性材が配設されているとともに、上記磁性材は上記両コイルの対向面と平行な面にスリットが形成されたものであることを特徴とする非接触電力伝送機器。
【請求項2】
上記スリットは磁性材の二次側受電用コイル側の面に磁性材を貫通しないものとして形成されていることを特徴とする請求項１記載の非接触電力伝送機器。
【請求項3】
上記スリットは、磁性材内を流れる磁束の方向に沿った方向のものであることを特徴とする請求項１または２記載の非接触電力伝送機器。
【請求項4】
上記スリットは、磁性材内を流れる磁束の密度が高い部分に密に設けられていることを特徴とする請求項１～３のいずれか１項に記載の非接触電力伝送機器。

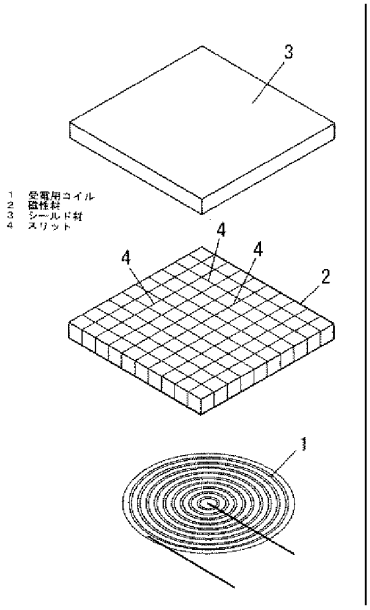
【発明の詳細な説明】
【技術分野】
【0001】
本発明は、非接触で電力伝送を行う非接触電力伝送機器、殊にその受電側の機器に関するものである。
【背景技術】
【0002】
非接触電力伝送機器として、充電器側に設けた一次側送電用コイルと、負荷機器側に設けた二次側受電用コイルとの間でトランスを構成し、上記両コイル間の電磁誘導作用を利用して非接触で電力伝送を行う非接触充電器がある。非接触電力伝送では接点部分の露出がないために接点部分の劣化を気にしなくて良いことや防水性の確保が容易になること、電力送電側機器に対する電力受電側機器の着脱を容易に行うことができるなどの点からコードレス電話機、シェーバー、歯ブラシなど様々な商品に用いられている。
【0003】
また、これらの商品に搭載されている電力伝送用コイル及び電力受電用コイルは、コアに巻き線を巻いたものや成型品で形成されたボビンに巻き線を巻いたものが一般的に用いられているが、携帯端末機器を初めとした機器や先に述べた商品に対して、小型化、薄型化、高機能化が要求されており、このために負荷機器側の機器に設ける二次側受電用のコイルとして、薄型化のために平面コイルを用いることが提案されている。しかし平面コイルにした場合、コアに巻き線を巻いたコイルと比較すれば磁気特性が劣るために二次側から取り出せる電力が低減してしまう。
【0004】
この点を補うために、二次側受電用のコイルを平面コイルで形成する場合、その背面側（一次側送電用コイルと反対側）に磁性材を配置することで、電力伝送効率を向上させているのであるが、導電性である磁性材は、送電用コイルと受電用コイルとの対向面を貫く磁気によって渦電流が流れ、この渦電流が磁性材を発熱させてしまうとともに、発熱損失によって電力伝送効率が低下するという問題があった。
【特許文献1】特開２００６－３１１７１２号公報
【発明の開示】
【発明が解決しようとする課題】
【0005】
本発明は上記の従来の問題点に鑑みて発明したものであって、磁性材での渦電流の発生を抑制して電力伝送効率を高めることができる非接触電力伝送機器を提供することを課題とするものある。
【課題を解決するための手段】

【0006】
上記課題を解決するために本発明に係る非接触電力伝送機器は、一次側送電用コイルからの電力を受けるための二次側受電用のコイルを備えた非接触電力伝送機器であって、上記二次側受電用コイルの少なくとも片面に磁性材が配設されているとともに、上記磁性材は上記両コイルの対向面と平行な面にスリットが形成されたものであることに特徴を有している。電力伝送効率の向上のための磁性材に設けたスリットは、磁束が磁性材を通ることによって発生する渦電流を抑制するために、熱損失を低減する。
【0007】
上記スリットは磁性材の二次側受電用コイル側の面に磁性材を貫通しないものとして形成されていると、磁性材の取り扱い性が向上する。
【0008】
上記スリットは、磁性材内を流れる磁束の方向に沿った方向のものであれば、磁束の流れをスリットが阻害することがないと同時に、渦電流を効果的に抑制することができる。
【0009】
また上記スリットは、磁性材内を流れる磁束の密度が高い部分に密に設けられていることが渦電流の抑制に効果的である。
【発明の効果】
【0010】
本発明の非接触電力伝送機器は、その二次側受電用のコイルに磁性材が設けられている上に、この磁性材に磁束が流れることによって磁性材に流れる渦電流は磁性材に設けたスリットで抑制されるために、渦電流による熱損失を低減することができるものであり、磁性材を設けたことによる電力伝送効率の向上を効果的に得ることができる。
【発明を実施するための最良の形態】
【0011】
以下、本発明を添付図面に示す実施形態に基いて説明すると、図１は非接触電力伝送機器における受電側の構成を示しており、平面コイルで形成された二次側受電用のコイル１と、このコイル１における一次側送電用コイル（図示せず）との対向面と反対側である背面側に配された磁性材２と、磁性材２上に更に配された磁束漏れ防止用のシールド板３とで構成され、これらコイル１と磁性材２とシールド板３とは積層接着されている。
【0012】
ここにおける磁性材２は、一次側送電用コイルから二次側受電用コイル１への電磁誘導作用を利用した非接触電力伝送の効率を高めるために設けたもので、たとえばアモルファス系の導電性を有するものからなり、図２にも示すように、０．１～５．０ｍｍ間隔で多数のスリット４が格子状に形成されている。なお、図２に示すものでは周縁部にスリット４を形成せずに周縁部が枠として機能するようにしているが、これは取り扱いの便を考えてのものであり、周縁部までスリット４が形成されていてもよい。
【0013】
ここにおける上記スリット４は、磁性材２を貫く磁束Ｍによって磁性材２を流れる渦電流を抑制するものとして働く。すなわち、上記スリット４が無い場合、磁性材２には図３(a)に示すように磁束Ｍによって大きな渦電流Ｉが流れるが、スリット４が形成されることで細かく分割されている場合、図３(b)に示すように渦電流Ｉは細かく分割された部分で夫々生じるだけで、大きな渦電流Ｉが流れにくくなるために、渦電流が生じることによって発生する熱損失による電力伝送効率の低下を抑えることができるものであり、このために磁性材２を設けることによる電力伝送効率の向上を効果的に得られるものである。
【0014】
磁性材２の厚み方向に貫通するスリット４を設けた場合、スリット４によって磁性材２が完全に分断されるために取り扱い性が問題となるが、Ｖ字形の切り込みとしてスリット４を形成し、図４(a)に示すようにシールド板３や粘着性シートに貼り付けた後にローラ圧延等で圧力を加えることで磁性材２を割ったり、あるいは図４(b)に示すようにコイル１とともにラミネートシート６で包んだ後に圧力を加えて磁性材２を割るとよい。

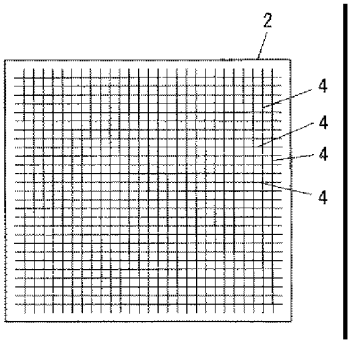
【0015】
図５に示すように磁性材２を厚み方向に貫通しないスリット４でもよく、この場合、磁性材２はその形状を自己保持するために、取り扱いが容易となる。また、スリット４のない他面側は、漏れ磁束を防ぐシールド板３としての機能を果たすことになるために、この場合、別途シールド板３を設けなくても済むものとなる。なお、この場合のスリット４は、磁性板２の厚みの２５～９５％程度の範囲で形成するのが好ましい。
【0016】
このほか、図６に示すように、磁性材２の両面から磁性材２を貫通しないスリット４を設けるとともに、一面側のスリット４と他面側のスリット４の位置とをずらして設けるようにしたものを用いてもよい。
【0017】
また、磁性材２としては、コイル１の一面側にのみ位置するのではなく、図７に示すように、コイル１の中央や周囲にも位置するものを好適に用いることができる。この場合、磁性材２による磁束の補足が効果的になされるために電力伝送効率が更に向上する。
【0018】
スリット４を格子状に設けたものを示したが、スリット４の配列はこの格子状に限るものではない。図８(a)は一筆書きとすることで磁性材２を貫通するにもかかわらず、分断されてしまうことがないようにしたスリット４の一例を示しており、図８(b)は十字状の多数のスリット４を設けた一例を示しており、図８(c)は平行線状の多数のスリット４を設けた例を示しており、図８(d)は図８(c)に示した平行線状のスリット４に交叉するスリット４を付加した例を示している。
【0019】
また、磁性材２に流れる磁束Mは、図９に示すように、コイル１の中心に該当する位置から放射状に広がるとともに、渦電流は該磁束Mと直交する方向に流れることから、図１０に示すように、磁束Mと平行となるスリット４を多数設けると、スリット４が磁束Mの流れを阻害することなく、効果的に渦電流を抑制することができるものとなる。
【0020】
ここで、図１０(a)は放射状にスリット４を設けて磁束Mの密度が高い部分にはスリット４の配置密度も高くなるようにしたものを示しており、図１０(b)は放射状スリット４を設けた場合に外周部のスリット４の配置密度が低くなってしまうことに鑑みて、外周部に更にスリット４を付加した例を示しており、図１０(c)は磁性材２の剛性確保のために、渦電流が流れないように留意しつつ、放射状のスリット４を内周側と外周側とで分けて形成した例を示している。ちなみに、このような放射状のスリット４は、渦電流による損失の低減効果が大きく、電力伝送効率の向上という点で極めて効果的であった。
【0021】
磁性材２は一枚だけを配置するのではなく、図１１に示すように、複数枚の磁性材２をコイル１の片面側に積層して配置してもよい。この場合、積層する磁性材２に設けるスリット４は、その位置をずらしておくことが好ましく、図１１(b)に示すものでは、平行線状のスリット４を備えた２枚の磁性材２をスリット４が公差するように設けており、図１１(c)に示すものでは２枚の磁性材２に設けた平行線状のスリット４の位置をずらしたものを示している。
【0022】
なお、このように複数枚の磁性材２を重ねて配置する場合においても、スリット４が磁性材２を厚み方向に貫通するものでは、図１２に示すようにシールド板３を配置しておくことが磁束漏れの防止という点で好ましく、この場合、シールド板３には放熱板としての機能も持たせておくことが好ましい。なお、シールド板３は磁性材２と同じ材料からなるものでも、別材料のものでもよい。
【図面の簡単な説明】
【0023】
【図1】本発明の実施の形態の一例を示す分解斜視図である。

【図2】同上の磁性材の平面図である。
【図3】磁性材を磁束が通る際の渦電流の流れを示す説明図であり、(a)はスリットがない場合、(b)はスリットがある場合を示している。
【図4】(a)(b)は夫々スリット作成についての説明図である。
【図5】他例を示すもので、(a)は表面側の斜視図、(b)は裏面側の斜視図である。
【図6】更に他例を示すもので、(a)は斜視図、(b)は断面図である。
【図7】別の例の断面図である。
【図8】(a)(b)(c)は夫々スリットの配列例を一部拡大模式で示している平面図、(c)はスリットの他の配列例を示している平面図、(d)はスリットの他の配列例を一部拡大模式で示している平面図である。
【図9】磁束の流れと渦電流の流れとを示した平面図である。
【図10】(a)(b)(c)は夫々スリットの放射状配列例を一部拡大模式で示している平面図である。
【図11】(a)(b)(c)は夫々他の例を示す分解斜視図である。
【図12】シールド板を更に付加した場合の分解斜視図である。
【符号の説明】
【0024】
1　受電用コイル
2　磁性材
3　シールド材
4　スリット

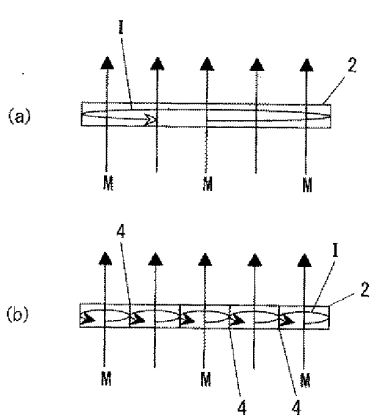
【図1】



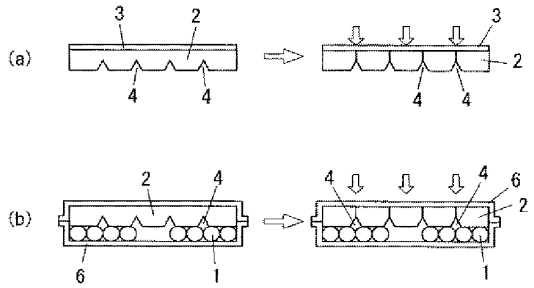
【図2】



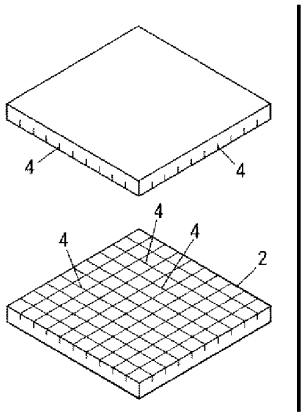
【図3】



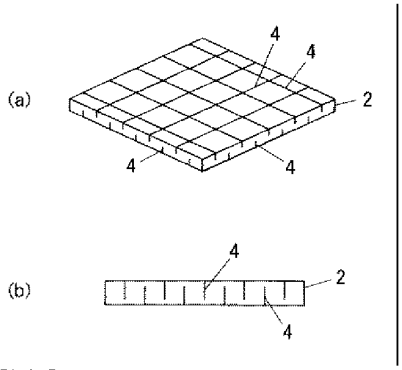
【図4】



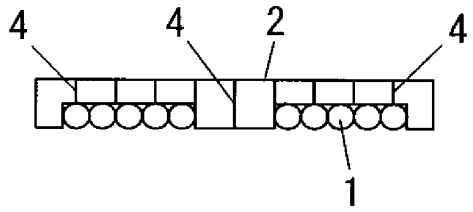
【図5】



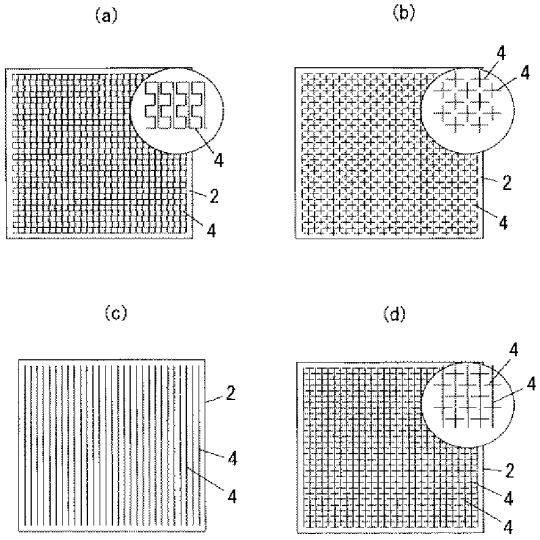
【図6】



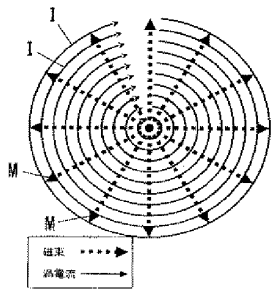
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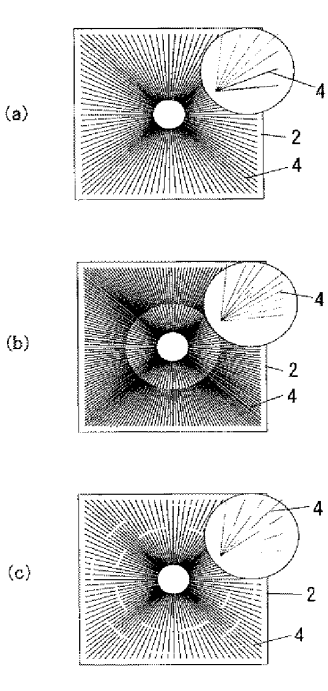
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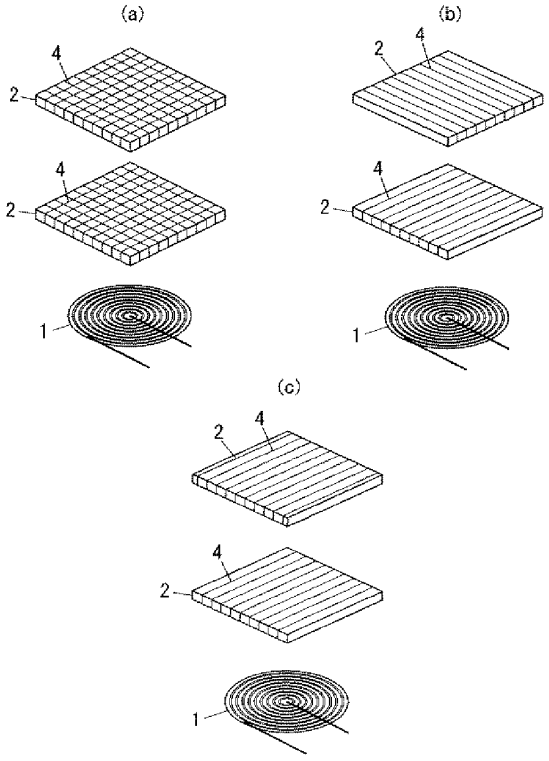
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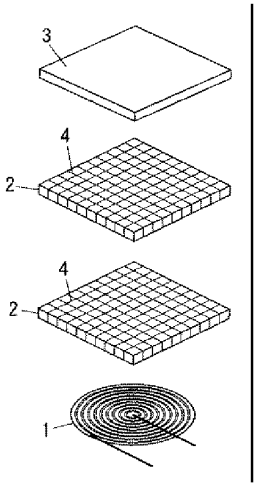
【図10】



【図11】



【図12】



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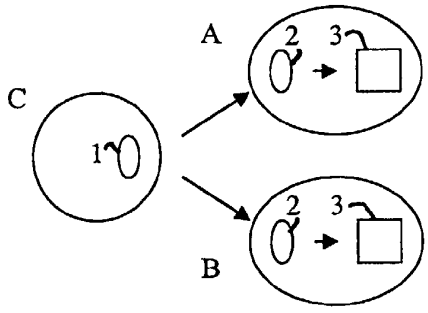
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(54) Title: BIDIRECTIONAL WIRELESS POWER TRASMISSION SYSTEM



Portable devices being charged

(57) Abstract: There is disclosed a system and method of power transfer, including at least first and second devices, each device having a power storage component and a power exchange component. The power exchange component of the first device is dynamically configurable so as selectively to receive power wirelessly from the power storage and exchange components of at least the second device and to direct the received power to the power storage component of the first device, and to transmit power wirelessly from the power storage component of the first device to the power exchange and power storage components of at least the second device. In this way, the first device may charge or power the second device and vice versa. For example, where the first device is a mobile telephone and the second device is a games console, a person carrying both devices may use one to power the other should the power supply of one of the devices run low.

BIDIRECTIONAL WIRELESS POWER TRANSMISSION SYSTEM

The present application claims priority from UK patent application no 0213023.5, filed on 7th June 2002.

This invention relates to a new system for the transfer of power between devices, and a new method for transferring power between devices.

As the use of portable devices increases, so does the use of rechargeable batteries for powering such devices. Some portable devices can be recharged by non-conductive means, such as magnetic fields, solar, microwaves, eliminating the need for exposed electrical contacts. Some examples include solar powered radios and inductively powered electric toothbrushes. Such non-conductive means for powering portable devices are typically part of a two-part recharging system:

1. A charging station, typically not very portable, which takes power from some source (for example a mains power supply, or a car power outlet) and uses it to transmit power in such a way that it can be received by the device. For example: in solar power systems, the charging station may emit light; in inductive systems, the station may emit a fluctuating magnetic field; in microwave systems, the station may generate microwaves.

2. A device, typically more portable, which, when located near the charging station, receives power from it via a charging component (which could be for example: a photovoltaic panel, a secondary coil or antennae) using it to power itself, and/or recharge its own batteries.

Examples of charging stations and devices of this nature are more fully explained in the present applicant's copending US patent application no 10/326,571 of 20th December 2002, and also International patent applications nos PCT/GB2003/002030 and PCT/GB2003/002038 of 13th May 2003, the full disclosures of which are hereby incorporated into the present application by reference.

However if users forget to recharge their portable devices, they may run out of power when far away from the charging station, which is inconvenient.

It is possible to construct a family of such portable devices which share a common design and/or have the same or similar charging component for receiving power, and which therefore can all be charged at the same type of charging station.

Typically a user owning several portable, rechargeable devices will discover that one of them runs out of power before the others. For example, a mobile phone may run out of power before a laptop computer. When the user is not in proximity to a charging station, he may wish to transfer some power from one device to another device. For example, if two users both have mobile phones but one has a fully charged battery and the other has an empty battery, they may wish to share the power between the two.

For portable devices which have power connections (for example devices complying to the common USB standard), it may be possible physically to connect the out-of-power device (e.g. the mobile phone) to a device which still has power (e.g. the laptop) via a cable, and thus power and/or recharge the out-of-power device. However, devices powered by non-conductive means have to-date been designed such that the module or charging component on portable devices is only able to receive power, therefore two such devices (e.g. mobile phone and laptop) cannot transfer power between each other.

According to a first aspect of the present invention there is provided a device capable of exchanging power with another device, the device including at least a power storage component and a power exchange component, wherein the power exchange component is dynamically configurable so as selectively:

a) to receive power by wireless transmission from an external transmitter into the power storage component; and

b) to transmit power by wireless transmission from the power storage component to an external receiver.

The external transmitter and/or receiver may be comprised as part of the power exchange component of the other device, or may be at least incorporated generally into the other device.

Such a device is advantageous because it allows the user conveniently to power one device from another, even if a convenient charger is not present. This adds a useful user feature without adding substantial additional cost.

It is desirable to have a number of devices with modules or charging components which are not only capable of receiving power but also capable of transmitting power and perform as a small temporary charging station. Such a family of devices would then be able to transfer power from one to another as required by the user.

According to a second aspect of the present invention, there is provided a system comprising at least first and second devices, each device including a power storage component and a power exchange component, wherein the power exchange component of the first device is dynamically configurable so as selectively:

a) to receive power wirelessly from the power storage and exchange components of at least the second device and to direct the received power to the power storage component of the first device; and

b) to transmit power wirelessly from the power storage component of the first device to the power exchange and power storage components of at least the second device.

According to a third aspect of the present invention, there is provided a method of exchanging power between a first device and a second device, each device including

a power storage component and a power exchange component, wherein the power exchange component of the first device selectively:

a) receives power wirelessly from the power storage and exchange components of at least the second device and directs the received power to the power storage component of the first device; and

b) transmits power wirelessly from the power storage component of the first device to the power exchange and power storage components of at least the second device.

According to a fourth aspect of the present invention, there is provided a method of exchanging power between a first device and a second device, each device including at least a power storage component and a power exchange component, wherein the power exchange component of each device is dynamically configurable so as selectively:

a) to receive power by wireless transmission from an external transmitter into the power storage component; and

b) to transmit power by wireless transmission from the power storage component to an external receiver.

The power storage component of one or more of the devices may be a rechargeable battery or the like. For a device that is intended only to transmit power and not to receive power, the power storage component need not be rechargeable.

The power exchange component may operate by transmission and/or reception of alternating electromagnetic energy, for example electromagnetic induction by way of an alternating electromagnetic field.

Alternatively or in addition, the power exchange component may operate by transmission and/or reception of light energy or the like.

Further means of power exchange are outlined hereinbelow.

Advantageously, the power exchange component may include a conductor, such as a wire or the like, wound or wrapped around or otherwise associated with a core component. The core component may be made of a magnetic material, such as a soft magnetic material, and in some embodiments is made of an amorphous metal material, optionally in an "as-cast" or non-annealed state.

Amorphous metal is a metal alloy, consisting for example of iron, boron and silicon, which has been melted and then cooled so rapidly ("quenched") that there is no time for it to crystallise as it solidifies, leaving it instead in a glass-like amorphous state. A more detailed description of amorphous metals may be found in US 4,877,464, the full disclosure of which is hereby incorporated into the present application by reference.

The following non-exhaustive list illustrates some examples of devices that may contain the said power-storage component and the power-exchange component. Possibilities are not limited to those described below:

- A mobile communication device, for example a radio, mobile telephone or walkie-talkie;
- A portable computing device, for example a personal digital assistant or palmtop or laptop computer;
- Portable entertainment devices, for example a music player, game console or toy;
- Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
- A portable imaging device, for example video recorder or camera;
- Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
- Consumer devices, for example torches, clocks and fans;

- A battery-pack for insertion into any of the above;
- A standard-sized battery pack (e.g. AA, C, D);

The following non-exhaustive list illustrates some examples of media via which non-conductive power transfer may be achieved:

- Magnetic or electromagnetic fields
- Light
- Infrared
- Microwaves
- Other frequencies of the electromagnetic spectrum
- Mechanical motion

For a better understanding of the present invention and to show it may be carried into effect, reference shall now be made, by way of example, to the accompanying drawings, in which:

FIGURE 1 shows an embodiment of the present invention showing a charger (C) transmitting power by non-conductive or wireless means (for example, electromagnetic induction or transfer of light energy) to two portable devices (A) and (B). Charger (C) is energising its power exchange component (1) to transfer power to the power exchange components (2) of (A) and (B), which receive the power and use it to recharge their power storage components (3).

FIGURE 2 shows the same portable device (A) with its power exchange component (2) now configured to transmit power from its power storage component (3). Portable device (B), configured as before, is receiving power from portable device (A).

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise"

and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A device capable of exchanging power with another device, the device including at least a power storage component and a power exchange component, wherein the power exchange component is dynamically configurable so as selectively:

a) to receive power by wireless transmission from an external transmitter into the power storage component; and

b) to transmit power by wireless transmission from the power storage component to an external receiver.

2. A device as claimed in claim 1, wherein the power storage component is a rechargeable battery.

3. A device as claimed in claim 1 or 2, wherein the power exchange component operates by transmission and reception of alternating electromagnetic energy.

4. A device as claimed in claim 3, wherein the power exchange component includes a conductive wire wound about a magnetic core.

5. A device as claimed in claim 4, wherein the magnetic core is made of amorphous metal.

6. A device as claimed in claim 1 or 2, wherein the power exchange component operates by transmission and reception of light energy.

7. A device as claimed in claim 1 or 2, wherein the power exchange component operates by transmission and reception of microwave energy.

8. A device as claimed in any one of the preceding claims, wherein the device is packaged in a battery pack enclosure.

9. A device as claimed in claim 8, wherein the battery pack enclosure is a standard-sized battery pack enclosure.

10. A device as claimed in any preceding claim, in combination with the said other device, wherein the external transmitter is incorporated into the said other device.

11. A device as claimed in claim 10, wherein the external transmitter is part of a power exchange component of the said other device.

12. A device as claimed in any preceding claim, in combination with the said other device, wherein the external receiver is incorporated into the said other device.

13. A device as claimed in claim 12, wherein the external receiver is part of a power exchange component of the said other device.

14. A system comprising at least first and second devices, each device including a power storage component and a power exchange component, wherein the power exchange component of the first device is dynamically configurable so as selectively:

a) to receive power wirelessly from the power storage and exchange components of at least the second device and to direct the received power to the power storage component of the first device; and

b) to transmit power wirelessly from the power storage component of the first device to the power exchange and power storage components of at least the second device.

15. A system as claimed in claim 14, wherein the power storage component of at least one of the first and second devices is a rechargeable battery.

16. A system as claimed in claim 14 or 15, wherein the power exchange components operate by transmission and reception of alternating electromagnetic energy.

17. A system as claimed in claim 16, wherein the power exchange component of at least one of the first and second devices includes a conductive wire wound about a magnetic core.

18. A system as claimed in claim 17, wherein the magnetic core is made of amorphous metal.

19. A system as claimed in claim 14 or 15, wherein the power exchange components operate by transmission and reception of light energy.

20. A system as claimed in claim 14 or 15, wherein the power exchange components operate by transmission and reception of microwave energy.

21. A system as claimed in any one of claims 14 to 20, wherein at least one of the first and second devices is packaged in a battery pack enclosure.

22. A system as claimed in claim 22, wherein the battery pack enclosure is a standard-sized battery pack enclosure.

23. A method of exchanging power between a first device and a second device, each device including a power storage component and a power exchange component, wherein the power exchange component of the first device selectively:

a) receives power wirelessly from the power storage and exchange components of at least the second device and directs the received power to the power storage component of the first device; and

b) transmits power wirelessly from the power storage component of the first device to the power exchange and power storage components of at least the second device.

24. A method according to claim 23, wherein the power storage component of at least one of the first and second devices is a rechargeable battery.

25. A method according to claim 23 or 24, wherein power exchange takes place by transmission and reception of alternating electromagnetic energy.

26. A method according to claim 25, wherein the power exchange component of at least one of the first and second devices includes a conductive wire wound about a magnetic core.

27. A method according to claim 26, wherein the magnetic core is made of amorphous metal.

28. A method according to claim 23 or 24, wherein power exchange takes place by transmission and reception of light energy.

29. A method according to claim 23 or 24, wherein power exchange takes place by transmission and reception of microwave energy.

30. A method according to any one of claims 23 to 29, wherein at least one of the first and second devices is packaged in a battery pack enclosure.

31. A method according to claim 30, wherein the battery pack enclosure is a standard-sized battery pack enclosure.

32. A device capable of exchanging power with another device, substantially as hereinbefore described with reference to or as shown in the accompanying drawings.

33. A system comprising at least first and second devices, substantially as hereinbefore described with reference to or as shown in the accompanying drawings.

34. A method of exchanging power between a first device and a second device, substantially as hereinbefore described with reference to or as shown in the accompanying drawings.

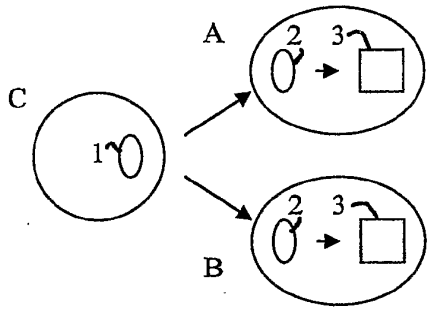


Figure 1 – Portable devices being charged

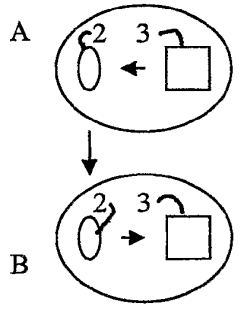


Figure 2 – Device A charging device B

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 196 49 682 A (SCHLEIFRING & APPARATEBAU GMBH) 4 June 1998 (1998-06-04)	1-5, 10-18, 23-27, 32-34
Y	the whole document	6-9, 19-22, 28-31
Y	US 5 428 961 A (SAKAKIBARA TAKAHISA ET AL) 4 July 1995 (1995-07-04) abstract figures 6,7 column 6, line 15 - line 68	6,7,19, 20,28,29
Y	US 6 040 680 A (TOYA SHOICHI ET AL) 21 March 2000 (2000-03-21) abstract	8,9,21, 22,30,31

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 September 2003	19/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hurtado-Albir, J

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 621 913 A (TUTTLE JOHN R ET AL) 15 April 1997 (1997-04-15) the whole document	1,14,23, 32-34

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter[redacted]ional Application No
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0228425.5	6 December 2002 (06.12.2002)	GB
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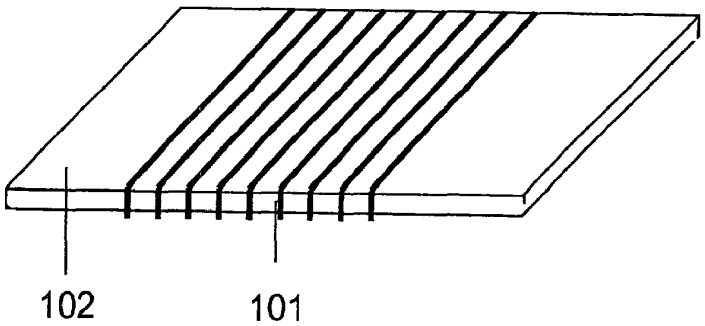
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(54) Title: IMPROVEMENTS RELATING TO THE TRANSFER OF ELECTROMAGNETIC POWER



(57) Abstract: There is disclosed a magnetic core component for receiving electrical power by induction. The core component includes a thin sheet of amorphous magnetic material in a substantially amorphous or non-annealed state. In contrast to known core components, which use annealed amorphous magnetic materials, the non-annealed material of the present invention is flexible and non-brittle. This means that it has significant advantages including resistance to physical shocks. This is of importance when the core component is used in portable electronic devices such as mobile telephones and the like which may be subject to physical shocks, for example by being accidentally dropped.

WO 03/096361 A1

IMPROVEMENTS RELATING TO THE TRANSFER OF ELECTROMAGNETIC POWER

The present application claims priority from UK patent applications nos 0210886.8 of 13th May 2002, 0213024.3 of 7th June 2002, 0225006.6 of 28th October 2002 and 0228425.5 of 6th December 2002, as well as from US patent application no 10/326,571 of 20th December 2002. The full contents of all of these prior patent applications is hereby incorporated into the present application by reference.

This invention relates to a new apparatus for transferring electromagnetic power, particularly in relation to the powering of portable devices.

In a conventional electrical transformer, an input alternating current flows through a primary coil, inducing an alternating magnetic flux within the transformer core. This alternating magnetic flux then induces an alternating current in a secondary coil.

In certain designs of transformer, for example U-U, U-I, E-I or E-E cores, there may be an air-gap between the two halves of the transformer (see Figure 1). Therefore it is possible to separate the transformer into two: a primary side and a secondary side. When brought together in the correct relative position, the alternating magnetic field in the primary side couples to the core in the secondary side, recreating a transformer and hence power is transferred inductively from the primary side to the secondary side without the need for direct electrical contacts.

Referring to Figure 2, if the primary part is contained within a base unit, and the secondary part within a portable device, then the transformer created when the portable device is placed onto the base unit can be used to provide power to the device without direct electrical contacts, for example to recharge a battery in the secondary device.

Those skilled in the art will recognize that this kind of "separable two-part" transformer system may be implemented with a variety of different core designs and

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magnetic field shapes. An alternative, for example, is the simple "axial" design shown in Figure 3. This has poorer field coupling because the magnetic flux must return through the air, but has the advantage of being freely rotatable about its axis.

As portable devices become smaller and thinner - particularly consumer devices in which aesthetic qualities are particularly important - the penalties in volume and weight of such cores makes them undesirable. Bulkiness is one of the reasons why inductive charging has not been widely used in these applications. It is therefore highly desirable to find an alternative magnetic core material for these applications which is not bulky, has as little weight as possible, is not brittle and hence can be made into a laminar (including curved) or substantially flat or planar form-factor while being able to survive drop-tests.

Existing cores are typically made of silicon steel, ferrite or permalloy, materials which are used because of their low cost and high saturation magnetic flux density but which have the following disadvantages:

- Steel (even silicon steel) suffers high loss at higher frequencies (>10kHz) because of low resistivity and hence the generation of eddy currents, and has low permeability. The losses are less severe at low frequencies but the core needs to be larger and more bulky
- Ferrite has high permeability and is low-loss, but is brittle
- Permalloy has a permeability which drops sharply at 10's of kHz.

The above disadvantages make these materials inappropriate for use in thin cores for thin devices: the low permeability of steel and permalloy means that in a flat "form factor" they have insufficient overall permeability, and the brittleness of ferrite means that in a flat form factor it would be unacceptably brittle, failing drop tests.

A possible alternative core material is so-called "amorphous metal". Amorphous metal is a metal alloy, consisting for example of iron, boron and silicon, which has been melted and then cooled so rapidly ("quenched") that there is no time for it to crystallise as it solidifies, leaving it instead in a glass-like amorphous state. A more

detailed description of amorphous metals may be found in US 4,877,464, the full disclosure of which is hereby incorporated into the present application by reference.

A two-stage manufacturing process is used to make (prior art) amorphous metal magnetic cores.

STEP 1 : A typical Production method for amorphous metal tape

The alloy is melted, poured onto a rotating drum and rapidly quenched. The metal emerges in the form of a very thin ribbon, typically 16-25um thick. The resulting amorphous metal tape is magnetically "soft", has high permeability, has a moderate saturation magnetic flux density and is flexible.

STEP 2 : Typical Manufacturing method of conventional bulk magnetic cores from amorphous metal tape

To create a conventional bulk magnetic core (for example: U core, toroidal core) for a transformer or motor, many strips of such amorphous metal tape are then laminated (stacked or wound), usually alternated with insulating adhesive, into the shape of the desired core. The core is then annealed (the temperature is raised and then lowered in a controlled fashion), usually in the presence of a magnetic field. The annealing allows controlled nano-crystallisation of the metal, improving the saturation magnetic flux density. However a negative side-effect of nano-crystallisation is that it increases the atomic order of the material, making it very brittle. In a bulky adhesive-bound core this is often not a problem because any stress is spread throughout the volume of the core.

However this brittleness makes the above "Step 2" core-manufacturing process unsuitable for the production of thin magnetic cores. Throughout the present application, the word "thin" is to be taken to describe a shape substantially smaller in one dimension than in either of its other two dimensions, for example to describe a

shape whose thickness is substantially less than (e.g. less than 1/5 or preferably less than 1/10 of) both its width and length, for example a section of tape.

In most applications of amorphous material as magnetic cores in transformers, this two-step process of first creating an amorphous ribbon, then turning it into a bulk core is highly undesirable because it requires intermediate manufacturing steps, and so research has been conducted to identify ways to achieve the same with a one-stage bulk amorphous alloy production process so that the need first to create thin ribbons is eliminated.

In a thin laminar magnetic core, any shear stress (force applied perpendicular to the plane of the material) is naturally concentrated across a very small cross-section. Any attempt to make a thin magnetic core using the above "Step 2" core-manufacturing stage would result in a very brittle object which is hard to work with in subsequent manufacturing steps, and therefore expensive. Further, such a core would be unsuitable for use in, for example, portable devices which are exposed to very high g forces when dropped.

According to a first aspect of the present invention there is provided a magnetic core component for transferring power by induction to or from a device, the magnetic core component including a thin sheet of metal in a substantially amorphous or non-annealed state and being provided with means for transferring induced electrical power from the core component to a device.

According to a second aspect of the present invention, there is provided a device provided with a magnetic core component for receiving or transmitting power by electromagnetic induction, characterised in that the magnetic core component includes a thin sheet of metal in a substantially amorphous or non-annealed state.

The device will generally be an electronic or electrical device, usually containing a rechargeable cell or battery. Alternatively or in addition, the device itself may be a rechargeable cell or battery.

The amorphous metal is preferably at least 70% amorphous or non-annealed, and even more preferably at least 90% amorphous or non-annealed.

In preferred embodiments, the metal is what is generally known in the art as an "amorphous metal" or alternatively a "metallic glass".

The means for transferring induced electrical power to the device may comprise an electrical conductor wound around or otherwise associated with the thin sheet of amorphous metal and having first and second terminals for connection to power inputs of the device.

The device will generally be a portable device, although non-portable devices may also be provided with a magnetic core component as herein described.

Embodiments of the first aspect of the present invention may be adapted for retro-fitting to an existing device, for example being in the form of a thin patch or sticker suitable for mounting (e.g. by way of adhesion) onto an appropriate internal or external surface of the device and having means for connection to a power input of the device.

The amorphous magnetic core component of embodiments of the present invention has several advantages for use in portable devices, compared with using conventional magnetic cores:

1. It is thin, preferably 0.5mm or even 0.1mm or less, allowing devices into which it is incorporated to be ergonomic, and/or allowing more space for other functionality within such devices
2. It is flexible, therefore:
    a. it is not brittle, despite its thinness, and so:
        i. it is suitable for use in portable devices which may be subject to physical shock.
        ii. it is easy to handle in subsequent manufacturing steps

b. it can easily be flexed into non-flat shapes, possibly to be conformal with the contours of a portable device such as a mobile phone or a wireless headset.

c. it can be a component within a device which is itself flexible (for example a watch strap or an intelligent credit-card), particularly devices which have to flex as part of their operation – for example battery cells tend to bulge somewhat when they are recharged.

3. Because the field travels along the thin core, if the core is placed within a device which is itself thin relative to its length (for example a cell, headset boom or pen), the device can be rotated freely around its axis within an axial magnetic field.

Also of potential benefit, compared to a conventional core, is that very little tooling is required to manufacture the core of embodiments of the present invention.

An example of the material for manufacturing the core is Metglas® 2714A as manufactured by Honeywell. This is a cobalt-based amorphous metal with an ultra-high permeability of >80,000 at DC in the as-cast state, supplied as ribbon on reels.

In use, the core will typically couple to external electromagnetic field lines running in the same plane as the material. Because of its relatively high permeability, it will concentrate nearby lines into it, so will even "capture" field lines running past it. This is shown in Figure 5.

The core will saturate when subjected to a magnetic field above a certain threshold, placing an upper limit on the operational power of the system. Therefore the core must have a sufficiently large cross-section to ensure that saturation does not occur at the desired operational power level. Saturation offers some protection from exposure to very strong magnetic fields, as in this situation the core will saturate, limiting the power transferred to the device.

The core may be located within or near a device which itself contains parallel planes of metal, for example a copper printed circuit board or an aluminium cover. In this case, the performance of the present invention is significantly better than that of a conventional core because the field lines through a conventional coil will suffer flux-exclusion if the coil is placed up against the metal plane (because the lines of flux must travel perpendicular to the plane of the core). Since in the present invention the lines of flux travel along the plane of the core, and therefore of the metal plane, performance is improved. See Figure 6. An additional benefit of embodiments of the present invention compared to a conventional coil is that the core in the present invention may act as a shield for items (e.g. electrical circuits, battery cells) in close proximity to the magnetic core.

Because its permeability is higher than that of air, the core of the present invention acts to concentrate magnetic flux, thus capturing more flux than would otherwise flow through an equivalent cross-section of air. The size of the core's "shape factor" (the equivalent flux-capturing sphere) is determined to a first-order approximation by the longest planar dimension of the core. Therefore if the core of the present invention has planar dimensions with a significantly non-square aspect ratio, for example a 4:1 rectangle instead of a 1:1 square, it will capture proportionally more of any flux travelling parallel to the direction of its longest planar dimension. Therefore if used in devices which have a constrained aspect ratio (for example a long thin device such as a headset or pen), a significant increase in performance will be experienced compared with that of a conventional coil of the same area.

The core may comprise more than one sheet of amorphous metal, the sheets being arranged in parallel with one another (laminated). The sheets may be made of the same amorphous metal material, or of two or more different amorphous metal materials.

The core may be wrapped, encircled, wound or otherwise provided with a coil of conductive wire or tape or a flexible printed circuit. This is preferably wrapped or wound around a smallest of the planar dimensions of the sheet of amorphous metal .

The coil may be tuned to a higher "Q" (quality factor) with a capacitor, in parallel or series, resulting in higher amounts of energy being induced by an external magnetic field, but also in higher dissipation in the module and the need for tuning to a precise driving frequency. The capacitor may be made from multiple layers of amorphous metal in the core, interposed with a dielectric material such as polythene or the like.

The coil may be connected to a half- or full-wave rectifier to convert AC into DC, and may also be connected to an optional smoothing capacitor, an optional regulator or a battery charge-controller.

The core may be provided with a flexible printed coil arranged such that the amorphous core passes through the coil but in the same plane. Alternatively, the magnetic core component may comprise at least two pieces of amorphous sheet or ribbon laminated to each other with a coil located between the sheets or ribbons (see Figure 9).

The core component may be formed from a substantially triangular sheet of amorphous metal which is folded in a concertina-like manner so as to form an elongate ribbon that is thicker in a middle part thereof than at its ends (see Figure 10). Alternatively, a similar structure may be formed by laminating successively shorter strips of ribbon or the like on top of each other, each strip being generally centred about a predetermined point. These structures have the advantage that there is more amorphous metal at a thicker central part of the structure, where there is most flux during operation, than at its thinner ends, where there is less flux. In this way, saturation can be avoided at the central part of the structure while reducing the amount of amorphous material required at the end portions.

The core may be wrapped or wound with first and second coils, the second coil being substantially orthogonal to the first coil, so that power may be captured regardless of a direction of an external field within the plane of the sheet or sheets forming the core (no need for external field to rotate).

The core may be incorporated on or within a portable device which receives and/or transmits power using the core. The following non-exhaustive list illustrates some examples of such devices, possibilities are not limited to those described below:

a. Mobile communication device, for example a radio, mobile telephone or walkie-talkie;
b. Portable computing device, for example a personal digital assistant or palmtop or laptop computer;
c. Portable entertainment devices, for example a music player, games console or toy;
d. Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
e. A portable imaging device, for example a video camcorder or a camera;
f. Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
g. Consumer devices, for example torches, clocks and fans;
h. Power tools, for example cordless drills and screwdrivers;
i. Wireless peripheral devices, for example wireless computer mouse, keyboard and headset;
j. Time keeping devices, for example clock, wrist watch, stop watch and alarm clock;
k. Battery-pack for insertion into any of the above;
l. Standard-sized battery cell.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made by way of example to the accompanying drawings, in which:

FIGURE 1 shows a prior-art U-U core transformer;

FIGURE 2 shows how two cores of the type shown in Figure 1 may be incorporated

into an electronic device;

FIGURE 3 shows a prior art configuration similar to that of Figure 1, but using an axial core with air as the return path;

FIGURES 4a and 4b show a simple core component of an embodiment of the present invention;

FIGURES 5a to 5c show how the core component of Figures 4a and 4b interacts with an external magnetic field;

FIGURE 6a shows a prior art core component in an electronic device including a metal plane;

FIGURE 6b shows a core component of an embodiment of the present invention in the electronic device of Figure 6a;

FIGURE 7 shows a wireless headset device provided with a core of an embodiment of the present invention;

FIGURE 8 shows an embodiment of the present invention including a coil;

FIGURE 9 shows an embodiment of the present invention comprising two sheets of amorphous metal laminated about a printed coil;

FIGURES 10a to 10e illustrate a method of manufacturing an embodiment of the present invention;

FIGURES 11a to 11c show three different embodiments of the present invention incorporated into a rechargeable battery or cell;

FIGURE 12 shows the battery or cell of Figure 11 located near an external inductive

charging unit; and

FIGURE 13 is a circuit diagram illustrating an embodiment of the present invention.

FIGURE 1 shows a prior-art U-U core transformer showing primary coil 112 through which an alternating current induces an alternating magnetic field in primary core 111. This field then flows between the end-pieces of core 111 and the end-pieces of secondary core 102 through the space therebetween. The field 1 flowing in 102 then induces a current in secondary coil 101.

FIGURE 2 shows how the two cores 111 and 102 of Figure 1 may be incorporated into a prior art electronic device 120 and a charger 130 such that the device 120 may be brought into proximity of the charger 130 to complete a magnetic circuit and transfer power from the charger 130 to the device 120.

FIGURE 3 shows a prior art configuration similar to Figure 1, but using axial cores 102, 111 with air as the return path.

FIGURE 4a shows a laminar sheet of amorphous, non-annealed metal 102 forming a magnetic core component of the present invention coupling to an external magnetic field 1.

FIGURE 4b shows the core component 102 of Figure 4a incorporated within a portable electronic device 120. In the illustrated embodiment, the core 102 is placed on a bottom side of the device 120.

FIGURE 5a shows the device 120 of Figure 4b in plan view and FIGURE 5b shows the device 120 in side view. It can be seen how the high permeability of the core 102 pulls the electromagnetic field 1 into the core 102. Because of this, a field running predominantly under the device 120, shown most clearly in Figure 5b, will be pulled into the device 120, thus coupling effectively to it. FIGURE 5c shows more detailed field lines when two such cores 102 are placed onto a surface which generates a

distributed horizontal field. Note how the field lines travel not only into the ends of the cores, but also into the side surfaces.

FIGURES 6a and 6b show a device 120 which, for reasons unrelated to the present invention, includes a metal plane 125. The flow of flux 1 vertically into a conventional core 108 (Figure 6a) must go through the metal plane 125 and therefore the core 108 suffers from flux exclusion. With a core 102 designed according to embodiments of the present invention (Figure 6b), the flux 1 flows horizontally, alongside the metal plane 125 and through the core 102 with no flux exclusion.

FIGURE 7 shows a portable electronic device 120 in the form of a wireless headset. For ergonomic and aesthetic reasons it is important that this encloses its electronics within a case which is as small and light as possible while conforming to a shape of a human face or head. This makes it a complex curved three-dimensional shape. The laminar amorphous metal core 102 of embodiments of the present invention is able to be bent somewhat to conform to the shape of the headset 120, allowing it to extend for a substantial part of the length of the headset 120, and thus couple very effectively with an external field (not shown).

FIGURE 8 shows a possible arrangement of an electrically-conductive coil 101 spirally wound around a laminar amorphous metal core 102. It is to be noted that the coil 101 is wound about a shorter dimension of the core 102, since most flux will be captured when travelling along the longest planar dimension of the core 102 and therefore more current will be induced in the coil 101 when wound in this configuration.

FIGURE 9 (exploded view) shows a convenient possible method of manufacture of a core with a winding. Two layers of amorphous metal 102, 102' have a printed-circuit coil 101 sandwiched between them. The flux (not shown but travelling horizontally across this Figure) will travel horizontally through the left hand layer 102, then vertically through the printed circuit coil 101, and then horizontally through the right hand layer 102'. This embodiment is easy to manufacture and can be very thin.

FIGURE 10a shows how magnetic field lines 101 entering the core 102 from the ends and sides result in the field strength within the core 102 being a maximum at its centre. As a result, more material is required in the centre to avoid saturation. FIGURE 10b shows a way to fold a single triangular piece of amorphous metal 200 in a concertina-like manner along fold lines 210 to achieve this effect. FIGURE 10c shows the resulting core 102 from above, FIGURE 10d a view from the end of the partially-folded assembly, and FIGURE 10e a view from the side. It will be appreciated that a similar core 102 may be constructed by cutting the sheet of material 200 into strips along the fold lines 210 of Figure 10b and then laminating the strips on top of each other to arrive at a core 102 similar to that of Figures 10c and 10e. Indeed, an equivalent core 102 may be constructed simply by laminating successively shorter strips of amorphous magnetic material on top of each other, the strips not necessarily having been cut from a triangular sheet.

FIGURES 11a to 11c show three possible arrangements of laminar metal core 102 used within a battery cell 140, capable of inductively receiving power for recharging the battery cell 140. In Figure 11a, the core 102 is wrapped completely around the cell 140 as a cylinder, with a coil 101 being wound or wrapped around the core 102. In Figure 11b, a smaller core 102 is placed on or near an outer surface of the cell 140 and bent into a curve to conform with the curvature of the cell 140, again with a coil 101 being wound or wrapped around the core 102 (but not around the cell 140 itself, as in Figure 11a). Figure 11c shows a core 102 placed inside the cell 140 and wound or wrapped with a coil 101.

FIGURE 12 shows an external unit in the form of a charging pad 150 generating a substantially horizontal electromagnetic field 1 and a cell 140 containing a laminar core component 102 in the manner of Figure 11. If the cell 140 is placed on or in proximity to the unit 150, the field 1 generated by the unit 150 will couple to the laminar core 102 and can thus charge the battery 140. The important point to note is that because the cell 140 is relatively thin, and the field 1 is flowing along its length, the cell 140 will receive power regardless of its axial rotation rA. This is particularly

useful if the cell 140 has been placed in a random orientation into a battery holder within a portable electronic device (not shown), as is often the case.

FIGURE 13 shows one possible implementation of the present invention in which an externally-applied alternating magnetic field 1 flows into the ends of an amorphous metal core 102. The core is composed of 6 pieces of Metglas® 2714A cobalt-based amorphous metal tape, each 50mm x 25mm x 0.018mm, stacked on top of one another into a thin laminar composite core. The number of pieces is chosen to prevent saturation at the operational field strength which oscillates at 40kHz.

Around this core 102 are wrapped 40 turns of 0.25 mm diameter enamelled copper wire, creating a flat-wound coil 101. The number of turns is chosen in order to develop sufficient voltage for the subsequent circuit. The gauge is chosen in order to keep resistive (heating) losses low. A thin layer of protective material (e.g. paper or plastic), not shown, may be interposed between the core and the windings to protect the enamel insulation of the windings. The thickness of this entire magnetic assembly is less than 1mm.

Optionally, capacitor C1 (150nF) increases the Q of the magnetic assembly to a moderate value, allowing more energy to be captured from the external magnetic field 1. Raising the Q also tunes the assembly, and increases the dissipation in the coil 101, but this low value still leaves the assembly relatively efficient and insensitive to variations in the frequency of the externally-applied magnetic field 1. An alternative circuit topology would be a capacitor in series with the load (series-resonant) rather than the parallel-resonant topology shown here. However this causes a large current to flow through the capacitor and large voltages to be developed across it, causing it to become hot and possibly break down due to excessive voltage.

Optionally, the power collected by the above magnetic assembly can flow directly into a component capable of utilizing AC power directly, for example resistor R1, which is a heating coil, providing heat to a cup-warming device (not shown) for example. However more typically the power is converted to DC for use by

conventional electric or electronic circuits.

In this regard, the coil 101 is centre-tapped and current flows from it into a full-wave rectifier consisting of power diodes D1, D2, and thence into smoothing capacitor C2 of 1uF which smoothes the 40kHz ripple to an acceptable level, providing a DC voltage of approximately 5V.

In some applications, the external alternating magnetic field 1 may, in addition to its alternation at 40kHz, also rotate approximately in the plane of the core 102, perhaps at some lower frequency. In this case the smoothing capacitor C2 must be of sufficient capacity to ride out the dips in voltage caused when the external field 1 is at 90 degrees to the coil 101 and thus induces no current therein.

An optional 3-terminal regulator Q1 may be provided to convert the smoothed DC into regulated DC.

The circuit then connects to the device 120 in/to which it is fitted, providing the device 120 with power. For example, the entire circuit above may be fitted inside the back casing of a mobile telephone and connected to its power/charging circuits, delivering 2W to charge at the same rate as a conventional plug-in charger.

Optionally, the device 120 might be a rechargeable cell, in which case regulator Q1 might be a charge-controller integrated circuit capable of managing fast-charging, trickle charging and the like.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A magnetic core component for transferring power by induction to or from a device, the magnetic core component including a thin sheet of metal in a substantially amorphous or non-annealed state and being provided with means for transferring induced electrical power from the core component to a device.

2. A core component as claimed in claim 1, wherein the metal is at least 70% amorphous or non-annealed.

3. A core component as claimed in claim 1, wherein the metal is at least 90% amorphous or non-annealed.

4. A core component as claimed in any preceding claim, wherein the sheet of metal has a thickness of 0.5mm or less.

5. A core component as claimed in any one of claims 1 to 3, wherein the sheet of metal has a thickness of 0.1mm or less.

6. A core component as claimed in any preceding claim, wherein the sheet of metal is flexible.

7. A core component as claimed in any preceding claim, wherein the sheet of metal is a multilayered sheet.

8. A core component as claimed in claim 7, wherein the multilayered sheet comprises layers of two or more different metals.

9. A core component as claimed in any preceding claim, wherein the sheet of metal is provided with a coil of conductive wire or tape or a flexible printed circuit.

10. A core component as claimed in claim 9, wherein the sheet of metal has a

longer and a shorter planar dimension, and wherein the coil of conductive wire or tape or the flexible printed circuit is wrapped or wound around the shorter planar dimension.

11. A core component as claimed in claim 9 or 10, wherein the coil or the flexible printed circuit is tuned to a higher quality factor (Q) with a capacitor connected in series or in parallel.

12. A core component as claimed in claim 11 depending ultimately from claim 7, wherein the capacitor is formed by separate metal layers of the multilayer sheet, separated by layers of a dielectric material.

13. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a half- or full-wave rectifier.

14. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a smoothing capacitor.

15. A core component as claimed in claim 9 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a regulator or a battery charge-controller.

16. A core component as claimed in any preceding claim, wherein the core component includes at least two sheets of metal material laminated to each other about a coil.

17. A core component as claimed in any preceding claim, wherein the sheet of metal material is thicker in a central part thereof than at end parts thereof.

18. A core component as claimed in claim 17, wherein the sheet of metal material is formed by folding a larger sheet of metal material in a concertina-like manner.

19. A core component as claimed in claim 18, wherein the larger sheet of metal material is generally triangular.

20. A core component as claimed in claim 9 or claim 16 or any claim depending therefrom, wherein an additional coil or flexible printed circuit is provided in a configuration substantially orthogonal to the said coil or flexible printed circuit.

21. A device provided with a magnetic core component for receiving or transmitting power by electromagnetic induction, characterised in that the magnetic core component includes a thin sheet of metal in a substantially amorphous or non-annealed state.

22. A device as claimed in claim 21, wherein the metal is at least 70% amorphous or non-annealed.

23. A device as claimed in claim 21, wherein the metal is at least 90% amorphous or non-annealed.

24. A device as claimed in claim 22 or 23, wherein the sheet of metal has a thickness of 0.5mm or less.

25. A device as claimed in claim 22 or 23, wherein the sheet of metal has a thickness of 0.1mm or less.

26. A device as claimed in any one of claims 21 to 25, wherein the sheet of metal is flexible.

27. A device as claimed in any one of claims 21 to 27, wherein the sheet of metal is a multilayered sheet.

28. A device as claimed in claim 27, wherein the multilayered sheet comprises

layers of two or more different metals.

29. A device as claimed in any one of claims 21 to 28, wherein the sheet of metal is provided with a coil of conductive wire or tape or a flexible printed circuit.

30. A device as claimed in claim 29, wherein the sheet of metal has a longer and a shorter planar dimension, and wherein the coil of conductive wire or tape or the flexible printed circuit is wrapped or wound around the shorter planar dimension.

31. A device as claimed in claim 29 or 30, wherein the coil or the flexible printed circuit is tuned to a higher quality factor (Q) with a capacitor connected in series or in parallel.

32. A device as claimed in claim 31 depending ultimately from claim 27, wherein the capacitor is formed by separate metal layers of the multilayer sheet, separated by layers of a dielectric material.

33. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a half- or full-wave rectifier.

34. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a smoothing capacitor.

35. A device as claimed in claim 29 or any claim depending therefrom, wherein the coil or the flexible printed circuit is connected to a regulator or a battery charge-controller.

36. A device as claimed in any one of claims 21 to 35, wherein the core component includes at least two sheets of metal material laminated to each other about a coil.

37. A device as claimed in any one of claims 21 to 36, wherein the sheet of metal

material is thicker in a central part thereof than at end parts thereof.

38. A device as claimed in claim 37, wherein the sheet of metal material is formed by folding a larger sheet of metal material in a concertina-like manner.

39. A device as claimed in claim 38, wherein the larger sheet of metal material is generally triangular.

40. A device as claimed in claim 29 or claim 36 or any claim depending therefrom, wherein an additional coil or flexible printed circuit is provided in a configuration substantially orthogonal to the said coil or flexible printed circuit.

41. A device as claimed in any one of claims 21 to 40, wherein the sheet of metal material is at least partially wrapped around an axis of the device such that it couples with an electromagnetic field in any rotation about the axis.

42. A magnetic core component, substantially as hereinbefore described with reference to or as shown in Figures 4, 5a, 5b, 5c, 6b and 7 to 13 of the accompanying drawings.

43. A device provided with magnetic core component, substantially as hereinbefore described with reference to or as shown in Figures 4, 5a, 5b, 5c, 6b and 7 to 13 of the accompanying drawings.

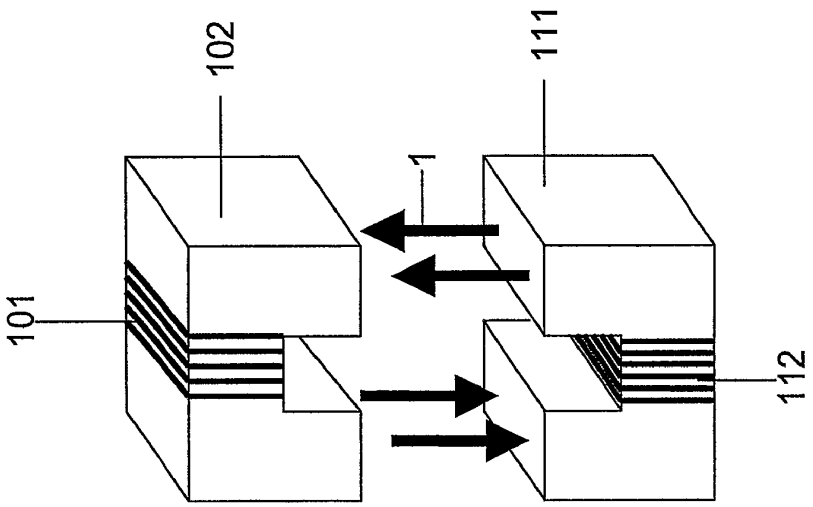


Figure 1 (Prior Art)

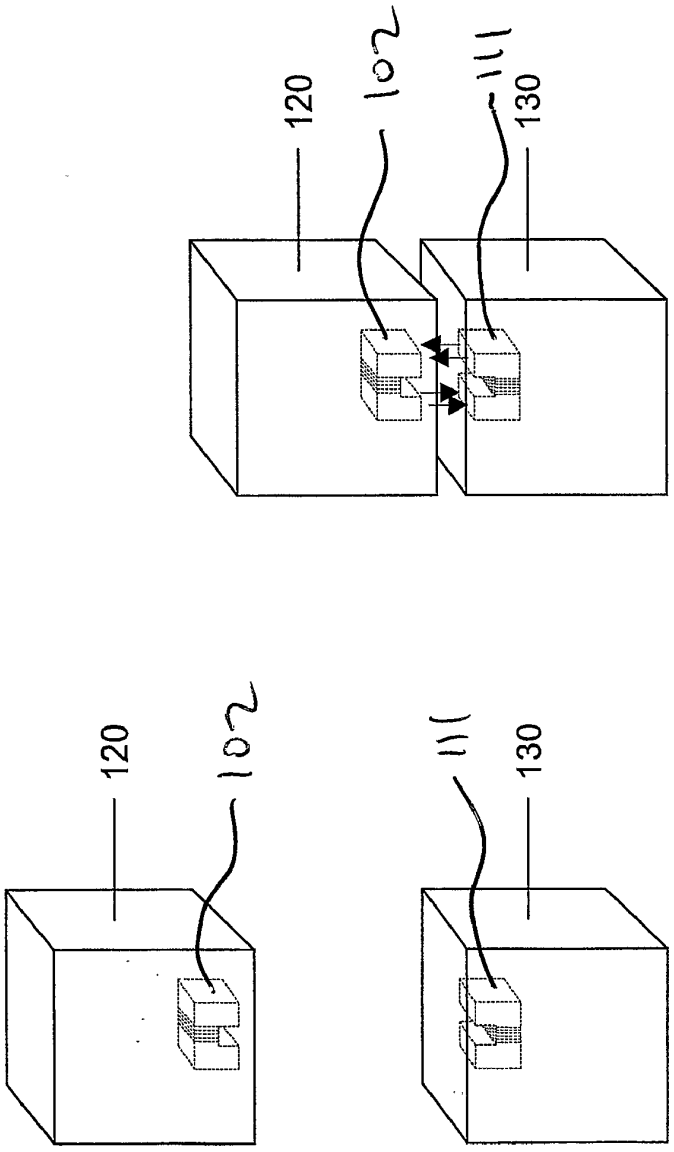


Figure 2
(Prior Art)

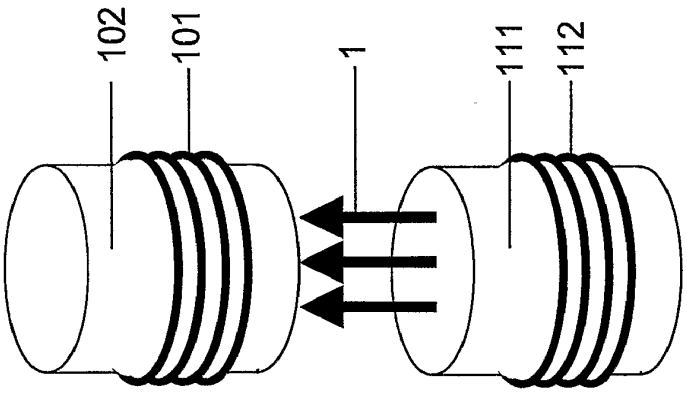


Figure 3 (Prior Art)

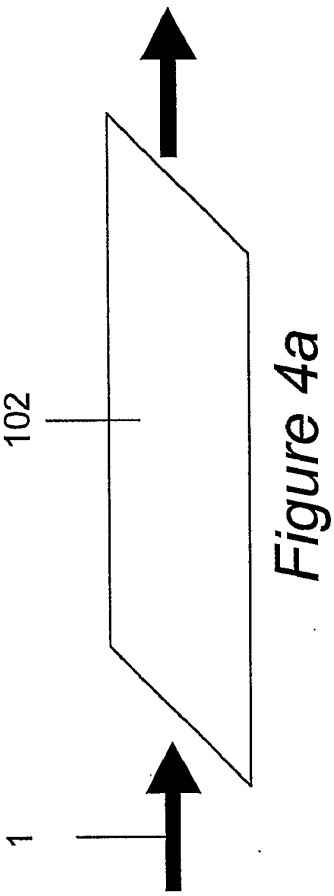


Figure 4a

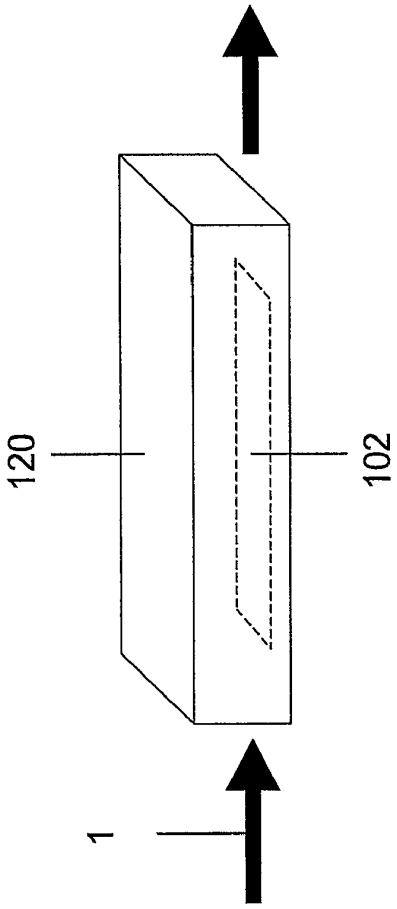


Figure 4b

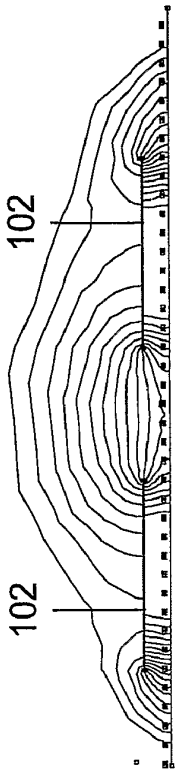


Figure 5c

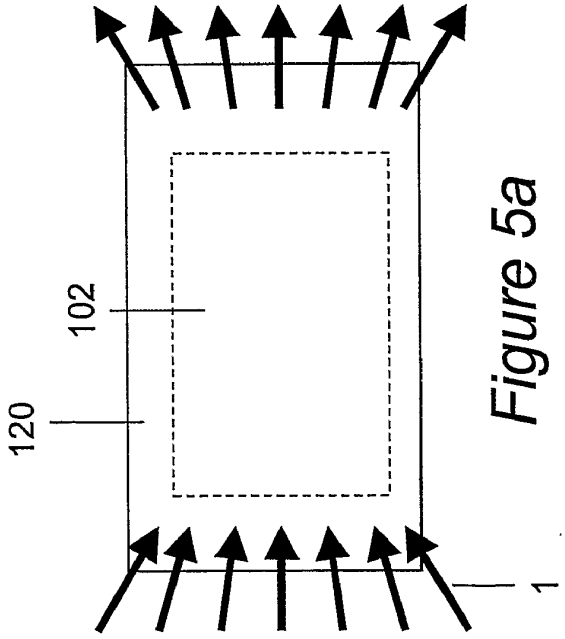


Figure 5a

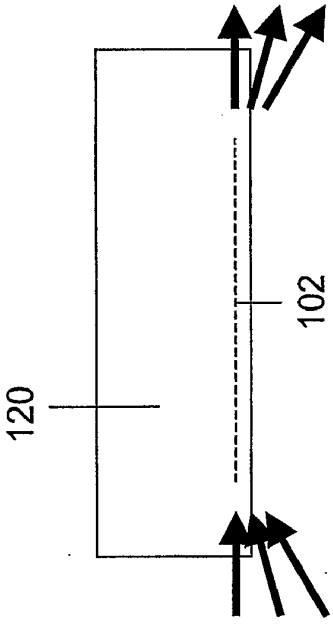
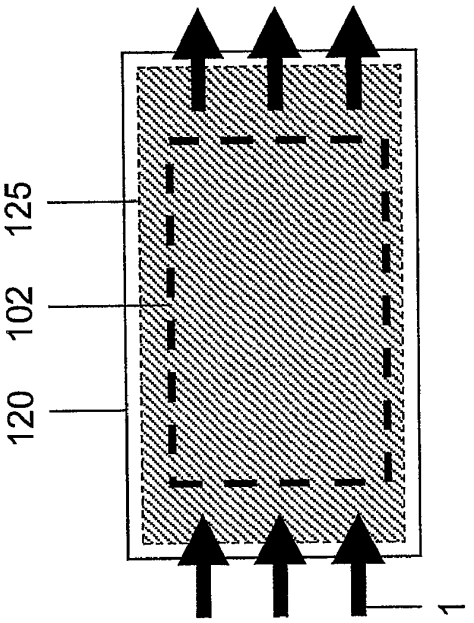


Figure 5b



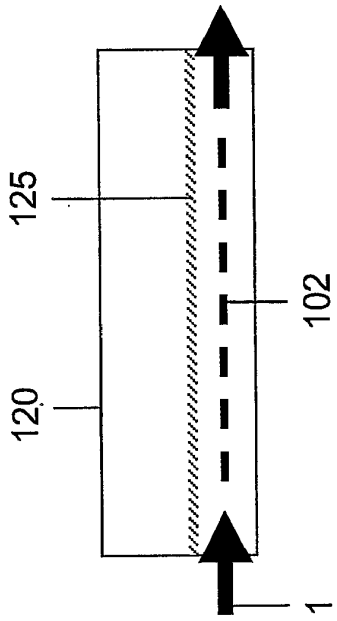
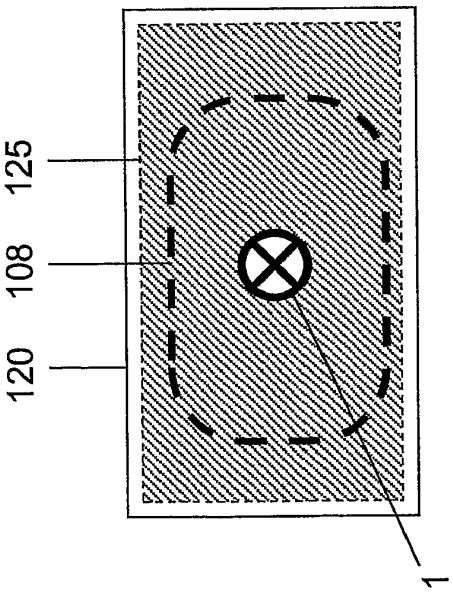


Figure 6b



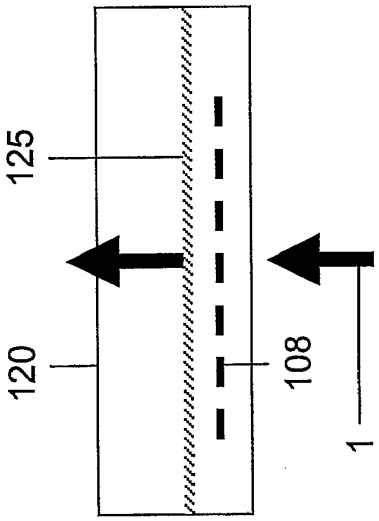


Figure 6a

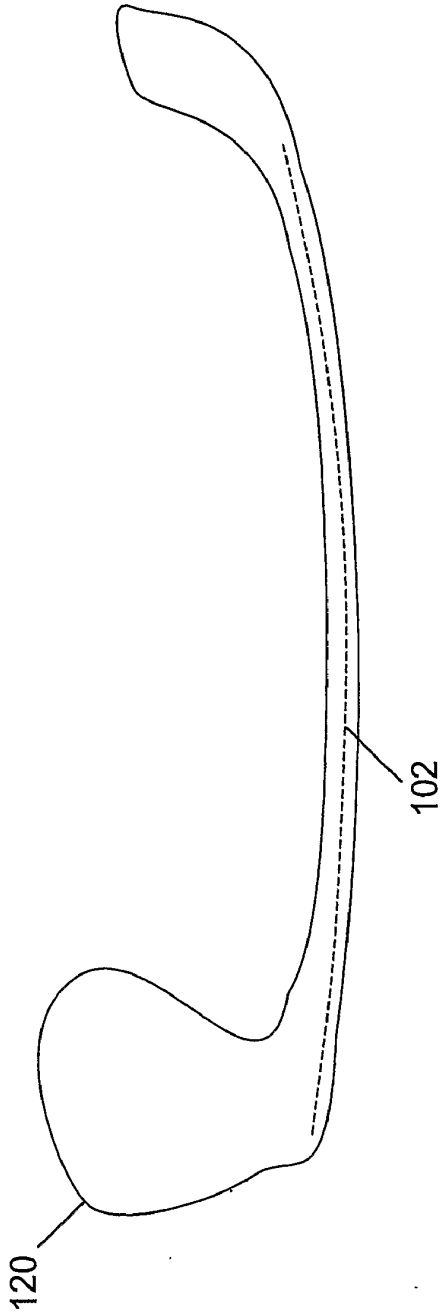


Figure 7

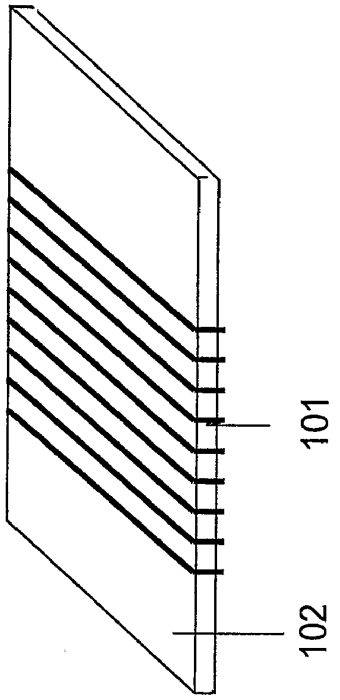


Figure 8

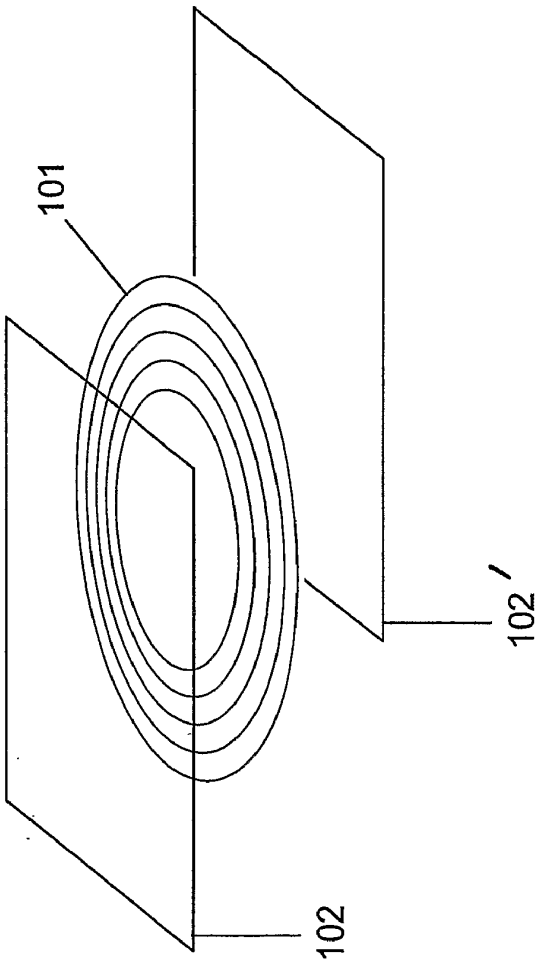


Figure 9
(exploded drawing)

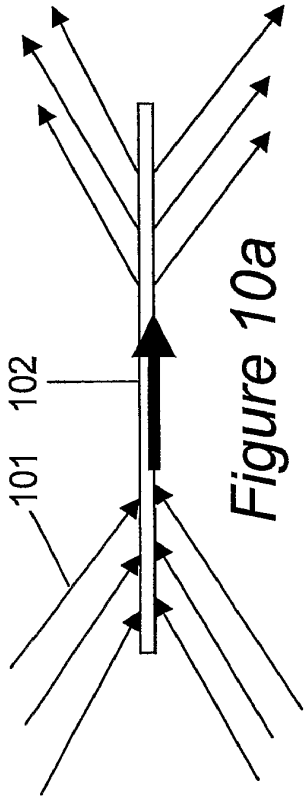


Figure 10a

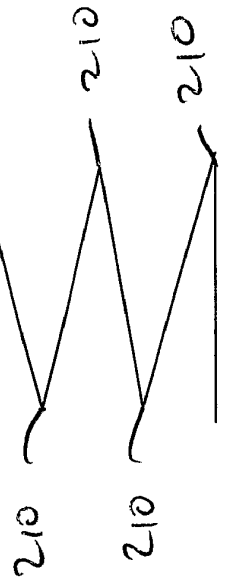


Figure 10d



Figure 10e

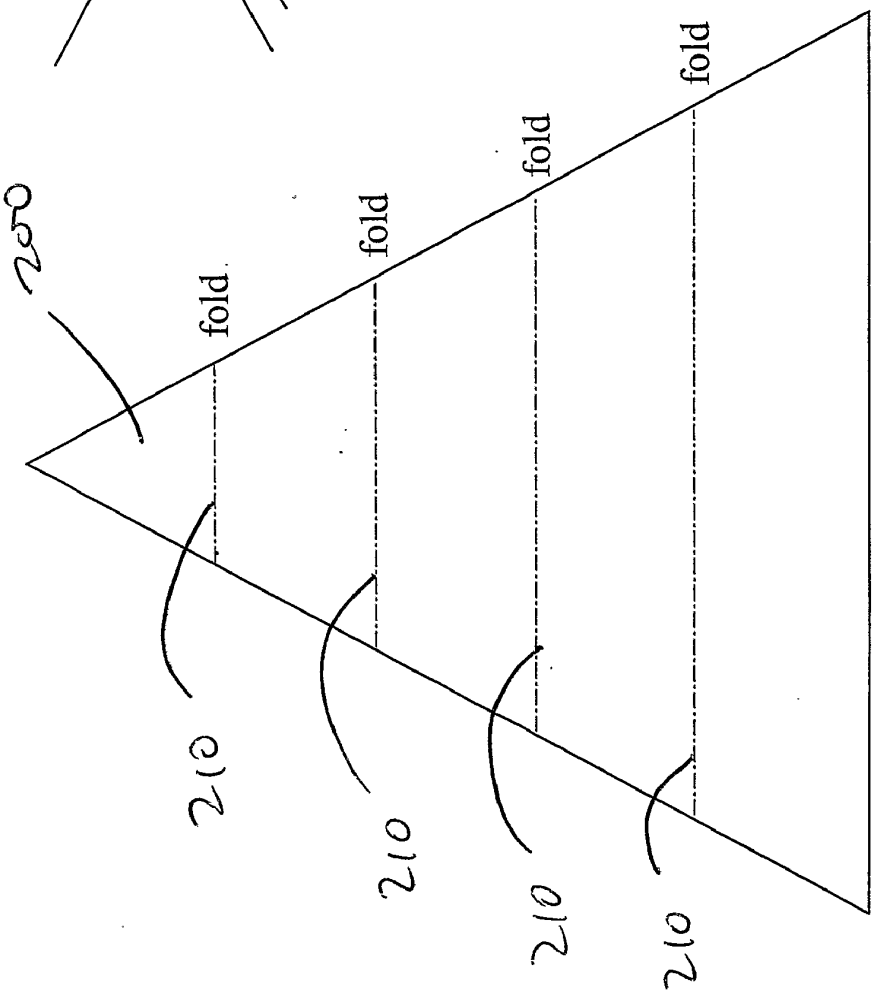


Figure 10b

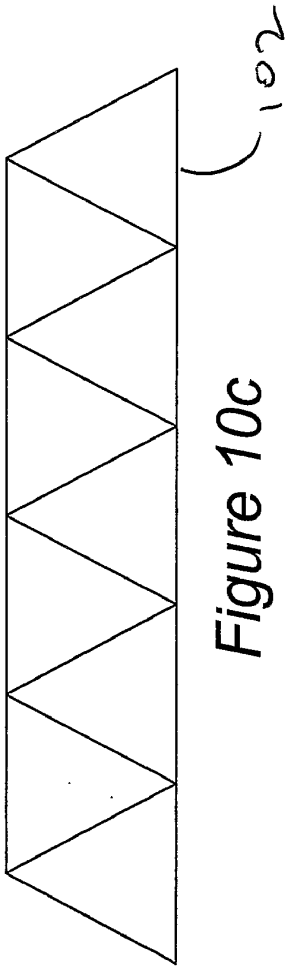


Figure 10c

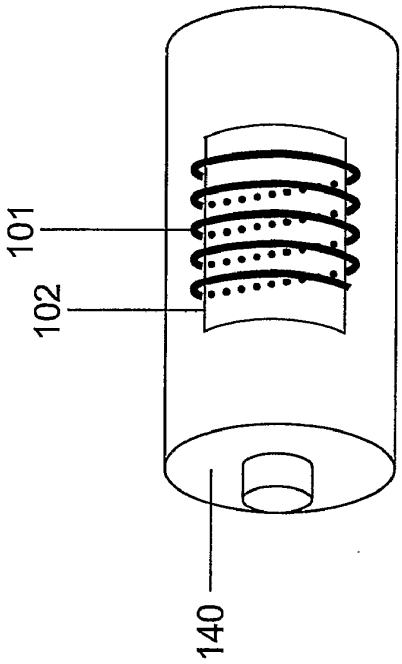


Figure 11b

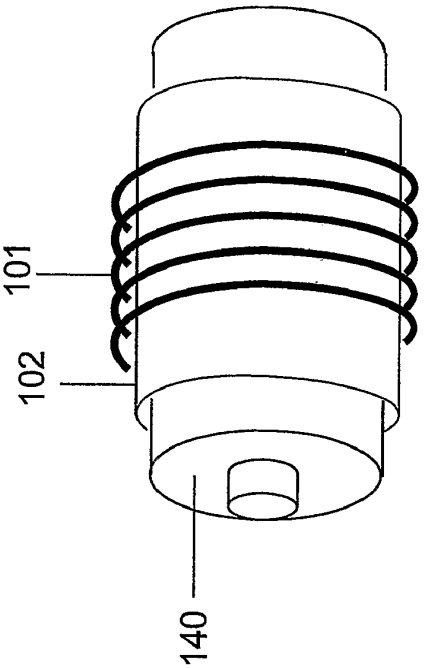


Figure 11a

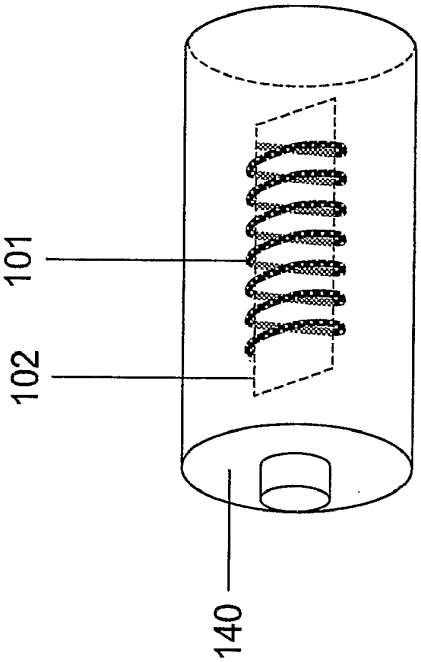


Figure 11c

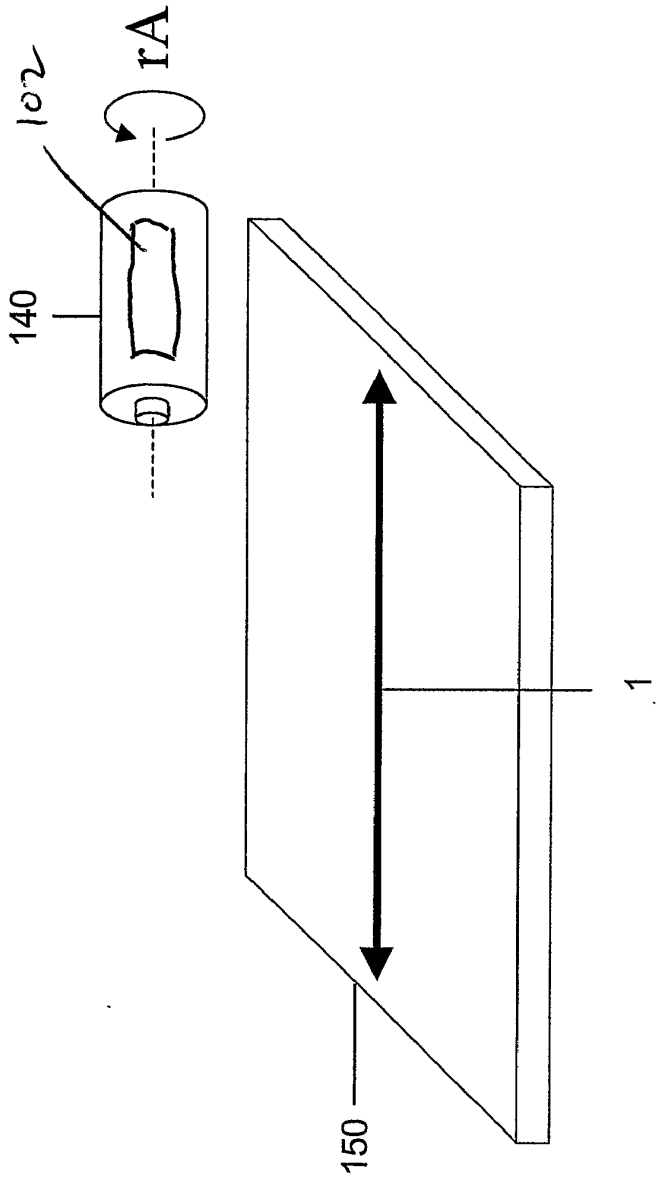


Figure 12

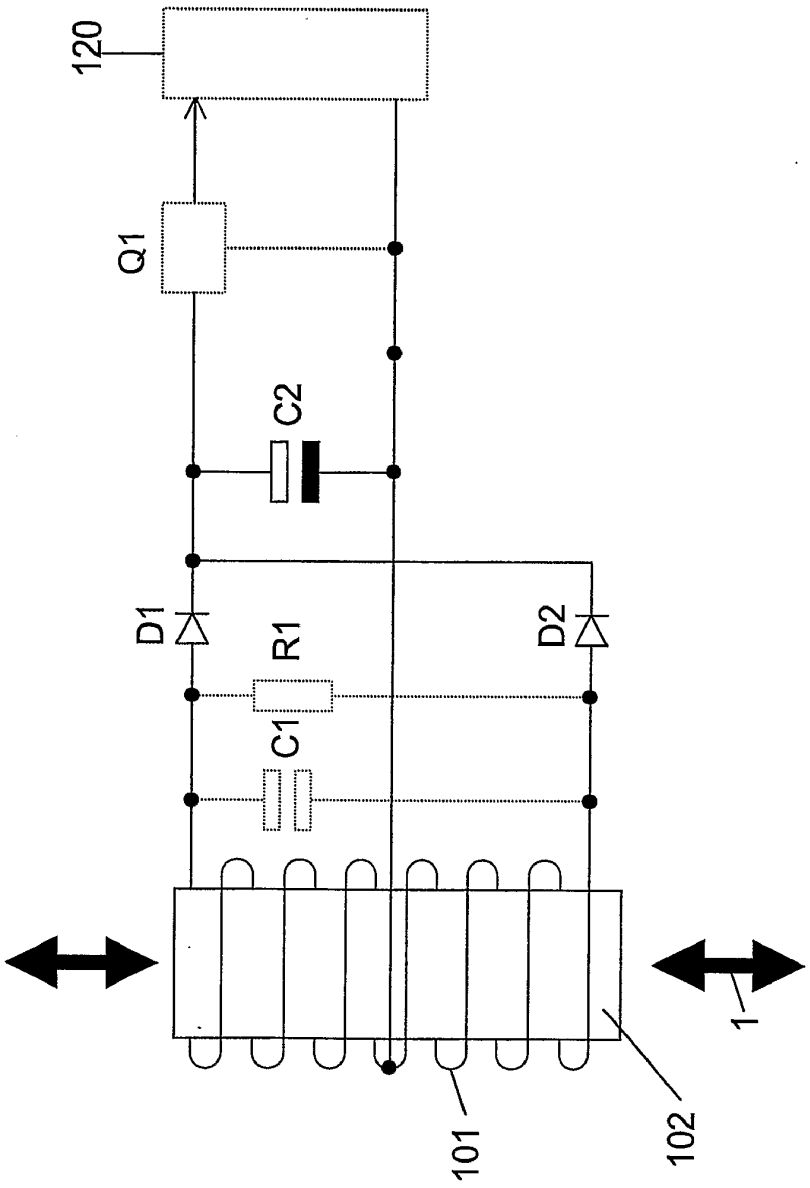


Figure 13

INTERNATIONAL SEARCH REPORT

Internat Application No
PCT/GB 03/02038

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01F41/02 H01F27/25 H02J7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01F H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 528 113 A (BOYS JOHN T ET AL) 18 June 1996 (1996-06-18) column 3, line 1-12; figure 2	1
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 14, 31 December 1998 (1998-12-31) & JP 10 241936 A (ALPS ELECTRIC CO LTD), 11 September 1998 (1998-09-11) abstract	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2003	04/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Durville, G

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Internati Application No
PCT/GB 03/02038

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5528113 A	18-06-1996	AU 8006494 A	08-05-1995
		AU 8006594 A	08-05-1995
		DE 4498007 T0	21-11-1996
		DE 69432262 D1	17-04-2003
		EP 0727105 A1	21-08-1996
		JP 7170681 A	04-07-1995
		WO 9511544 A1	27-04-1995
		WO 9511545 A1	27-04-1995
		NZ 274938 A	27-05-1998
		NZ 274939 A	24-06-1997
		US 5821638 A	13-10-1998
JP 10241936 A	11-09-1998	NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平8－838

(43)公開日　平成８年(1996)１月９日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
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審査請求　未請求　請求項の数３　ＦＤ　（全　６　頁）

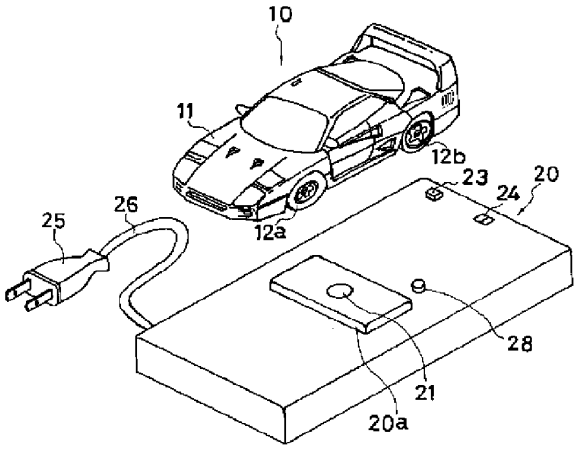
(21)出願番号　特願平6－159687

(22)出願日　平成６年(1994)６月20日

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東京都葛飾区東四つ木１丁目23番17号
(74)代理人　弁理士　桜井　隆夫

(54)【発明の名称】　電磁誘導充電方式の乗物玩具

(57)【要約】
【目的】　電池を搭載したまま充電することにより電池の充電に際し電池の劣化を防ぎ、また充電器プラグなどの破損や腐食による接触不良をなくし、誰でも簡単に安全かつ確実に電池を充電できる乗物玩具を提供する。
【構成】　外部磁界による電磁誘導により、乗物玩具１０に内蔵された電池１７を充電する電磁誘導充電手段を備える。



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【特許請求の範囲】
【請求項１】　外部磁界による電磁誘導により、乗物玩具に内蔵された電池を充電する電磁誘導充電手段を備えた電磁誘導充電方式の乗物玩具。
【請求項２】　電磁誘電により電流を発生する第１の誘導コイルと、第１の誘導コイルに発生した交流電流を直流に変換して充電する整流器と、該整流器の電流により充電される充電式電池と、該電池により駆動される駆動手段と、該電池と前記整流器または駆動手段との回路を切り換え接続する切り換え手段とを搭載した乗物玩具本体と、前記第１の誘導コイルに接近させると該第１の誘導コイルに電磁誘導電流を発生させるような磁界を発生する第２の誘導コイルと、第２の誘導コイルを充電制御手段を介して電源に接続する接続手段とを設けた充電台とを備えた請求項１に記載の電磁誘導充電方式の乗物玩具。
【請求項３】　前記乗物玩具本体を前記充電台の上に載せたときに、前記乗物玩具本体の整流器と充電式電池との回路がオンに、該電池と駆動手段との回路がオフになり、乗物玩具本体を充電台から下ろしたときは、前記整流器と充電式電池の回路がオフになり充電式電池と駆動手段との回路がオンになる第１の切り換え手段を乗り物玩具本体に備え、乗物玩具本体を充電台の上に載せたときは商用電源と充電台との回路がオンになり、乗物玩具本体を充電台から下ろしたときは、商用電源と充電台との回路がオフとなる第２の切り換え手段を充電台に備えた請求項１または２に記載の電磁誘導充電方式の乗物玩具。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、電池駆動の乗物玩具を誘電磁界を発生させる充電台の上に置くだけで乗物玩具に内蔵された電池に充電することのできる乗物玩具に関するものである。
【０００２】
【従来の技術】従来、電池駆動の乗物玩具などにおいて、使用する電池を充電する場合には、玩具から電池を取り出した後に専用の充電器により電池を充電するか、あるいは電池は玩具に内蔵したまま外部の充電器から接続プラグを介して充電を行っていた。
【０００３】しかしながら、玩具から電池を取り出して充電する場合には、頻繁に電池の脱着を繰り返すため電池の被膜などが劣化したり、外部の充電器からプラグを介して充電する場合には、プラグが破損したり腐食により充電しにくくなる欠点があった。また、電池を交換する場合に、電池の陽極と陰極の方向を間違えて入れてしまうことがあった。
【０００４】
【発明が解決しようとする課題】そこで本発明は、電池を搭載したまま充電することにより電池の充電に際し電池の劣化を防ぎ、また充電器プラグなどの破損や腐食による接触不良をなくし、誰でも簡単に安全かつ確実に電池を充電できる乗物玩具を提供することを目的とする。

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【０００５】
【課題を解決するための手段】上記目的を達成するために、本発明の電磁誘導充電方式の乗物玩具は、外部磁界による電磁誘導により、乗物玩具に内蔵された電池を充電する電磁誘導充電手段を備えるものである。
【０００６】また、電磁誘電により電流を発生する第１の誘導コイルと、第１の誘導コイルに発生した交流電流を直流に変換して充電する整流器と、該整流器の電流により充電される充電式電池と、該電池により駆動される駆動手段と、該電池と前記整流器または駆動手段との回路を切り換え接続する切り換え手段とを搭載した乗物玩具本体と、前記第１の誘導コイルに接近させると該第１の誘導コイルに電磁誘導電流を発生させるような磁界を発生する第２の誘導コイルと、第２の誘導コイルを充電制御手段を介して電源に接続する接続手段とを設けた充電台とを備えることが好ましい。
【０００７】さらに、前記乗物玩具本体を前記充電台の上に載せたときに、前記乗物玩具本体の整流器と充電式電池との回路がオンに、該電池と駆動手段との回路がオフになり、乗物玩具本体を充電台から下ろしたときは、前記整流器と充電式電池の回路がオフになり充電式電池と駆動手段との回路がオンになる第１の切り換え手段を乗り物玩具本体に備え、乗物玩具本体を充電台の上に載せたときは商用電源と充電台との回路がオンになり、乗物玩具本体を充電台から下ろしたときは、商用電源と充電台との回路がオフとなる第２の切り換え手段を充電台に備えることが好ましい。
【０００８】
【作用】本発明の構成の電磁誘導充電方式の乗物玩具は、外部磁界による電磁誘導の原理で乗物玩具に内蔵された電池に充電される。
【０００９】また、乗物玩具本体を充電台の上に載せて、充電台に内蔵した電磁誘電効果を生ずる磁界を発生した第２の誘導コイルに乗物玩具本体に搭載した第１の誘導コイルを接近させて、該第１の誘導コイルに電磁誘導により交流電流を発生させる。この第１の誘導コイルに発生した交流電流を整流器により直流に変換して充電式電池に充電する。充電された電池は、切り換え手段により乗物玩具本体のの駆動手段に接続され駆動手段を駆動する。前記充電台の第２の誘導コイルは、充電制御手段を介して商用電源に接続され、接近した置かれた前記第１の誘導コイルに電磁誘電電流を発生させるような磁界を発生させる。
【００１０】さらに、乗物玩具本体を充電台の上に載せると内蔵した整流器と電池との回路がオンになり、電池と駆動部との回路がオフになる第１の切り換え手段を備えるので充電台に乗物玩具車体を載せるだけで内蔵した

電池に自動的に充電される。また、前記第１の切り換え手段は、乗物玩具車体を充電台から下ろすと整流器と電池の回路がオフになり、電池と駆動部との回路がオンになるので、直ちに駆動手段により駆動できる。

【００１１】

【実施例】以下、本発明を図示の一実施例により具体的に説明する。図１乃至図８は本発明の実施例であり、図１は乗物玩具本体及び充電台の斜視図、図２は乗物玩具本体内部の機器配置を示す断面図、図３は乗物玩具本体内部の機器配置を示す平面図、図４は充電台の機器配置を示す断面図、図５は充電台の機器配置を示す平面図、図６は送信機の斜視図、図７は送信機の内部構成を示す図、図８は全体構成を示すブロック図である。

【００１２】これらの図において、本発明の電磁誘導充電方式の乗物玩具は、乗物玩具本体１０と、この乗物玩具本体１０に内蔵した電池を充電するための充電台２０と、乗物玩具本体１０をラジオ・コントロールにより操縦するための送信機３０などとからなる。

【００１３】乗物玩具本体１０は、プラスチックなどの材料を成型して形成された車体１１に左右の操縦車輪１２ａ，１２ａと左右の駆動車輪１２ｂ，１２ｂとを備えており、操縦車輪１２ａ，１２ａは操縦部１３で左右に操縦され、駆動車輪１２ｂ，１２ｂは駆動部１４の駆動モータ１４ａで駆動されるようになっている。

【００１４】車体１１のほぼ中央部の下部側には、第１電磁誘導コイル１５が配設され、また車体１１内部には、整流器１６及び充電式電池１７が配設され、さらに切換えスイッチ１８（第１切換え手段）が車体１１を充電台２０に載せたときその充電台２０に形成された突起２８に対応する位置に設けられている。この切換えスイッチ１８（第１切換え手段）は、車体１１を充電台２０に載せたとき突起２８によって押し上げられて作動し、整流器１６と電池１７との間がオンに、電池１７と受信部１９との間がオフになり、車体１１を充電台２０から下ろすと、整流器１６と電池１７との間がオフになり、電池１７と受信部１９との間がオンになるようになっている。

【００１５】充電台２０は、例えば、プラスチックなどの材料からなり、上部に車体１１を載せることができる大きさの扁平な矩形状に形成されるとともに、中央部の上部は矩形状の低い突起部２０ａが形成されている。この充電台２０の突起部２０ａの内側部分には、車体１１を突起部２０ａに合わせて充電台２０に載せたとき、第１電磁誘導コイル１５ができるだけ接近するように、これに対応する位置に第２電磁誘導コイル２１が配設され、かつこの第２電磁誘導コイル２１を制御する充電制御部（充電制御手段）２２が配設されている。また、充電台２０には、車体１１に設けられた突起２９に対応する位置にスイッチ２３（第２の切換え手段）が設けられている。このスイッチ２３（第２の切換え手段）は、車

体１１を充電台２０に載せないときは主スイッチ２４と充電制御部２２との間の回路を切断し、車体１１を充電台２０に載せたときは突起２９により押し下げられて主スイッチ２４と充電制御部２２の回路を接続するようになっている。充電台２０は、スイッチ２３（第２の切換え手段）、主スイッチ２４、電線２６及び接続プラグ２５を介して商用電源に接続されるようになっている。

【００１６】送信機３０は、そのケース３１の正面側にコントロール・スティック３５ａ，３５ｂ、上部の中央部にアンテナ３２が設けられ、内部には送信部３３、この送信部３３へ電源を供給する電池３４及びスイッチ３６が設けられている。

【００１７】上記構成によれば、まず接続プラグ２５を商用電源に接続し主スイッチ２４をオンにすると、充電台２０には電源が供給されるが、乗物玩具本体１０が充電台２０の上に載っていない状態では、スイッチ２３がオフになっており充電制御部２２には電流は流れない。

【００１８】次に、乗物玩具本体１０を充電台２０の上に載せると、充電台２０のスイッチ２３は車体１１下部の突起２９により押し下げられオンになる。これにより、充電台２０には充電制御部２２を介して第２誘導コイル２１に電流が流れて誘電磁界を発生する。

【００１９】充電台２０の上に載せた車体１１の切換えスイッチ１８は、電池１７と受信部１９の回路をオフし、整流器１６を電池１７に接続する。一方、充電台２０の上に載せられた車体１１に設けられた第１の誘導コイル１５は、充電台２０の第２の誘導コイル２１に対応する位置に接近するため、この第２の誘導コイル２１の磁場により第１の誘導コイル１５に電磁誘導の原理により誘導電流が発生する。この誘導電流は整流器１６により直流に変換され、電池１７を充電する。

【００２０】このようにして乗物玩具本体１０を充電台２０の上で所定時間載せたままにしておくことにより、充電が完了する。充電が完了して乗物玩具１０を充電台２０の上から下ろすと、充電台２０のスイッチ２３は車体１１の突起２９から離れるのでオフになり、充電制御部２２、第１誘導コイル２１の電流は断たれる。また、車体１１の切換えスイッチ１８は、充電台２０の突起２８から離れて切換わり第１の誘導コイル１５及び整流器１６と電池１７の回路がオフになり、電池１７と受信部１９の回路が接続される。

【００２１】そこで、乗物玩具１０を床の上に置き、送信器３０のスイッチ３６をオンにしてコントロール・スティック３５ａ，３５ｂを操作することにより操縦、駆動の信号がアンテナ３２から送信され、この信号が車体１１側の受信部１９で受信され、操縦部１３及び駆動部１４が制御されることにより、乗物玩具１０を前進、停止、前後左右に自在に操作できる。

【００２２】なお、上記実施例では、充電台２０に車体１１を載せたときに充電が行われるようにスイッチを設

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けた例を説明したが、これらのスイッチを設けず充電台に載せる車体の方向に無関係に充電できるようにすることもできる。

【００２３】本発明の好適な実施例について説明したが、本発明の精神を逸脱しない範囲において種々の改良及び変更をなし得ることはもちろんである。

【００２４】

【発明の効果】以上説明したように、本発明の電磁誘導充電方式の乗物玩具によれば、誘導コイルと電池を内蔵した乗物玩具を充電台の上に置くだけで、電磁誘導の原理で乗物玩具に内蔵された電池に容易に充電でき、乗物玩具から電池を取り出したり乗物玩具に接続プラグを直接つないだりする必要がない。したがって、充電が極めて容易で幼児でも充電操作を行うことができ、また電池の破損の機会が少なく、プラグの腐食などによる充電不良を防止できる。さらに、充電の際の取り扱いが簡単になり幼児にも安全である。

【図面の簡単な説明】

【図１】本発明実施例の乗物玩具本体及び充電台の斜視図である。

【図２】本発明実施例の乗物玩具本体内部の機器配置を示す断面図である。

【図３】本発明実施例の乗物玩具本体内部の機器配置を示す平面図である。

【図４】本発明実施例の充電台の機器配置を示す断面図である。

【図５】本発明実施例の充電台の機器配置を示す平面図である。

【図６】本発明実施例の送信機の斜視図である。

【図７】本発明実施例の送信機の内部構成を示す図である。

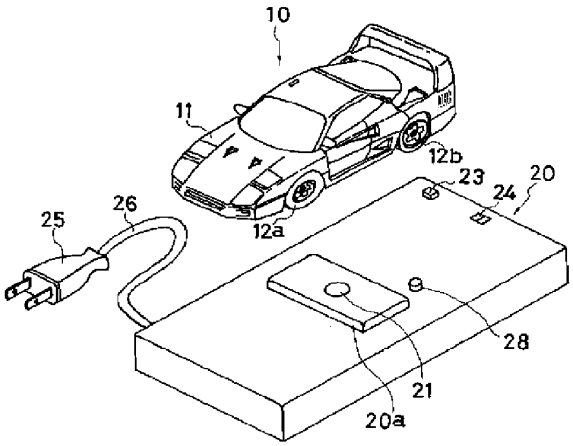
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【図８】本発明実施例の全体構成を示すブロック図である。

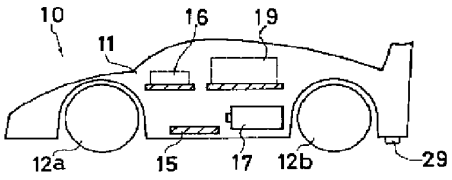
【符号の説明】

１０　乗物玩具
１１　車体
１２　車輪
１３　操縦部
１４　駆動部
１４ａ　駆動モータ
１５　第１の誘導コイル
１６　整流器
１７　電池
１８　切換えスイッチ
１９　受信部
２０　充電台
２１　第１の誘導コイル
２２　充電制御部
２３　スイッチ
２４　主スイッチ
２５　接続プラグ
２６　電線
２８　突起
２９　突起
３０　送信機
３１　ケース
３２　アンテナ
３３　送信部
３４　電池
３５　コントロール・スティック
３６　スイッチ

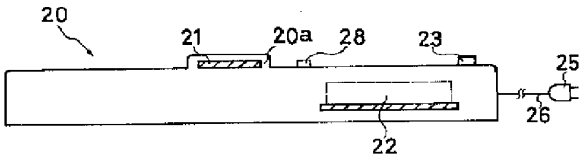
【図１】



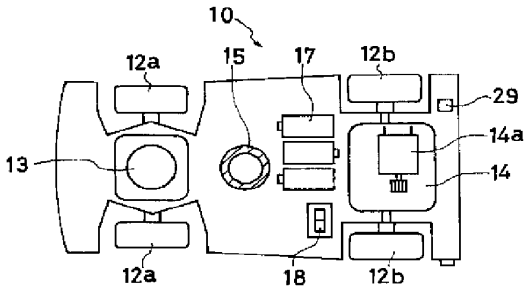
【図２】



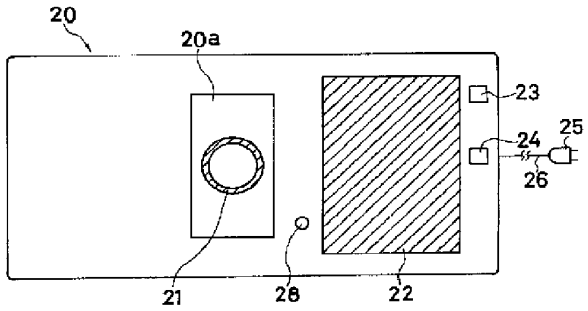
【図４】



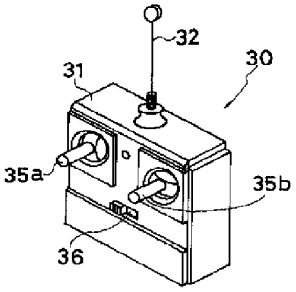
【図３】


10
12a
15
17
12b
29
14a
13
14
12a
18
12b

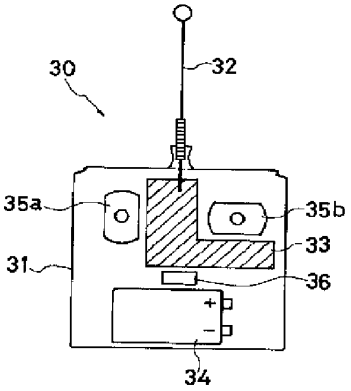
【図５】


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20a
23
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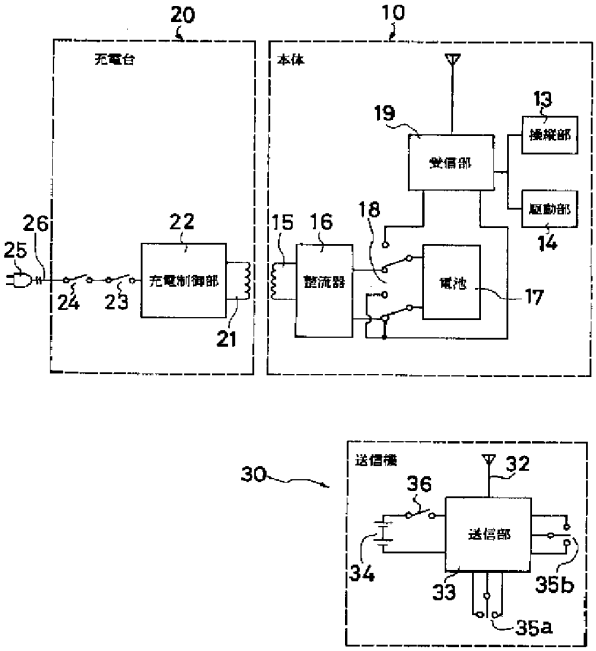
【図６】


32
31
30
35a
35b
36

【図７】


30
32
35a
35b
33
31
36
+
−
34

【図８】


20
10
充電台
本体
19
13
受信部
操縦部
駆動部
14
26
25
22
15
16
18
24
23
充電制御部
整流器
電池
17
21
30
送信機
32
36
送信部
34
33
35b
35a

PAT-NO: JP408000838A

DOCUMENT-IDENTIFIER: JP 08000838 A

TITLE: VEHICLE TOY OF ELECTROMAGNETIC INDUCTION CHARGING SYSTEM

PUBN-DATE: January 9, 1996

INVENTOR-INFORMATION:

NAME	COUNTRY
SUDO, SHOHEI	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
TAIYO KOGYO KK	N/A

APPL-NO: JP06159687

APPL-DATE: June 20, 1994

INT-CL (IPC): A63H030/02

ABSTRACT:

PURPOSE: To easily, safely and surely perform charging by eliminating any contact defect caused by the damage or corrosion of a charger plug by preventing a battery from being degraded in the case of charging by providing an electromagnetic induction charging means for charging the battery built in the vehicle toy with electromagnetic induction due to an external magnetic field.

CONSTITUTION: First of all, when a connection plug 25 is connected to a commercial power source and a main switch 24 is turned on, power is supplied to a charging stand 20. Next, when a main body 10 of the vehicle toy is put on the charging stand 20, a switch 23 is pushed down with a projection at the lower part of a car body 11 and turned on, a current flows through a charging control part to a second induction coil 21 of the charging stand 20, and an induction magnetic field is generated. On the other hand, since a first induction coil provided at the car body 11 put on the charging stand 20 is made closer to the position corresponding to the second induction coil 21 of the charging stand 20, with the magnetic field of this second induction coil 21, an induction current is generated at the first induction coil by the principle of electromagnetic induction. This induction current is converted to DC by a rectifier and charges the battery built in the car body 11.

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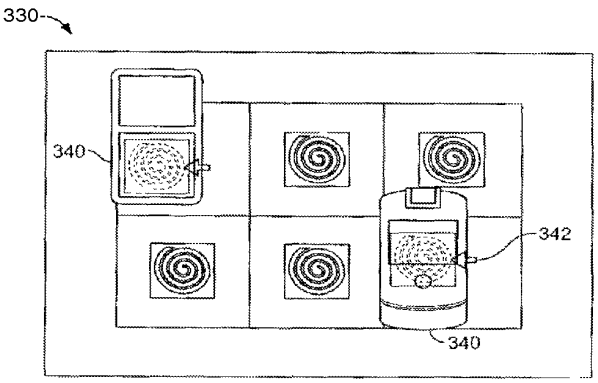
(74) **Agents: KENNA, Karl, F.** et al; Fliesler Meyer LLP, 650 California Street, Fourteenth Floor, San Francisco, California 94108 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FT, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

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[Continued on next page]

(54) **Title:** SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES



FIG, 16

(57) **Abstract:** A system and method for variable power transfer in an inductive charging or power system. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile device, battery, or other device. In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or receiver side; and additional circuits and components that perform specialized tasks, such as mobile device or battery identification, and automatic voltage or power-setting for different devices or batteries.

WO 2008/137996 A1

NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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Attorney Docket; AFPA-01013WO0

SYSTEIVI AMD METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES

inventors;
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Michael Sears

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Claim of Priority:

[0001] This application claims priority to U.S. patent application 12/1 16,876, filed May 7, 2008, titled "SYSTEM AND METHOD FOR INDUCTiVE CHARGING OF PORTABLE DEVICES", which is a continuation-in-part of U.S. patent application 11/669,1 13, filed 1/30/2007, titled "INDUCTiVE POWER SOURCE AND CHARGING SYSTEM", which application claims the benefit of U.S. provisional patent application 60/763,816, filed 1/31/2006, titled "PORTABLE INDUCTIVE POWER SOURCE"; U.S. provisional patent application 60/810,262, filed 6/1/2006, titled "MOBILE DEViCE, CHARGER, AND POWER SUPPLY"; U.S. provisionai patent appiication 60/810,298, filed 6/1/2006, titled "MOBILE DEVICE, BATTERY, CHARGiNG SYSTEM, AND POWER SUPPLY"; and U.S. provisional patent application 60/868,674, filed 12/5/2006, titled "SYSTEM FOR PROVIDING A PORTABLE iNDUCTIVE POWER SOURCE"; this application also claims the benefit of U.S. provisional patent application 60/916,748, filed 5/8/2007, titled "CHARGING AND POWERING MOBILE DEVICES, BATTERIES"; U.S. provisional patent application 60/952,835, filed 7/30/2007, titled "INDUCTIVE CHARGING OF PORTABLE DEVICES"; U.S. provisionai patent application 61/012,922, filed 12/12/2007, tified "WIRELESS CHARGER WITH POSITION INSENSITIVITY"; U.S. provisional patent application 61/012,924, fiied 12/12/2007, titled "CONTROL, REGULATION, AND COMMUNICATION IN CHARGERS"; U.S. provisionai patent application 61/015,606, filed 12/20/2007, titled "PORTABLE INDUCTIVE POWER SOURCE"; and U.S. provisional patent application 61/043,027. fiied 4/7/2008, titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; this appiication is also related to copending U.S. patent application 11/757,067 fiied 6/1/2007, titied "POWER

SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", each of which above applications are herein incorporated by reference.

Field of Invention:

[0002] The invention is related generally to power supplies, power sources, and particularly to a system and method for inductive charging of portable devices.

Background:

[0003] There is currently a need for powering portable or mobile devices for use in commercial, business, personal, consumer, and other applications. Examples of such devices include cellular telephones, persona! digital assistants (PDAs), notebook computers, mobile email devices, Blackberry devices, Bluetooth headsets, hearing aids, music players (for example, MP3 players), radios, compact disk players, video game consoles, digital cameras, walkie-talkie or other communication devices, GPS devices, laptop computers, electric shavers, and electric toothbrushes. fttost of these devices include a rechargeable internal battery that must be first charged by an externa! power supply or charger, before the device itself can be used. The power supply typically provides direct current (DC) voltage through a special connector to the device. The power supply can then be disconnected, and the device will continue to run for a short period of time until the battery is depleted. The voltage and power requirements of the different devices vary, and to date there is currently no standardized connector for the devices. As a result of this, each mobile device is invariably sold or distributed bundled with its own charger. The costs associated with these multiple different types and numbers of charger are paid by the consumer indirectly by being incorporated into the prices being charged for the mobile device.

|0004] The rapid increase in the total number and variety of mobile products has meant that most people have several of the above-mentioned devices. In a typical day, that user would have to separately connect their multiple devices to each of their appropriate chargers for charging of each device. In addition. many people find it necessary to charge their devices in different locations such as their offices and cars. Thus, many users have purchased additional chargers for their offices and cars, for use in charging their mobile phones, notebook computers, and music players in those locations.

[0005] It will be evident that the above situation has caused typical users to have a multitude of incompatible devices (i.e. power supplies and chargers) that essentially provide the same function of charging a mobile device, but because of the number and variety that must be kept by the user are inconvenient to use. In many situations, users simply forget to charge their devices, or else find they need to recharge their device in situations where no

appropriate charger is available. This leads to loss of ability to use the device when desired or needed.

[0006] In addition, when traveling way from home, mobile users have a particular problem in that they need to pack and carry the multiple chargers for their devices, In many situations, these chargers are bulkier and heavier than the devices themselves, and use of these devices in foreign countries requires clumsy adaptors, and sometimes voltage converters. This leads to a high degree of inconvenience for the ever-more-mobile consumer.

[0007] in addition, the power connector for the mobile devices is often cheaply manufactured, and a source of mechanical and electrical failure. In many applications, such as toothbrushes or applications where the device is exposed to water and needs to be hermetically seaied, such a physical connection can not be used. Thus an alternative means of powering those types of devices must be used.

[0008] Sβvβrai products have tried to address this situation. Some companies propose the use of a universal charger that consists of a power supply base unit, and interchangeable tips that both fit into the base unit and in turn fit different devices. The tip includes a customized regulator that sets the voltage required by the particular device. However, a user must carry the muitiple tips he or she needs for each of the various devices they have, and then charge each device serially by connecting the device to the power supply. While this product reduces the overall weight of the charging tools the user must *carry,* the user still needs to carry and exchange the tips to connect to different devices. In addition, the charging of muitiple devices simultaneously is often not possible.

[0009J Realizing that a power suppiy typically contains a transformer for voltage conversion, another approach is to split the transformer into two parts: a first part can contain the first winding and the electronics to drive this winding at the appropriate operating frequency, while the second part consists of a winding where power is received and then rectified to obtain DC voltage. If the two parts are brought into physical proximity to each other, power is transformed from the first part to the second inductively, i.e. by induction, without any physical electrical connection. This is the approach that is used in many electrical toothbrushes, shavers, and other products that are expected to be used in wet environments. However, a common problem with such inductive units is that the windings are bulky, which restricts their use in lightweight portable devices. Furthermore, to achieve adequate power transfer, the parts must be designed to fit together suitably so that their windings are closely aligned. This is typically done by molding the device casing (for example, an electric toothbrush) and its charger/hoider so that they fit together in only one

suitable way. However, the molded base and shape of the portable device means they cannot be used in a universal fashion to power other devices.

[0010] Some companies have proposed pad-like charging devices based on inductive concepts, but that also ostensibly allow for different types of devices to be charged. These pads typically include grids of wires in an x and y direction, that carry *an* electrical current, and that generate a uniform magnetic field parallel to the surface of the pad. A receiver coil wound around a magnetic core lies on the surface of the pad and picks up the magnetic field parallel b the surface, and in this manner energy can be transferred. However, each of these methods suffer from poor power transfer, in that most of the power in the primary is not picked up in the receiver, and thus the overaii power efficiency of the charger is very low. In addition, the magnetic cores used for the primary and receiver are often bulky and add to the total cost and size of the system, and limit incorporation into many devices.

[0011] Another point to note is that, while all of the above devices allow a user to charge a device, they also require the charging device or base unit to be electricaily connected to a power source, such as a power outlet or a DC source. In many cases, the user may not have access to such a power source such as when traveling, camping, or working in an area without access to power. However, to date, no device has been provided that is portable, and that allows for inductive charging of multiple devices with differing power requirements, and which itself can be intermittently or occasionally charged either by an external power source, or by other means, or that is self-powered or includes its own power source.

Summary:

[0012] A portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices or rechargeable batteries is disclosed herein. in accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobiie or other device or rechargeable battery. The receiver may comprise coiis. windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

[0013] In some embodiments the receiver can also comprise eiectronic components or logic to set the voltage and current to the appropriate levels required by the mobile device

or the charging circuit in the device, or to communicate information to the pad. In additional embodiments, the charging or power system can provide for additional functionality such as communication of data stored in the electronic device or to be transferred to the device. Some embodiments may aiso incorporate efficiency measures that improve the efficiency of power transfer between the charger and receiver, and ultimately to the mobile device or battery. in accordance with an embodiment the charger or power supply includes an interna! battery for self-powered operation. In accordance with other embodiments the charger or power supply can include a solar eel! power source, hand crank, or other means of power suppiy for occasional self powered operation. Other embodiments can be incorporated into charging kiosks, automobiles, trains, airpianes, or other transport and other applications.

[0014] In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system lo be easily modified for applications that have different power requirements. These include variations in the material used b manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or secondary side; and additional circuits and components that perform specialized tasks, such as mobile device identification, and automatic voltage or power-setting for different devices.

Brief Description of the Figures;

[001 5] Figure 1 shows a pad using multiple transmitter or charger coils in accordance with an embodiment.

[0016] Figure 2 shows a figure of a circuit diagram in accordance with an embodiment.

[0017] Figure 3 shows a charging pad using multiple coiis in accordance with an embodiment.

[0018] Figure 4 shows a charging pad using multipie overlapping coil layers in accordance with an embodiment.

[0019] Figure 5 shows the use of multiple coil types and sizes in overlapping pad layers in accordance with an embodiment.

[0020] Figure 6 shows a receiver with an integrated battery in accordance with an embodiment.

[0021] Figure 7 shows a coupling of receiver with a device to be charged or powered in accordance with an embodiment

[0022] Figure 8 shows a pad aiiowing modular or multiple connectivity in accordance with an embodiment.

[0023] Figure 9 shows a figure of a circuit diagram in accordance with an embodiment.

[0024] Figure 10 shows a figure of a circuit diagram in accordance with an embodiment.

[0025] Figure 11 shows a figure of a circuit diagram in accordance with an embodiment.

[0026] Figure 12 shows a figure of power transfer chart in accordance with an embodiment.

[0027] Figure 13 shows a figure of a coil layout in accordance with an embodiment.

[0028] Figure 14 shows a figure of a coil layout in accordance with art embodiment.

[0029] Figure 15 shows a figure of a charging pad with muitiple coils in accordance with an embodiment.

[0030] Figure 18 shows a figure of a charging pad with movable coils and two devices receiving power or charge in accordance with an embodiment.

[0031] Figure 1? shows a figure of a circuit diagram in accordance with an embodiment.

[0032] Figure 18 shows an illustration of a means of stacking coils, in accordance with an embodiment.

[0033] Figure 19 shows a figure of a circuit diagram for identification verification in accordance with an embodiment.

[0034] Figure 20 shows a figure of a circuit diagram for bidirectionai communication in accordance with an embodiment.

[0035] Figure 21 shows a figure of a circuit diagram for output controller in accordance with an embodiment.

[0036] Figure 22 shows a figure of a circuit diagram for the receiver with regulator in accordance with an embodiment.

[0037] Figure 23 shows a figure of a circuit diagram for MCU regulation in accordance with an embodiment.

[0038] Figure 24 shows a figure of a circuit diagram for unidirectional communication in accordance with an embodiment.

[0039] Figure 25 shows a figure of a circuit diagram for time-based regulation in accordance with an embodiment.

[0040] Figure 26 shows a high level view of a flyback power supply geometry in accordance with an embodiment.

[0041] Figure 27 shows an embodiment in which the output voStage to a load is monitored and with changes in the load condition, a chip or a Micro Controller Unit (MCU) varies the frequency or the duty cycie of the FET driver to achieve optimum operation.

[0042] Figure **28** shows an implementation of a charger in accordance with an embodiment, wherein the primary stage and the receiver stage communicate wireSessiy.

[0043] Figure 29 shows an embodiment that inciudes Zero Voltage Setting (ZVS).

[0044] Figure 30 shows an embodiment in which, instead of a digital feedback circuit, an analog circuit based on coupling between a Sight emitting diode (LED) and a light detector can be used.

[0045] Figure 31 shows an embodiment in which the opto-coupSβr is replaced by a Voltage Controlled Oscillator (VCO) and FET and in the primary, the signal is sent to adjust a frequency controiler to provide optimum output voltage.

[004β] Figure 32 shows an embodiment in which the wireless link can be analog or digitai or can be integrated into the device to take advantage of existing wireless links in the device,

[0047] Figure **33** shows a basic schematic for an inductive single coil charging system in accordance with an embodiment.

[0048] Figure **34** shows the main components of a wireless power/charging system in accordance with an embodiment.

[0049] Figure 35 shows a typical experimental curve for power transferred and Power Transfer in accordance with an embodiment

[0050] Figure 36 shows an embodiment in which a coii mosaic is used to cover the surface area of a pad.

[0061] Figure 37 shows an embodiment in which the number of drive (and sensing) circuits may be reduced by using eiectrical or electronic switches,

[0052] Figure 38 shows an embodiment in which three coii iayer printed circuit board (PCB) is arranged to provide a duster for uniform power in an area using only one coii powered at any given time.

[0053] Figure 39 shows an embodiment in which the coils are arranged such that by powering only one of the coils in the ciuster, any receiver coil piaced with a center within any iocation in the effective area can receive the specified power if the appropriate charger coil is activated.

[0054] Figure 40 shows an embodiment in which the number of switches required is reduced.

[00S5] **Figure 41** shows an embodiment of a muiti-charger pad that incorporates a piuraSity of charging dusters.

[0056] Figure 42 shows an embodiment that uses a cluster of two layers of three coils and a centra! coil to create an effective area.

10057] Figure 43 shows a mosaic of hexagonal coils with the central port to each coil shown as circles.

[0058] Figure 44 shows an embodiment of a MEMS pad including the top view.

[0059] Figure 45 shows an embodiment of a MEMS pad including a segmented MEMS charger pad.

[0060] Figure 46 shows an embodiment in which one or more regulated power supplies are connected to the charger pad.

[0061] Figure 47 shows an array of contacts on the surface of a pad in accordance with an embodiment.

[00S2] Figure 48 shows the side view of a MEMS conductive charger pad in accordance with *an* embodiment,

[0063] Figure 4θ shows an embodiment wherein several regulated power supplies provide power to the pad, to allows charging of several devices simultaneously.

[0064] Figure 50 shows an alternative embodiment of a pad using a segmented surface.

[0065] Figure 51 shows an industry standard means that is used for measuring emissions from a product.

[00S6] Figure 52 shows an embodiment which illustrates absorption through a copper layer.

[0067] Figure 53 shows attenuation values for Copper and Aluminum layers for several thicknesses.

[0068] Figure 54 shows transmitted power through Copper and Aluminum layers of varying thickness for an incident field at 1 MHz.

[006S] Figure 55 shows *an* embodiment which allows for obtaining local alignment independence between coils in the charger and the receiver.

[0070] Figure 56 show an embodiment in which coil magnets can divided into sections.

[0071] Figure 57 shows an embodiment in which one or more alignment magnets can be used behind each coil.

[0072] Figure 58 shows an illustration of a device for inductive power charging that includes an internal battery for self-powered operation, in accordance with an **embodiment.**

[0073] Figure 59 shows an illustration of an inductive charger unit with a solar cell power source for self powered operation, in accordance with an embodiment.

[0074] Figure 60 shows an illustration of an inductive charger unit with an incorporated communications and/or storage unit, in accordance with an embodiment.

[0075] Figure 61 shows an illustration of a kiosk that incorporates an inductive charger unit in accordance with an embodiment.

[0076] Figure 62 illustrates some common regular (non-charger) mobile phone holders types, in accordance with an embodiment.

[0077] Figure 63 illustrates various products for a music player, that includes an external rechargeable battery pack, in accordance with an embodiment.

[0078] Figure 64 illustrates a multi-function device that includes a hard drive, rechargeable battery, and wireless connectivity, in accordance with an embodiment.

[007S] Figure 65 illustrates a system for use with a charger case to inductively power or charge a mobile device, in accordance with an embodiment.

[0080] Figure 66 shows a pad using muitiple receiver/energizer coils in accordance with an embodiment.

[0081] Figure 67 shows, in a multi-charger or power supply where multiple coils are used, such a high heat conductivity layer may be repeated around each coil or cover all areas between the multiple coils, in accordance with an embodiment.

[0082] Figure 68 shows a similar method that may be used for heat removal from wound coils of other shape and type.

[0083] Figure 69 shows an embodiment in which the layer can be patterned to provide heat conductivity channels rather than a continuous layer.

[0084] Figure 70 shows an illustration of the electronics for the PCB coil inductive charger and/or power supply or the inductive receiver as fabricated on the same PCB as the coil, in accordance with an embodiment.

[008S] Figure 71 shows an embodiment in which magnets placed at the center of a stationary coil or a moving, floating charger and/or power supply coil and the receiver coil can provide a method for alignment of the coils and to achieve this result.

[0086] Figure 72 shows an embodiment in which two or more magnets that do not cross the center of the coil are used.

[0087] Figure 73 is an illustration that shows how the magnets may be placed outside the PCB coil area, in accordance with an embodiment.

[0088] Figure 74 shows an embodiment in which magnetic arc-shaped parts around a circular coil are used.

[0089] Figure 75 illustrates the use of bar magnets on or around the coil, in accordance with an embodiment.

Detailed Description:

[0090] A portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, rechargeable batteries, and other devices is disclosed herein. in accordance with an embodiment the system comprises two parts: The first part is a pad or similar base unit that contains a primary, which creates *an* alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. In some embodiments the pad can also contain various signaling, and switching or communication circuitry, or means of identifying the presence of devices or batteries to be charged or powered. in some embodiments the pad can also contain multiple coils or sections to charge or power various devices or to aüow charging or powering of devices or batteries placed anywhere on the pad. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it ɒ a mobile battery, or other device. The receiver can comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it ɒ produce a direct current (DC) voltage, which is then used to charge or power the device or battery.

[0091] In some embodiments the receiver can also comprise eiectronic components or iogic to set the voltage and current to the appropriate levels required by the mobile device or battery. in some embodiments, the receiver can also contain circuitry to sense and determine the status of the electronic device or battery to be charged, the battery inside a device, or a variety of other parameters and to communicate this information to the pad. In additional embodiments, the system can provide for additional functionality such as communtcatton of data stored in the electronic device (for example, digital images stored in cameras, telephone numbers in ceil phones, songs in MP3 piayers) or data into the device.

[0092] Embodiments can also incorporate efficiency measures that improve the efficiency of power transfer between the charger or power supply and the receiver, and ultimately to the mobile device or battery. In accordance with an embodiment, the charger or power supply comprises a switch, (for example, a MOSFET device or another switching mechanism), that is switched at an appropriate frequency to generate an alternative current (AC) voltage across a primary coil, and generates an AC magnetic field. This field in turn generates a voltage in the coil in the receiver that is rectified and then smoothed by a capacitor to provide power to a ioad, with the result being greater efficiency.

[0093] In accordance with other embodiments the coils are mounted such that they can move laterally within the pad and within an area of their segments, while continuing to be connected to their driver electronics placed on the edges of the area. The floating coils and the drive circuit are sandwiched in between thin upper and lower cover layers that act to

allow the coils lateral movement white limiting vertical movement. When a receiver is placed on the pad, the pad senses the position of the receiver coil and moves the coils to the right position to optimize power transfer. Magnets can be used to better orient the coils and improve greater power transfer efficiency.

[0094] Additional embodiments are also described herein. For example, in accordance with an embodiment the charging/power supply device includes an internal battery for self-powered operation, In accordance with other embodiments the charging/power supply device can include a solar cell power source, hand crank, or other means of power supply for occasional self powered operation. Other embodiments can be incorporated into charging kiosks, automobiles, computer cases, and other electronic devices and applications.

Inductive Charging System

[0095] While the above mentioned technologies describe various aspects of inductive charging, they do not address the basic requirements that a consumer and manufacturer desire in such a product. These include the foüœwing desired features:

- The pad should be able to charge or power a number of devices or batteries with various power requirements efficiently. A typical number may be one to six or even 12 or moredevices or batteries, including four or more Sow power (up to 5 W) devices or batteries simultaneously. When multiple devices or batteries are being charged, a method for energizing only those coils near a device or battery is preferable.
- The same pad should be able to power low-power devices (mobile phones, PDAs, cameras, game consoles, etc.) or batteries with power requirements of 5 W or less, and higher-power devices such as notebook computers (which often have a power requirement of 60 W or higher) or high power batteries.
- The power transfer efficiency between the primary coil and the receiver should be maximized. Lack of efficiency in the power transfer would necessitate larger and heavier AC to DC power supplies. This would add cost and decrease product attractiveness to customers. Thus methods where the entire pad is energized are not as attractive.
- A simple method for verification of the manufacturer of the receiver, and possibly information for power requirements, should be supported as necessary to ensure product compatibility and to provide means of product registration and licensing.
- The EM! radiation from the system should be minimized, and ideally, the system should radiate little or no EM! with no device present. A charger should preferably not emit any power until an appropriate device or battery is brought close b the charger or power supply itseif. In this way, electric power is not wasted, and electromagnetic power is not

emitted needlessly. In addition, accidental effects on magnetically sensitive devices such as credit cards, disk drives and such are minimized.

- The pad and the receiver should be reasonably simple to construct, and cost effective. Since both parts can be integrated into mobile devices or batteries, the overall size, weight, and form factor should be minimized.

[0096] As used herein, the term "charger" can refer to a device for supplying power to a mobile or stationary device for the purpose of either charging its battery, operating the device at that moment in time, or both. For example, as is common in portable computers, the power supply can operate the portable computer, or charge its battery, or accomplish both tasks simultaneously. The charger may include circuitry for driving a coil appropriately to generate an AC magnetic fteid, power or current sense or regulation circuitry, microcontrollers, and means of communication with a receiver, battery, or device. It may also be able to communicate data with a device or battery or perform other functions. As used herein, the term 'receiver' means an inductive coil or coils and the circuitry for rectiffcation and smoothing of received current, any possible control or communication circuitry for communication with the charger and regulation of power and any possible circuit for managing charging or measurement of status of a battery or a device to be charged or powered such as a charge management circuit, fuel gauge, current, voltage, or temperature sensor, etc. The receiver can also incorporate appropriate circuitry for data transfer between a device or battery and the charger. In accordance with an embodiment, the mobile device charger and/or power supply can have any suitable configuration, such as the configuration of a flat pad. The power received by the mobile device from the mobile device charger/power supply (such as the primary in the mobile device charger) can be rectified in the receiver and smoothed by a capacitor before being connected to the rechargeable battery which is represented by the load in the figures. To ensure proper charging of the battery, a regulator or charge management circuit can be placed between the output of the output of the rectifier/capacitor stage and the battery. This regulator or charge management circuit can sense the appropriate parameters of the battery (voltage, current, capacity), and regulate the current drawn from the receiver appropriately. The battery can contain a chip with information regarding its characteristics that can be read out by the regulator or charge management circuit. Alternatively, such information can be stored in the regulator or charge management circuit for the mobile device to be charged, and an appropriate charging profile can also be programmed into the regulator or charge management circuit.

[0097] Figure 1 shows a pad using multiple receiver/eπergizer coils in accordance with an embodiment. In its simplest format, the mobile device or battery charger or power supply preferably has a substantially flat configuration, such as the configuration of a pad

100, and comprises multiple coils or sets of wires 104. These coils or wires can be the same size as or larger than the coils or wires in the mobile devices, or battery and can have simiiar or different shapes, including for example a spiral shape. For example, for a mobile device charger or power suppiy designed to charge or provide power to up to four mobile devices of simiiar power (up to 10 W each) such as mobile phones, MP3 players, batteries, etc, four or more of the coils or wires will ideally be present in the mobile device or battery charger. The charger or power supply pad can be powered by plugging into a power source such as a wall socket or itseif be powered or charged inductively. The pad can also be powered by another eiectronic device, such as the pad being powered through the USB outlet of a laptop or by the connector that laptops have at the bottom for interfacing with docking stations, or powering other devices. The pad can also be incorporated into a docking station, such as may be used by notebook computers or built into a table or other surface.

[0098] In accordance with an embodiment, a mobile device can include a receiver that includes one or more coils or wires to receive the power from the mobile device charger or power supply. As described in further detail below, the receiver can be made part of the battery in the mobile device or of the shell of the mobile device. When it is part of the mobile device shell, the receiver can be part of the inside surface of the mobile device shell or of the outside surface of the mobile device shell. The receiver can be connected to the power input jack of the mobile device or can bypass the input jack and be directly connected to the battery or charge management circuit inside the mobile device. In any of these configurations, the receiver includes one or more appropriate coil or wire geometries that can receive power from the mobile device charger or power suppiy when it is placed adjacent to the mobile device charger or power supply. In accordance with an embodiment, the coils in the mobile device charger or power suppiy and/or the coils in the mobile devices or battery can be printed circuit board (PCB) coils, and the PCB coils can be placed in one or more layers of PCB.

[0099] In some embodiments, the charger or power supply can also itself be built into a mobile device or battery. For example, a laptop computer or other portable or mobile device can incorporate a charger or power supply section so that other mobile devices can be charged or powered as described above. Alternatively, using the same set of coils or wires, or a separate set of coils or wires, any mobile device or battery can itself be used as an inductive charger or power suppiy to power or charge other mobile devices or batteries.

[00100] In accordance with an embodiment, the mobile device charger/power supply or pad, and the various mobile devices or batteries, can communicate with each other to transfer data. In one embodiment, the coils in the mobile device charger/ power suppiy that are used for powering or charging the mobile device, or another set of coils in the same PCB

layer or in a separate layer, can be used for data transfer between the mobile device charger/power supply and the mobile device to be charged or powered or the battery directly. Techniques employed in radio and network communication, such as radio frequency identification (RFID), Bluetooth, WiFi, Wireless US8 ; or others can be used, In one embodiment a chip connected to an antenna {for example, the receiver coil or separate data antenna) or another means of transfer of information can be used to provide information about, for example, the presence of the mobile device or battery, its authenticity (for example its manufacturer code) and the devices' charging/power requirements (such as its required voltage, battery capacity, and charge algorithm profile).

[00101] In accordance with an embodiment, a typical sequence for charger/power supply operation is as follows:

- The mobile device charger or power supply can be in a low power status normally, thus minimizing power usage,
- Periodically, each of the coils (or a separate data coil in another PCB layer) is powered up in rotation with a short signal such as a short radiofrequency (RF) signal that can activate a signal receiver in the receiver such as an RF ID tag or a circuitry connected to the receiver coil.
- The mobile device charger/power supply then tries to identify a return signal from any mobile device, battery (or any receiver) that may be nearby.
- Once a mobile device, or battery (or a receiver) is detected, the mobile device charger or power supply and the mobile device or battery to proceed to exchange information.
- This information can inciude a unique ID code that can verify the authenticity and manufacturer of the charger or power supply and mobile device or battery, the voltage requirements of the battery or the mobile device, and the capacity of the battery. For security purposes or to avoid counterfeit device or pad manufacture, such information can be encrypted, as is common in some RFiD tags or other verification systems.

[00102] In accordance with various embodiments, other protocols such as Near Field Communications (NFC) or Felica can be used, wherein the circuitry containing the ID and the necessary information is powered either by the mobile device or battery or remotely by the mobile device charger or power supply. Depending on the particular implementation needs, Bluetooth, WSFi, Wireless USB, and other information transfer processes can be used. Additional information regarding the charging profile for the battery can also be exchanged and can include parameters that are used in a pre-programmed charge profile stored in the mobile device or battery charger. However, the information exchanged can be as simple as an acknowledge signal that shows the mobile device charger that a mobile device or

rechargeable battery is present. The charger or power supply can also contain means for detection and comparison of the strength of the signal over different locations on the charger or power supply. fn this way, it can determine the location of the mobile device or battery on the charger or power supply, and then proceed to activate the appropriate region for charging or powering,

[00103] In some embodiments that require greater simplicity, no communication need take place between the mobile device charger or power supply and the mobiie device or battery. In some embodiments the mobile device charger or power supply can sense the mobile device or battery by detecting a change in the conditions of a resonant circuit in the mobile device charger or power supply when the mobile device or battery is brought nearby. In other embodiments the mobile device or battery can be sensed by means of a number of proximity sensors such as capacitance, weight, magnetic, optical, or other sensors that determine the presence of a mobile device or battery near a coil in the mobile device or battery charger or power supply. Once a mobile device or battery is sensed near a primary coil or section of the mobile device or battery charger or power supply, the mobile device charger or power supply can then activate that primary coiS or section to provide power b the receiver coil in the mobile device's battery, shell, receiver module, battery, or the device itself.

Inductive Charging Circuit

[00104] Each mobile device and its battery has particular characteristics (voltage, capacity, etc). Sn order to facilitate these different devices or batteries with a single universal mobiie device charger or power supply, several circuit architectures are possible, some of which &r& described in further detail below.

[0010S] **Figure 2** shows the main components of a typical inductive power transfer system 110. The circuit illustrated is used to illustrate the principle of inductive power transfer and is not meant to be limiting to an embodiment. in accordance with an embodiment, the charger 112 comprises a power source 118, and a switch T 126 (which can be a MOSFET or other switching mechanism) that is switched at an appropriate frequency to generate an AC voltage across the primary coil Lp 116 and generate an AC magnetic field. This field in turn generates a voltage in the coil 120 in the receiver 114 that is rectified and then smoothed by a capacitor to provide power 122 to a load Ri 124. For ease of use, a receiver can be integrated with a mobile device, such as integrated inside the mobile device or attached to the surface of the mobile device during manufacture, to enable the device to receive power inductively from a mobile device charger or integrated into, or on its battery.

[00106] In accordance with an embodiment, the circuit shown in **Figure** 2 can receive energy fed to it from a power source, store the energy alternately in the inductor and the timing capacitor (much like a tank stores liquid), and subsequently produce an output as a continuous alternating current (AC) wave. As the voltage is applied to the primary side, the tank circuit supplies the energy to the receiver. One of the benefits of such a design is that the timing capacitor in the circuit can be easily replaced. For example, if a relatively higher value for capacitance (referred to in some instances as a timing capacitance) is used, then the frequency of operation is lowered. This increases the on-time for the circuit, and provides longer power transfer and current through the transformer, and thus more power. As such a higher vaiue of capacitance can be used for high power applications. Conversely, if a relatively lower value for capacitance is used, then the frequency of operation is increased. This reduces the on-time and provides less power transfer and current through the transformer, and thus less power. Thus, a Sower value of capacitance can be used for low power applications. Replacing the timing capacitance can be easily handled during manufacturing to tune the power requirement on a macro level, i.e. to get the output into an appropriate range for the chosen application. Additional techniques can then be used to set the voltage output on a more accurate basis.

[00107] The mobile device or its battery typically can include additional rectifier(s) and capacitor(s) to change the AC induced voltage to a DC voitage. This is then fed to a regulator/charge management chip which includes the appropriate information for the battery and/ or the mobile device. The mobile device charger provides power and the regulation is provided by the mobile device. The mobile device or battery charger or power supply, after exchanging information with the mobile device or battery, determines the appropriate charging/powering conditions to the mobile device. It then proceeds to power the mobile device with the appropriate parameters required. For example, to set the mobile device voltage to the right value required, the value of the voltage to the mobile device charger can be set. Alternatively, the duty cycle of the charger switching circuit or its frequency can be changed to modify the voitage in the mobile device or battery. Alternatively, a combination of the above two approaches can be followed, wherein regulation is partially provided by the charger or power supply, and partially by the circuitry in the receiver.

Inductive Charger Pad

[00108] To allow the operation of the mobile device or battery charger or power supply regardless of position of the mobile device or battery, the total area of the mobile device or battery charger or power supply can be covered by coils or by another wire geometry that creates magnetic field.

[00109] Figure 3 shows a charging pad using multiple coils in accordance with an embodiment. As shown in Figure 3, in accordance with an embodiment the pad 140 is largely covered with individual receiver coils 144.

[00110] Figure **4** shows a charging pad using multiple overiapping coil layers in accordance with an embodiment. This embodiment addresses the problem of voids between the multiple coils. As shown in Figure 4, any areas of the pad 150 with minimal magnetic field between a first set of coils 152 can be filled by a second set of coils 154, so that the coils are tiled such that the centers of this coil array fill the voids in the primary set. This second set can be at a different layer of the same PCB, or in a different PCB. In each of these geometries, the sensing circuitry can probe each location of a coil in a raster, predetermined, or random fashion. Once a mobile device or battery on or near a coil is detected, that coil is activated to provide power to the receiving unit receiver of the appropriate device.

£00111] It can be seen from the above example that by providing more layers of the PCB with coils, or by providing coils of different geometry or size, one can obtain as much resolution or coverage as desired.

[00112] In accordance with an embodiment, to power mobile devices or batteries with power requirements that exceed maximum powers attainable by typical coils in a surface, the mobile device or battery, during its hand shake and verification process can indicate its power/voltage requirements to the mobile device or battery charger or power supply. Several geometries for achieving power/voltage levels otherwise not attainabSe from a single primary coil of the mobile device or battery charger or power supply are possible.

[00113] In accordance with one embodiment of the system geometry, the power receiving unit of the mobile device or battery has several coils or receiving units that are connected such that the power from several primary coils or sets of wires of the mobile device or battery charger or power supply can add to produce a higher total power. For example, if each primary coil is capable of **outputiting** a maximum of 10 Watts, by using six primary coils and six receiver coils, a total output power of 60 Watts can be achieved. The number of primary and receiver coils need not be the same, and a large receiver coil (receiving unit) that is abie to capture the majority of magnetic flux produced by 6 or other number of primary coils or a large primary coil powering six or another number of receiver coils can achieve the same effect. The size and shape of the multiple primary coils and receiver coils also do not *need* to be the same. Furthermore, neither set of primary and receiver coils need to be in the same plane or PCB layer. For example, the primary coils in the examples shown above can be dispersed such that some lay on one PCB plane and the others in another plane.

[00114] In accordance with another geometry, the PCB of the mobile device or battery charger or power supply has multiple layers, wherein coiis or wire patterns of certain size and power range can be printed on one or more layers and other layers can contain coiis or wire patterns of larger or smaller size and power capability, In this way, for example, for iow power devices, a primary from one of the layers will provide power to the mobile device or battery, if a device or battery with higher power requirements is placed on the pad, the mobiie device or battery charger or power supply can detect its power requirements and activate a larger coil or wire pattern with higher power capabilities or a coil or wire pattern that is connected to higher power circuitry. One may also achieve similar results by using a combination of the different processes and geometries described above.

[00115] Figure **5** shows the use of multiple coil types and sizes in overlapping pad layers in accordance with an embodiment. As shown in **Figure** 5, the mobile device or battery charger or power supply or pad 160 can comprise two overiapping layers with a first layer 162 containing low power coils, and a second layer 164 containing high power coils.

Jnductive Charging Receiver

[00116] As described above, the inductive charging or power suppiy pad is used to power a receiver, which in turn is used to power or to charge a portable or mobile device or battery. in accordance with one embodiment of the receiver, the power from the mobile device or battery charger or power supply is emitted at a magnitude that is sufficient to power any foreseeable mobile device or battery (such as 5 W or 10 W for small mobile devices or batteries). The receiver that is appropriate for each mobile device or battery has a power receiving part that when matched to the mobile device or battery charger or power supply is able to receive sufficient power for the mobiie device or battery. For example a receiver for a mobile phone requiring 2.5 W can be a coil with certain diameter, number of turns, wire width, etc. to allow receipt of the appropriate power. The power is rectified, filtered, and then fed into the battery or power Jack of the device. As discussed above, a regulator or charge management circuit can be used before the power is provided to the battery or the mobile device.

[00117] To save energy, the power emitted by the mobiie device or battery charger or power suppiy can be regulated. It is desirable to regulate the power emitted by the charger or power supply because if the charger or power supply is emitting 10 W of power and the receiver is designed to receive 5 W. the rest of the emitted power is wasted, In one embodiment, the receiver or the mobile device can, through an electrical (such as RF), mechanicai, or optica! method, inform the charger or power supply about the voltage/current characteristics of the device or battery. The primary of the charger or power supply in the

circuit diagrams shown above then can be driven to create the appropriate voltage/current in the receiver. For exampie, the duty cycle of the switch in that circuit can be programmed with a microprocessor to be changed to provide the appropriate levels in the receiver.

[00118] In accordance with an embodiment, the programming can be performed by a look up table in a memory location connected to a microprocessor or by using an algorithm pre-programmed into the microprocessor. Alternatively, the frequency of the switch can be changed to move the circuit into, and out of, resonance to create the appropriate voltage in the receiver. In an alternate geometry, the voltage into the circuitry in the primary can be changed to vary the voltage output from the receiver. Furthermore, the induced voltage/current in the mobile device can be sensed and communicated to the charger to form a closed-loop, and the duty cycle, frequency, and/or voltage of the switch can be adjusted to achieve the desired voltage/current in the mobile device.

[00119] In accordance with an embodiment, the receiver is built onto or into the battery for the mobile device. The receiver can include one or more coils or wires shaped to receive power from the charger or power supply. The one or more coils or wires can be either printed on one or more PCBs, or formed from regular wires. As described above, the receiver can also contain rectifier(s) and capacitor(s) to produce a cleaner DC voltage. This output can be directly, or through a current limiting resistor, connected to one of the contacts on the battery. To avoid overcharging the battery, a battery regulator or charge management chip can also be used. This circuit then measures the various parameters of the battery (voltage, degree of charging, temperature, etc.) and uses an internal program to regulate the power drawn from the circuit to ensure over-charging does not occur. The circuit can also include LEDs to show the receiver being in the presence of a magnetic field from the charger, complete charge LEDs and/or audible signals.

[00120] In typical commercial and end-user applications, such as in ceil phones, PDAs, and MP3 players, the battery can be incorporated into the battery pack or the device by the original equipment manufacturer (OEM), or as an after-market size and shape compatible battery pack that can replace the original battery pack. The battery compartment in these applications is typically at the bottom of the device. The user can open the battery compartment, take out the conventional battery, replace it with a modified battery in accordance with an embodiment, and then replace the battery lid. The battery can then be charged inductively when the mobile device is placed adjacent a mobile device charger.

[00121] To enhance the ability of the receiver to receive power, it may be desirable to minimize the distance between the charger's primary coil and the receiver's coil or wire. In order to achieve this, in accordance with an embodiment the receiver's coil or wire can be put on the outside of the battery pack.

[00122] Figure 6 shows a battery with an integrated receiver in accordance with an embodiment. As shown in Figure 6, the receiver 170 comprises the battery 182, together with the receiver coil 172, and any rectifiers 174, capacitors 178, regulators or charge management chips 180 necessary for proper operation of the charging receiver, if the battery compartment Sid of the device prevents a power receiving light emitting diode (LED) to be seen, the lid can itself be repiaced with a see-through Sid or a lid with a Sight pipe that will aSSow the user to see the charging indicator LED when the mobiie device is piaced adjacent to the charger.

[00123] In an alternative embodiment, the receiver battery can include a mechanical, magnetic, or optical method of alignment of the coils or wires of the charger and mobile device for optimum power transfer. In accordance with an embodiment, the center of the primary in the charger contains a magnet such as a cyiinder or disk or ring with the poies para‖ei to the charger surface and the magnetic field perpendicular to the charger surface. The receiver aiso contains a magnet or magnetic metal part of a similar or different shape behind or in front of the coil or wire receivers. When the mobile device or battery is placed on or adjacent to the charger or power supply, the magnets attract and pull the two parts into alignment with the centers of the two coils or wires aligned. The magnets do not need to be especiaily strong to actively do this. Weaker magnets can provide guidance to the user's hand and largely achieve the intended results. Alternatively, audible, or visual signs (for exam pie an LED that gets brighter as the parts are cioser aiigned), or mechanical means (dimples, protrusions, etc.) can be used for alignment.

[00124] In accordance with another embodiment, the coil or wires and the magnet in the charger or power supply *are* mechanicaiiy attached to the body of the charger or power supply such that the coil can move to aügn itself appropriateiy with the mobile device or battery when it is brought into close proximity to the charger or power supply. In this way, an automatic alignment of coils or wire patterns can be achieved.

[0012S] In another embodiment, the receiver electronics described above are preferably made from flexible PCB which can be formed into a curved shape. Such a PCS can be placed on the surface of a battery pack, including one that is not flat, or that has a curved shape. The curve on the battery or back of a mobile device battery lid can be matched to a curved primary in the mobile device or battery charger or power supply and be used for alignment. One example of usage of this embodiment can be for example flashlights that have circular handles: the batteries can be charged with coils on the side of circular batteries, or circling the cylindrical battery. Similarly, the mobile device or battery charger or power supply can have a curved shape. For example, the charger or power suppiy surface can be in the shape of a bowl or some similar object. A mobile device or battery that

may have a fiat or curved back can be placed info the bowl. The shape of the bowl can be made to ensure that the coil of the mobile device or battery is aligned with a primary coil to receive power.

[00126] In another embodiment, the primary can be incorporated into a shape such as a cup. A mobiie device can be placed into the cup standing on end and the receiver can be built-in to the end of the mobile device (such as a mobile phone) or battery or on the back or circumference of the device or battery. The receiver can receive power from the bottom or wall of the cup.

[00127] In another embodiment, the primary of the charger can have a flat shape and the mobile devices or battery can be stood up to receive power. The receiver is built into the end of the device or battery in this case and a stand or some mechanical means can be incorporated to hold the device or battery while being charged.

[00128] In another embodiment, the charger or power supply can be made to be mounted on a waii or a similar surface, vertically or at an angle (such as on a surface in a car), so as to save space. The charger or power supply can incorporate physical features, magnets, fasteners or the like to enable attachment or holding of mobiie devices to be charged. The devices or batteries to be charged or powered can also incorporate a retainer, magnet, or physica! shape to enable them to stay on the charger or power supply in a vertical slanted, or some other position. In this way, the device or battery can be charged or powered by the primary while it is near or on it.

[00129] For those applications where the iid of the battery compartment or the bottom part of the mobile device is made from a metal, a replacement non-metallic lid or backing can be used. Alternatively, the coii can be attached to the outside of the metal surface. This allows electromagnetic (EM) fields to arrive at the power receiver coil or wires. The rest of the receiver (i.e. circuitry) can be placed behind a metal for the receiver to work. In some other applications where the battery has metal parts, these parts may interfere with the EM field and the operation of the coil in the receiver. In these cases, it may be desirable to provide a distance between the metai in the battery and the coils. This can be done with a thicker PCB or battery top surface. Alternatively, to provide additional immunity, ferrite material (such as those provided by Fβrrishieid Inc.) can be used between the receiver and the battery to shield the battery or device from the Elvl fields. These materials can be made so as to be thin, and then used during the construction of the integrated battery/receiver.

[00130] In accordance with another embodiment, the receiver in the battery or mobile device also includes a means for providing information regarding battery manufacturer, required voltage, capacity; current, charge status, serial number, temperature, etc. to the charger. In a simplified embodiment, only the manufacturer, required voltage, and/or seria!

number is transmitted. This information is used by the charger or power supply to adjust the primary to provide the correct charge or power conditions. The regulator or charge management chip in the receiver can then regulate the current and the load to charge the battery correctly and can end charge at the end. In another embodiment, the receiver can control the charging process fuify depending on the time dependent information on battery status provided to it. Alternatively, the charging process can be controlled by the charger in a similar manner, As described above, the information exchange between the charger and the receiver can be through an RF link or an optica! transmitter/ detector, RFID techniques, Near-Field Communication (NFC), Feiica, Bluetooth, WFi, or some other method of information transfer. Similarly, the receiver can send signals that can be used by the charger to determine the location of the receiver to determine which coil or section of the charger or power supply to activate. The communication link can also use the same coil or wires as antenna for data transfer or use a separate antenna. In some embodiments the received can use the actual capabilities of the mobile device (for example, the built-in Bluetooth or NFC capabilities of mobile phones) to communicated with the charging or power supply pad.

[00131] As described above, in accordance with some embodiments the receiver can be integrated into the body of the device or battery itself at a location that may be appropriate and can be exposed to Elvl radiation from outside. The output of the receiver can be routed to the electrodes of the battery internally inside the device and appropriate circuitry inside the device can sense and regulate the power. The device can include LEDs, messages, etc, or audible signs that indicate to the user that charging is occurring or complete or indicate the strength of the received power (i.e. alignment with a primary in the charger) or the degree of battery charge. In other embodiments, the receiver is built into an inner or outer surface of a component that is a part of the mobile device or battery's outer surface where it is ciosest to the charger. This can be done as original equipment or as an after-market item. The component can be the lid of the battery pack or the bottom cover of the mobile device. In yet other embodiments, the receiver can be integrated into the back or front of the battery compartment or an interchangeable shell for the mobile device for use in after-market applications. For example, in a mobile phone application, the back battery cover or shell can be removed and replaced with the new shell or battery cover with the receiver built in.

[00132] Figure 7 shows a coupling of receiver with a device to be charged or powered in accordance with an embodiment. As shown in Figure 7, the original mobile phone setup 190 includes a device 192 with sheii 194 and power jack 196. The after-market modification 200 replaces the original shell with a combination shell 210 that includes the necessary receiver coiis and battery couplings. The contacts from this circuitry can then make direct contact to the battery electrodes inside the mobile device or to some contact points inside the

mobile device if such contacts exist or become provisioned by the device manufacturer during manufacture. Alternatively, the receiver may be a component (such as a shell) that has a connector that plugs into the input power jack of the mobile phone or electrodes of a battery. The receiver can be fixed to, or detachable from, the mobile device or battery. This can be achieved by having a plug that is attached either rigidly or by a wire to the receiver (shell). Alternatively, the replacement receiver (shei!) can be Sargβr than the original sheSl and extend back further than the original shell and contain the plug so that when the receiver (shell) is attached, simultaneously, contact to the input power jack is made. Alternatively, the receiver (shell) can have a pass-through plug so that while contact is made to this input power connector, the connector allows for an external regular power supply plug to be also used as *&n* alternative. Alternatively, instead of a pass-through, this part can include a power jack in another location in the back so that a regular power supply can be used to charge the battery. In cases where the connector to the device performs other functions such as communication to the device, a pass-through connector can allow communication/ connectivity to the device.

[00133] In accordance with another embodiment, the replacement receiver (i.e. the replacement shell) or the plug in unit, in addition to the power receiver components and circuitry, can include additional circuitry that can provide further functionalities to the mobile device. These can include, for example, the ability to exchange data through Bluetooth, WSFi, NFC, Felica, vViMax, RFID, or another wireless or optical mechanism, it can also provide extended functionalities such as Globai Positioning System (GPS) location information, flashing lights, flashlight, or other decorative or electronic functions. As described above, various methods for improving coil alignment, or location, battery manufacturer, or battery condition information transfer can also be integrated into the receiver or replacement shell.

[00134] In another embodiment, the receiver is supplied in the form of a separate unit that is attached to the input jack of the mobile device or battery or integrated into a receiver protective skin for the mobile device. Many leather or plastic covers for mobile phones, cameras, and MP3 players already exist. The primary purpose of these covers is to protect the device from mechanical scratches, shocks, and impact during daily use. However, they typically have a mere decorative or advertising application, in accordance with one embodiment, the receiver is formed of a thin PCB with the electronics formed thereon, and the receiver coil or wire that is attached to the back of the device and plugs into the input jack similar to the shell described above. Alternatively, it can be connected through a flexible wire or flexible circuit board that is routed to a plug for the input power jack.

[00135] In accordance with another embodiment, the receiver can be a separate part that gets plugged into the input jack during charging and is piaced on the charger and can then be unplugged after charging is finished.

[00136] In another embodiment, the receiver is built in the inside or outside surface or in between two iayers of a plastic, leather, silicone, or cloth cover for the mobile device and piugs in or makes contact to the contact points on the device.

[00137] It will be noted that certain devices such as notebooks and some music piayers have metal bottom surfaces. The methods described above for changing the back surface or use of a plug in the mobile device or a secondary skin with an integrated receiver is particularly useful for these applications. As described previously, the effect of the metal surface can aiso be minimized, if necessary, by increasing the distance between the wires of the receiver and the metal surface or by placing a ferrite layer in between the receiver and the metal bottom.

[00128] It is aiso noted that the use of methods such as curving the receiver or integrating magnets, LEDs, audio signals or messages, etc. for alignment, or methods for location, manufacturer or charging condition identification, as described above are possible with ail embodiments of an embodiment described above. In any of the above cases, the charger or power supply can contain lights, LEDs, displays, or audio signals or messages to help guide the user to piace the mobile device or battery on a primary coil for maximum reception, to show charging is occurring, and to show the device is fully charged. Displays to show how full the battery is or other information can also be incorporated.

Ftextble/Modufar Charging Pad

[00129] In accordance with an embodiment a flexible mobile device charger or power supply is provided in the shape of a pad that can be folded or rolled up for carrying, in one impiementation of an embodiment, the eiectronics of the charger or power supply are placed on a thin flexible PCB or the coils are made of wires that can be rolled up or shaped. The electronics components made of silicon chips, capacitors, resistors and the like may not be flexible but take up very iittie space. These rigid components can be mounted on a flexible or rigid circuit board, while the main section of the pad containing the coils or wires for energy transfer can be made to be flexible to allow conformity to a surface or to be roiled up. Thus the pad resembles a thin mouse pad or the like.

[00130] In some cases, it may be advantageous to the user to have a mobile device charger or power supply that is extendibie in functionalities. The cases include but are not limited to:

- A user may purchase a mobile device or battery charger or power supply for charging or

powering a single low power device or battery but, at a later stage, may want to extend the capability to charge or power more devices or batteries simultaneousiy.

- A user may purchase a mobile device or battery charger or power supply for charging or supplying power to one or more low power devices or batteries but may want to charge or supply power to more low power or high power devices or batteries.
- A user may buy a mobile device or battery charger or power supply that can charge or supply power to one or more low-power or high-power devices or batteries and later wish to have the communication or local storage, or a rechargeable battery, or means of power generation such as solar panels or some other capability, added to the charger or power supply.

[00131] In all of the cases above and others, it can be useful to have a modular approach to expand the capabilities of the mobile device or battery charger or power supply.

[00132] Figure 8 shows a pad 220 in accordance with an embodiment that allows for modular or multiple connectivity. In this case, the user can purchase a first unit 222 that is powered by an electric outlet 224. However, interconnects 226 for power and data are provided so that additional units 228, 230 can simply fit or plug into this first one directly or indirectly and expand the capabilities as the customer's needs grow. Data communications and storage units 234 can also be attached in a modular fashion. This approach would enable the customer to use the technology at a low cost entry point and grow his/her capabilities over time.

[00133] Some of the electronics devices that can benefit from these methods include: mobile phones, cordless phones, personal data assistants (PDAs), pagers, walkie-talkies, other mobile communication devices, mobile electronic mail devices. Blackberry's, MP3 players, CD players, DVD players, game consoles, headsets, Bluetooth headsets, hearing aids, head-mounted displays, GPS units, flashlights, watches, cassette players, laptops, electronic address books, handheld scanning devices, toys, electronic books, still cameras, video cameras, film cameras, portable printers, portable projection systems, IR viewers, underwater cameras or any waterproof device, toothbrushes, shavers, medical equipment, scientific equipment, dental equipment, military equipment, coffee mugs, kitchen appliances, cooking pots and pans, lamps or any battery, DC, or AC operated device.

[00134] In addition, inductive power transfer can provide power to devices that are not so far battery operated. For example, a mobile device charger or power supply in the shape of a pad placed on a desk or a kitchen table can be used to power lamps or kitchen appliances. In one embodiment for the use in a kitchen, a flat charger, or power supply such as a pad, placed on or built into a counter can allow the chef to place devices on the charger or power supply to be inductively charged or powered during use and simply place them

away after use. The devices can be, for example, a blender, mixer, can opener, or even pot, pan, or heater. This can eliminate the need for a separate cooking and work area. It will be noted that placement of a metal pan close to the inductive pad can directly heat the pan and the contents while keeping the charger or power supply surface cool. Due to this reason, inductive kitchen ranges have been commercialized and shown to be more efficient than the electric ranges that work by resistive heating of a coil.

[00135] In another embodiment, rather than direct heating of metal pans by nearby inductive fields, cooking pans may include a receiver and heating or even cooling elements. Once placed on a charger, the pan wiil heat up or cool down as desired by a dial or the like on the pan allowing precise temperature control of the pan and the contents,

[00136] Similarly, in an office or work area setting, if a charger or power supply is readily available for charging or powering mobile devices or batteries, if can also be used to power up lamps for illumination of the desk or used to power or charge office appliances, such as fax machines, staplers, copiers, scanners, telephones, and computers. In one embodiment, the receiver can be built into the bottom of a table lamp and the received power is used to power the incandescent or LED lamp.

[00137] In another embodiment, a mug, cup, glass, or other eating appliance such as a plate can be fitted with a receiver at its bottom. The received power can be used to heat the mug, etc. with a heating coil thus keeping beverages or food warm to any degree desired. Furthermore, in accordance with an embodiment, by use of devices such as thermoelectric coolers the contents can be cooled or heated as desired.

[00138] Similarly, many children's toys often run out of battery power due to extended use or simple forgetfulness to turn the device off. Often these batteries are included inside a battery compartment that for safety reasons can only be opened by a screwdriver. Inclusion of the receiver into toys or batteries inside can reduce the need to change the device batteries and allow recharging with a much simpler method.

[00139] In another implementation, the receiver can be built into medical devices or their batteries that are implanted or inserted in the body. Since batteries in these devices such as pace makers, cochlear implants, hearing aids, or other monitoring devices may need periodic charging, inductive power transfer can provide an ideal non-contact method for charging and testing the performance of the devices (i.e. check up) or downloading data that the devices have logged.

[00140] In another implementation, some active RFID tags include batteries that can send out information about the status or location of a package or shipment. An inexpensive method for charging these tags is to include a receiver with each tag. Thus, a charger can be used to power or charge these RFID tags.

[00141] It will be noted that the effective working distance of the inductive charger is dependent on the power and the frequency of the source and the size and geometry of the coil. By increasing the frequency to several or tens of MHz, one can obtain a working distance of several inches or feet depending on the application for the technology, it will also be noted that any of the above embodiments that eliminate the input power jack are especiaiiy important because they add to product reliabiiity by removing a source of mechanicai or environmental failure. In addition, elimination of the jack is imperative for water proof appiications and for extra safety.

Efficiency Enhancements through Coi! Circuit

[00142] In accordance with an embodiment, in order for the power efficiency to be maximized and to minimize iosses in the coil, the coiis should be manufactured to have as low a resistance as possible. This can be achieved by use of more conductive materiai such as gold, silver, etc. However the costs of these materials are sometimes prohibitive. Sh practice, reduced resistivity can be obtained by using thicker copper-clad PCBs or wider tracks. Most common PCBs use 1-2 02 copper PCBs. in accordance with some embodiments the coii PCB used for the wireless charger can be made from PCBs clad with between 2 and 4, or even 6 oz copper. The process of manufacture of the PCB can also be optimized to achieve higher conductivity. For example, sputtered copper has a higher conductivity than rolled copper and is typically better for this appiication. In operation, the coil and the circuitry demonstrate a resonance at a frequency determined by the parameters of the design of the coil {for example, the number of windings, coii thickness, width, etc.). Previous work has concentrated on circuits driven by square waves with a MOSFET. This approach has the disadvantage that since a square wave is not a pure sinusoid, it produces harmonics. These harmonics are undesirable because;

- The PCB coii produces optimum power transfer efficiency at a particuiar frequency. The harmonics in the primary signal are not transferred as efficiently and decrease the overall system efficiency.
- The rapid voltage change in the leading and falling edge of the square wave creates osciiiations that create further harmonics resulting further EMI.
- The harmonics radiated by the primary create higher frequency components that contribute to the EMI that is more radiative (due to higher frequency). It is desirabie to limit the frequency range of the operation of the overall system to as Sow a frequency as possible while maintaining the other requirements of the system (such as sufficient working distance, etc.), so these harmonics must be avoided.
- At the instance of switch turn-on and turn-off, the change in the in-rush current to the

coil causes huge voltage swings across the coil for a short period of time. Ail the power is transferred to the receiver during these times that are short.

[00143] Previous attempts to achieve 90% transfer efficiency with PCB coil primary and receiver *have* used a laboratory power supply to drive thetr circuit. Whtie this approach has demonstrated the higher efficiency that can be achieved with a sinusoidal voltage on the coiL such power supplies are complex, costly, and too large to be able to be used for any practical charger application, sn accordance with an embodiment, a capacitor is added in paraiiei to the drain/source contacts of the MOSFET.

[00144] Figure 9 shows a figure of a circuit diagram 240 in accordance with an embodiment. The coil in the wireless charger system is driven by switching the FET at the resonance frequency of the circuit when the receiver is present. Without the receiver nearby, the circuit is detuned from resonance and radiates minimal EML The capacitor 244 acts as a reservoir of energy that discharges during switch off time and enhances energy transfer. As with the exampies described above, changing the value of the capacitance allows for tuning the power and efficiency levels on a lower-power/ high-power basis, and additional features and techniques can be used b fine tune the power output for particular devices.

[00145] The circuit designs illustrated in Figure 2 and Figure 9 use a zero-crossing power supply. Briefly, in a zero-crossing power supply, when the transistor in the primary coil is first turned on, electrical current passes through the primary coil and the transistor to ground. When the transistor is then turned off, the voltage level at the transistor swings high (for example, if the input voltage is 5V, then the voltage level may swing to 10V, or even 100V). A non-zero-crossing circuit allows the current to drop to zero, before the cycle is restarted. A forward mode circuit can then use an inductor in series with the load to revive the current and charge up the inductor, while a diode allows charging in both directions (when full phase AC is used),

[00146] In a traditional transformer design, zero-crossing is not used, since it invariably results in lower efficiency compared to non-zero designs, at least with higher power or ferrite cores. This is primarily because the traditional ferrite cores act as capacitors and store energy, which in turn reduces the circuit efficiency. As described above, in accordance with an embodiment, when a non ferrite coil there is no magnetic flux, so the efficiency is not affected to the same extent.

[00147] Furthermore, since the system does not use a ferrite or ferromagnetic core, the overall size and weight of the device can be reduced, in accordance with some embodiments the coil can be formed on a printed circuit board (PCB), with no heavy ferrite coils, no soldering and no wiring to the coils. in accordance with some embodiments there is

no need for a magnetic core in the secondary in the receiver. Since magnetic cores are usually iarge and heavy this results in considerable size savings.

[00148] By way of example, in accordance with an embodiment that uses an SRFR0220 chip as a FET and use 4 oz copper cotls with 9 turns and 1,25" diameter, the circuit in **Figure** 2 above, can be loaded with RL of 10 Ohm and tuned to operate at 1.3 MHz. With matching coils in the primary and secondary in the receiver, without capacitor C, totai circuit efficiency of the circuit inciuding the dock and FET driver circuit approaches 48%. Addition of a 1600 pF capacitor in parallel to the FET increases the total circuit efficiency to 75% (a better than 50% increase in efficiency), while simultaneously decreasing the voltage across the FET and also the harmonics in the circuit. The coil to coil transfer efficiency with the capacitor piaced in parallel with the FET is estimated to be approximately 90%. The advantages of this approach include:

- High efficiency (-90% coil to coil).
- Low ringing oscillation and EML
- Simplicity and low cost.
- Lower FET source-drain voltage swing allowing use of a larger selection of FETs.

[00149] In many applications, it is also desired that the pad and the receiver are arranged so that the pad does not emit power unless the receiver is nearby.

[00150] **Figure 10** and **Figure 11** show circuit diagrams in accordance with an embodiment. In addition to high efficiency, one method that is required for minimizing EMI and maintaining high overall efficiency is the ability to recognize the presence of a receiver nearby, and then turning on the pad only when appropriate. Two methods for this are described below.

[00151] As shown in **Figure 10,** in accordance with one embodiment, the pad circuit 260 incorporates a micro control unit (MCU1) 266 that can enable or disable the FET driver 268. The MCU1 receives input from another sensor mechanism that will provide information that it can then use to decide whether a device is nearby, what voltage the device requires, and/or to authenticate the device to be charged or powered.

[00152] One of the sensor mechanisms for this information are through the use of an RFID reader 280 that can detect an RFID tag of circuit and antenna in the receiver (i.e. device or battery to be charged or powered). The information on the tag can be detected to identify the voltage in the receiver required and to authenticate the circuit to be genuine or under license. The information on the tag can be encrypted to provide further security. Once a device or battery containing the tag is nearby the pad, the RFiD reader can be activated, can read the information on the tag memory, and compare with a table to determine authenticity/voltage required or other info. This information table can aiso reside on the

MCU 1 memory. Once the information is read and verified, the MCU 1 can enable the FET driver to start driving the coi! on the pad and to energize the receiver.

[00153] In another embodiment the MCU1 reiies on a dock 270 to periodically start the FET driver. The current through the FET driver is monitored through a current sensor 264. Severs! methods can be implemented with this implementation, including for example :.

- A small resistor can be placed in series with the FET to ground contact. The voltage across this resistor can be measured by a current sensor chip, such as a Linear Technology Current Sense Amplifier part number LT1787.
- A Hall sensor, such as a Sentron CSA- 1A, that measures the current from a wire running under it, can be placed on top of the PCB line from the FET to the ground to measure the current without any electrical connection to the circuit. The advantage of this approach is that no extra resistor in series with this portion of the circuit is necessary reducing the impedance.
- Other techniques may be used to measure the current.
- A Hal! sensor or a Reed switch can sense a magnetic field. If a small magnet is placed inside the receiver unit of the system, a Hail sensor or Reed switch can be used to sense presence of the magnet and can be used as a signal to start the FET.
- Other capacitance, optical, magnetic, or weight, etc. sensors can be incorporated to sense the presence of a secondary or receiver and to begin the energy transfer process.

[00154] Figure **11** shows a figure of a circuit diagram 290 in accordance with an embodiment. In accordance with an embodiment, the MCU1 can periodically start the FET driver. if there is a receiver nearby, it can power the circuit. The regulator 296, or another memory chip in the circuit can be programmed so that on power-up, it draws current in a pre-programmed manner. An example is the integration of an RFiD transponder chip in the path, such as ATMEL e5530 or another inexpensive microcontroller (shown here as MCU2 294), that upon power-up modulates the current in the receiver that can then be detected as current modulation in the primary. As with the previous example, other sensors, such as an RFID antenna 292 can also be used to provide positiona! and other information.

[00155] **Figure 12** shows a figure of a power transfer chart 300 in accordance with an embodiment, illustrating transferred power as a function of offset between coiSs.

Efficiency Enhancements in Coit Layout

[00156] An important aspect of power transfer efficiency relates to the alignment of coils with respect to each other.

[00157] Figure 13 and Figure **14** show figures of a coi! layout in accordance with an embodiment. If position independence is required, the pad PCS can be patterned with a coi!

pattern to cover the full area. Figure 13 shows a pad type charger or power supply 310 including a layer of coils 312 with minima! spacing 314 between the coils. Each coil has a center 316 associated with it. In accordance with an embodiment, the power transfer for a 1.25" diameter coil as the center of the receiver is offset from the center of primary. The power drops off to 25% of the maximum value when the two coils are offset by a coil radius, As described above, in order to better keep the coils aligned, use of magnets centered on the primary and the receiver coii can provide an automatic method of bringing the two parts into alignment.

[00158] In order to produce uniform fteids, a number of coiis around the receiver coil will typically need to be turned on to produce a field. However, with such a pattern, if a receiver coil is placed in between two primary coiis, the voltage is still not optimized. Research has shown that to obtain uniform fields, three layers of coil patterns offset with respect b each other are required.

[001 59] Figure 14 shows a pad-type charger 320 with two of the three layers 322, 324 required to achieve position independent magnetic field pattern. For a receiver placed at the center of the circle, ai! the coils nearby (in and around the circle 328) wii! need to be turned on to achieve a uniform field in the desired iocation 326. While this approach solves the offset issue and can be used b provide position independence, it does not produce high transfer efficiency. The reason is that ten or more coils have to be turned on near the receiver center to create the uniform field in that area, which in turn leads to inefficient power transfer.

Efficiency Enhancements through Independent Coil Movement

|00160] In accordance with some embodiments, techniques are included to provide high transfer efficiency while maintaining position independence,

[00161] Figure 15 shows a figure of a charging pad with multiple coils in accordance with an embodiment. The area of the pad 330 is divided into a plurality of, or multiple segments 332, that are bounded 336 by a wali or physical barrier, or simply some tethering means with no physical walls but that otherwise restrict movement b within the segment. The coiis 334 are mounted such that they can move laterally, or float, within the area of their segments while continuing to be connected b the drive electronics piaced on the edges of the area. In accordance with an embodiment, the floating coils and the drive circuit are sandwiched between thin upper and lower cover iayers that act to allow the coils lateral movement while limiting vertical movement. When a receiver coil is placed on the pad, the pad senses the position of the receiver coil and moves the coils to the right position to optimize power transfer.

[00162] Figure 16 shows a figure of a charging pad with movable coils in accordance with an embodiment. When the mobtie device, for exampie a eel! phone 340, or a battery is piacβd on the pad 330, the nearest coil moves 342 within its segment to better orient itseif with the mobtie device or battery, In accordance with one embodiment, the method used for achieving this is by attaching a magnet to the bottom center of each coil in the pad. A matching magnet at the center of the receiver coi! attracts the primary magnet nearby and centers it automatical ₅ with respect to the receiver cos!.

[00183] In accordance with an embodiment, each coii in this configuration can be suspended by the wires carrying power to the coil or by a separate wire/spring or by another mechanism so that each coi! can move freely in the plane of the pad while it can receive power from an individual or shared driving circuit. In order to facilitate movement, the surface of the coiis or the bottom surface of the top iayer for the base unit (the area where the coils move against) or both layers can be made smooth by use of a low friction materia!, attachment of a low friction materia!, or lubrication. The wire/spring or current carrying mechanism described above can also be used to center each coil in an area at the center of desired movement sector for each coii. In this way, without a receiver coil in the vicinity, each coii in the base unit stays at the central tøcation of its sector and responds and moves to match a receiver coil when a device or battery is brought nearby. Overiap of movement between adjacent charger or power suppiy coils can be controiied by means of iimiting movement through iimiting iength of current carrying wires to the coil, arrangement of the suspension, or spring, or piacement of dividing sectors, pillars or by any other mechanism.

[00184] in another embodiment, the pad wiii include a method for detecting the presence of the mobile device, battery/receiver and taking appropriate action to turn on the coil and/or to drive the coi! with the appropriate pattern to generate the required voitage in the receiver. This can be achieved through incorporation of RFiD ₁ proximity sensor, current sensor, etc. A sequence of events ᵬ enable position independence and automatic pad turn-on can be:

- MuStiple movable coiis are used to cover the pad surface area.
- The coiis in the pad are normally off and periodically powered *up* sequentially to sense whether the receiver is nearby by measuring the current through the primary coi!. Alternatively, proximity sensors under each section can sense the presence of a magnet or change in capacitance or other parameter to know where a device is piaced, RFiD techniques with localized antennas under each section or such can aSso be used.
- Once a device is identified as piaced in a section, the pad can interrogate the device through one of the processes described eariier to authenticate and to understand its volfage/power, etc. requirements.

* The MCU 1 unit uses the information received above to set the PVWI pattern which it will use to drive the FET drive to produce the appropriate voltage in the receiver.

• The board continues to 'search' for other devices on the pad by scanning coifs or using the RFID system, etc. and then turn on other coiSs as appropi ate,

• The pad aiso uses monitoring to find out when and if the first mobile device is removed from the pad, or when the end of charge is reached.

Efficiency Enhancements ïn Coif Registration and Switching

[00165] In accordance with an embodiment, a globai RFID system that can identify the approach of a mobile device to the pad can be used to 'Wake up' the board. This can be followed by sequentia! poiiing of individual coiis to recognize where the device is piaced in a manner similar to described above Other embodiments can be used to provide safeguards against faise charging of objects placed on the base unit. It is known that a metal object piaced on coils such as the ones in the base of the charger or power supply system wiii cause current to flow in the primary and transfer power dissipated as heat to the metal object. in practicai situations, this will cause placement of keys and other metai objects on the base unit to trigger a start and to neediessly draw current from the base unit cot! and possibly lead to failure due to over-heating. To avoid this situation, in embodiments such as described above, the switching of voitage to the coii wiil not start uniess an electronic device with a verifiabie RFiD tag is nearby thereby triggering the sequence of events for recognizing the appropriate coil to turn on and operate. in an aiternate geometry, the total system current or individual coii current is monitored, and, if a sudden unexpected drawn current is noticed, measures to investigate further or to shut down the appropriate coii indefiniteiy or for a period of time or to indicate an alarm is taken.

[00166J In another embodiment, the regulators or battery charging circuit in mobile devices or batteries, or the reguiator in a receiver eiectronics, typically has a start voltage (such as 5 V) that is required to start the charging process. Once the battery charge circuit detects the presence of this voltage, it switches on and then proceeds to draw current at a preset rate from the input to feed the battery for charging. The battery charger circuits operate such that an under or over voitage at the start will prevent startup. Once the startup occurs, the voltage at the battery charger output is typically the voitage of the battery and depends on the state of charge, but is for example 4.4 V to 3.7 V, or iower for Lithium-ion batteries. With a wireless charge system such as described here, the voitage on the receiver is highly dependent on relative position of the primary and receiver coil as shown in Figure 5. Since typicaiiy the start voltage of the battery charger is within a narrow range of the

specified voltage, under-voltage and over-voltage in the receiver coil clue to misalignment or other variation will resttit in shutdown of the battery charger circuit.

Effɹiency Enhancements through Coiɨ Voitage Clamping

[00167] **Figure 17** shows a figure of a circuit diagram 350 in accordance with an embodiment In accordance with one embodiment, **a** Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior to the regulator or battery charger circuit, as shown in **Figure** 17. Using a Zener aiiows more insensitivity to placement between the primary and receiver coil while maintaining the ability to charge or power the device. For example, the drive pattern on the primary can be set so that when the primary and receiver coii are aligned, the voltage on the receiver is above the nominal voltage for the battery charger startup. For example, for a 5 V startup, the voltage at center can be set for 8 or 7 volts. In this way, the Zener can be chosen ɒ have an appropriate value (5 V) and clamp the voltage at this value at the input to the battery charger unit while the coils are centered or mis-aligned. Once the battery charger starts operation after detection of the appropriate voitage at the input, the battery charger circuitry will pull the voltage at this point to the pre-programmed voltage or voltage of the battery. in this way, the use of Zener diode enables less sensitivity to position and other operationai parameters in wireSβss chargers or power supplies and is extremely useful.

Efficiency Enhancements through Coil Stacking

[00168] **Figure 18** shows an illustration of a means of stacking coils, in accordance with an embodiment. In accordance with an embodiment, to achieve higher flux densities, a coil is constructed with two or more layers, for example by using two or more layers of printed circuit board. Multiple layer boards can be used to allow compact fabrication of high flux density coils. By altering the dimensions of the coil in each layer (including the thickness, width, and number of turns) and by stacking multiple layers, the resistance, inductance, fiux density, and coupling efficiency for the coils can be adjusted so as to be optimized for a particular application.

[00169] In accordance with an embodiment, a transformer comprising two PCB coiis separated by a distance has many parameters that are defined by the design of the coil, including:

R1 is the primary winding resistance,

RI is the secondary (in the receiver) winding resistance referred to the primary,

RL is the resistive load,

LIk1 is the primary leakage inductance,

L'ikZ is the secondary leakage inductance referred to the primary,
LMf is the primary mutual inductance,
Cf is the primary winding capacitance,
C2 is the capacitance In the secondary winding referred to the primary,
C12 is the capacitance between primary and secondary windings, and
n is the turns ratio.

[00170] In accordance with the embodiment shown in **Figure 18,** a multi-layer PCB coil 356 is created in separate PCB layers 357, which are then connected 358, and manufactured together via common techniques used in PCB fabrication, for example by use of a via or contacts. The resulting overall stack is a thin multi-layer PCB that contains many turns of the coil. In this way, wide coiis (low resistance) can be used, while the overail width of the coil is not increased. This technique can be particularly usefui for cases where smaS! x-y coil dimensions are desired, and can be used to create higher flux densities and more efficient power transfer.

Efficiency Enhancements through Coii Shape and Materials

[00171] In accordance with an embodiment, the system can use a non-ferrite material for both the primary and the secondary (receiver) coils. For example, the coils can be made of copper materia! that is sputtered, deposited, or formed onto a printed circuit board (PCB), as described above. As also described above the coils can be formed in any number of different shapes, including, for example, flat or planar hexagonal shapes, or spirals. The coils can also be distributed in layers of coils, spirals, and other various shapes,

[00172J One of the advantages of using a non-ferrite or non ferromagnetic material for the primary and secondary (receiver) is that the coils can be made much flatter and thinner than a ferrite coil. Additionally, non-ferrite coils can be made to have a lower inductance than a comparable coil made from a ferrite material (the inductance is on the order of 1 micro Henry, although the actual value wii! vary depending on the frequency of the voltage appiied to the coil). The non-ferrite nature effectively eliminates hysteresis in the coil, and allows the system to be switched on and off more rapidiy, and with less energy storage artifacts.

Variations in Coii Circuitry

[00173J In accordance with some embodiments, an inductance-capacitance (often referred to as an LC or "tank capacitor") circuit can be used to provide a range of power outputs to approximately suit the intended application. For example, the circuit can be optimized to suit either low-power applications, or high-power applications.

[00174] Depending on the particular intended application, the origina! capacitor (referred to herein as a "timing capacitor") in the circuit design can be removed and/or replaced with a different vaiue of capacitor to obtain a different overall level of power output. From a manufacturing perspective this is a relatively simple and inexpensive procedure. This technique can also be used to easily manufacture different charger or pad embodiments for different end-user applications, in that the majority of the pad components can be designed to be common to each pad design, with the primary difference being the vaiue for a single capacitor. This single capacitor can then be specified or changed during the manufacturing process. Although the timing capacitor can be used to adjust the system for, e.g. high-power or low-power applications, the final power output as it is received at the mobile device can be fine-tuned using additional techniques and features such as those described in further detail below.

CoH Waveform Generation

[00175] In accordance with an embodiment, a half-phase electrical waveform is used to charge the tank circuit, and to subsequently provide inductive power to the receiver coil in the mobile device. Unlike a full-phase waveform, the half-phase waveform can be used with a zero-crossing power supply. In accordance with this embodiment, when the transistor in the primary coil is first turned on, electrical current passes through the primary coil and the transistor to ground. When the transistor is turned off, the voltage level at the transistor swings high (anywhere from twice, to many times the value of the input voltage). This is the standard oscillation behavior of an inductor. When the current falls to zero the transistor is turned on again, and the process is repeated.

[00176] Many traditional transformer designs do not use half-phase waveforms, and instead use a non-zero-crossing design, since their ferrite core acts like a capacitor and stores energy during the off phase, which results in large losses in power efficiency if zero-crossing was used. However, in accordance with an embodiment, the use of non-ferrite coils, coupled with lower power (on the order of 2 Watts) allows for suitable efficiency with a half-phase and a zero-crossing circuit.

[00177] Furthermore, in accordance with some embodiments the half-phase waveform can be designed to have an exponential or curved shape, rather than an abrupt shape, so that higher frequency emissions are reduced. These higher frequency emissions might otherwise cause problems with portable and other devices, or conflict with federal communications regulations that prohibit high frequency emissions in consumer electrical devices.

Automatic Voltage Setting

[00178] In accordance with some embodiments, the system can include additional circuits, components, features, and techniques, which perform specialized tasks, such as mobiie device identification, and automatic voitage or power-setting for different devices. As described above, aithough the timing capacitor can be repiaced to modify the circuit frequency and the resulting output voitage of the system, this is not a practice! solution for aiiowing a consumer to modify the voitage, or to modify the voltage to suit the particuiar requirements of individuai mobiie devices. in practice the timing capacitor can be used to provide a partteuiar range of output power (i.e. high power applications; or low power applications). Additional techniques are then used to adjust the power for a particular device. This is particuiarly important when the charger or the pad is designed to power or charge multiple different devices simultaneously, since each of those different devices may have different power and voltage requirements, in accordance with various embodiments, different features can be used b support this, including:

- Hardwiring the receiver coii to take the voitage requirements of its device into account, and to use the appropriate dimensions to receive the correct voitage for that device. However, whiie this approach works to adjust the voitage for that device, it is by its nature hard-wired and does not provide much flexibiiity to adjust the voltage for interoperability between different devices and different chargers or power supplies.
- Use of dynamic programming to obtain a different voitage. In accordance with this embodiment, if the timing capacitance is known, then the frequency of the circuit can be adjusted to produce the required output voltage.
- In a zero-switching circuit, cupping can be used to tune the voltage. This can inciude turning the circuit on, then aiiowing it to turn off but clipping the waveform earlier, and then turning it on again. The process is then repeated. The clipping may be iess efficient than undipped switching, but can be used to tune the voitage,

[00179] When used with the above capacitor-based techniques, the choice of timing capacitor can be used to determine the overall range of the charger, power supply, or pad (for example, whether if is best suited for low power, or for high power applications). The additional features can then be used to fine-tune the frequency and the output voltage. in accordance with some embodiments, additional features can be used to improve efficiency and to add functionaiity.

£00180] As described above, in accordance with one embodiment, the pad circuit 260 incorporates a micro control unit (MCU) 286 that can enable or disabie the FET driver 268, The MCU receives input from another sensor mechanism that wii! provide information that it

can then use to decide whether a device is nearby, what voltage the device requires, and/or to authenticate the device to be charged. The communicated feedback from the receiver to primary can be used by the primary to, for example, adjust the frequency, or to otherwise aiter the output voitage to that receiver, using the frequency/output characteristics described above. Some traditional transformer designs use a third coi! to provide a measure of feedback. However the use of an MCU as described herein eliminates the need for such extra coi! feedback devices,

[00181] Also as described above, in accordance with one embodiment, a Zener diode 352 is incorporated to damp the maximum voltage at the output of the receiver prior to the regulator or battery charger circuit. In each of the feedback designs described above, the actual communication between the receiver and the primary as to voitage requirements can be of open loop design, or of closed ioop design. In an open ioop design, the charging device, pad or power source provides the power to the primary, which is then inductively transferred to the receiver and the mobile device or battery other device to be charged. The primary itself determines how much power should be received at the receiver. In a closed loop design, such as in a switching mode power supply, the device/receiver communicates information back to the primary, and then the primary determines how much power should be sent to the receiver.

Device Identification and Verification

[00182] **Figure 19** shows a figure of a circuit diagram 400 for identification verification in accordance with an embodiment. In accordance with an embodiment, the circuit design can be used to ensure a device is valid, i.e. authorized to be used with the charger, power suppiy or pad. The information can also be used as part of an open-loop or closed-ioop design to set the voltage for the device. In operation, the primary circuit is first turned on. An initial signal is generated as the circuit induces power in the receiver. This information is quickly compared with a number or value stored in the MCU, and is used to determine whether the mobile device (or the receiver associated with that mobile device or battery) is valid for operation with the base unit, charger, power supply, or charging pad. In addition to validation the information can similarly be used to set the charging voitage for the receiver, battery, or mobile device.

[00183] Figure **20** shows a figure of a circuit diagram 420 for bidirectional communication in accordance with an embodiment. As shown in **Figure** 20, in accordance with an embodiment the charger or power supply or primary can include means for communication with the receiver, battery, or mobile device, including for example radio frequency (RF) or other means of communication.

[00184] **Figure 21** shows a figure of a circuit diagram 440 for output controller in accordance with an embodiment. As shown in **Fjgure** 21, in accordance with an embodiment the output controller in the receiver waits untii power is sufficient, and then turns the power on to the mobile device or battery.

[00185] **Figure 22** shows a figure of a circuit diagram 480 for receiver with regulator or charge management circuit in accordance with an embodiment. As shown in **Figure 22,** in accordance with an embodiment the receiver includes a reguiator for regulating the voltage.

[00186] **Figure 23** shows a figure of a circuit diagram 500 for MCU reguiation in accordance with an embodiment. As shown in **Figure** 23, in accordance with an embodiment the MCU can provide the voltage regulation.

[00187] Figure **24** shows a figure of a circuit diagram 540 for unidirectional communication and data transfer in accordance with an embodiment As shown in **Figure 24,** in accordance with an embodiment the receiver can include a means of transferring data to the mobile device to which it is coupied.

[00188] **Figure 25** shows a figure of a circuit diagram 580 for time-based regulation in accordance with an embodiment.

Zero Voltage Setting

[00189] In accordance with some embodiments, the system can use a technique such as Zero Voitage Switching (ZVS) to provide more efficient power transfer and power supply controi. These techniques can also be used to provide more efficient regulation for power transfer between coiis of small induction value, such as those created by spiral patterns in PCBs, stamped metal coils, and low number of turns wound wire coiis. in switching mode power supplies used today, the common geometries used are boost buck, flyback, boost, or a variation of these types. In most of these geometries, the input voltage is switched rapidiy by a transistor such as a FET and the energy is transferred across a transformer to a load. in accordance with an embodiment, by adjusting the duty cycSβ of the switching circuit, regulation of transferred power is achieved.

[00190] **Figure 26** shows a high ievel view of a flyback power supply geometry 580 in accordance with an embodiment. During the time that the FET is ciosed, the current through the primary coi! stores energy in this coi! and during the period that the FET is open, this energy is transferred to the secondary (receiver) coil and into the load. The energy stored in the coi! is directiy proportional to the inductance of the coii and values of severa! hundred Henry are typica! for 10's or 100's of Watts of power supply power.

[00191] In contrast. Printed Circuit Board Coiis (PCBCs) are typically spirai circular, rectangular, or other shape coils that are printed on rigid or flexible PCB materia! or stamped

out of sheets of copper or by other methods where the coil or transformer in a power supply is primarily flat and takes very little space. Two of these coils placed with a distance between them (such as on both sides of a PCB material) or with an air or material gap (such as in wireless power applications where a charger transmits power to a receiver in an electronic or electric device that can be separated or removed from the charger) can be used to form a transformer such as the one shown in Figure 26. Switching of these coiis at high frequency (-1 MHz depending on the coil geometry and size) can transfer power across an air or material gap and an efficient power supply with a very small transformer can be developed. Uses of such compact coils for wireless powering of mobile devices such as mobile phones and MP3 players have been demonstrated. However, many prior techniques used a laboratory power supply to provide a sinusoidal or similar voltage to the primary coil and study the transferred power, rather than a compact efficient circuit for a power supply.

[00192] In accordance with a ZVS geometry embodiment, a capacitor is added to the circuit so that in the switch OFF position, the capacitor and the coil inductor create a resonant circuit. During the switch ON time, current passes through the inductor while the voltage across the capacitor is zero. During the period where the switch is turned off, the voltage across the capacitor rises to a maximum value of twice the input voltage and then resonates back to zero. A characteristic of this geometry is that the switch is closed exactly when this voltage arrives back to zero (hence the name Zero Voltage Switching), thereby minimizing power usage and achieving high efficiencies. Some of the benefits of this geometry include: High efficiency and 'Loss-less' transitions; Reduced EMS/EMC due to soft switching and use of sinusoids rather than square waves; Peak current is not higher than square wave switching; and Relatively simple control and regulation. In addition, this geometry can work very efficiently with Sow inductance values and is therefore better suited for the PC8C applications. In accordance with various embodiments the geometry can be configured to operate in various topologies, for example buck, boost, buck-boost, and flyback.

[00193] Some embodiments provide more efficient power transfer and power supply control and regulation for power transfer between coils of small induction value such as created by spiral patterns in PCBs, stamped metal coils, low number of turns wound wire coils, etc, In addition, typically, magnetic cores are not used if the coils are driven at high frequency. For a spiral coil, the inductance of a coil is given by:

$$L = \frac{r^2 N^2}{(2r + 2.8d) \times W}$$

Where

L = inductance (H)

r = mean radius of coil (m)

N = number of turns

d = depth of coil (outer radius minus inner radius) (m)

[00194] For example, for a coil of 10 turns, an outer radius of 15 mm, and inner radius of zero, then L=1 H. While larger values can be obtained by increasing the number of turns or stacking a number of coiis vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor.

[0019S] Spiral coils printed on PCBs without use of any magnetic core can provide high power transmission efficiency if operated at high frequency. An analogous method to the above technique is one referred to as Zero Current Switching (ZCS). ZCS operates by simiSar principles; however switching is done during zero current passing through the switch thereby achieving iow switching losses. In the following discussion, ZVS switching is generally discussed; however, the ZCS geometry can equally be applied to the foilowing. in accordance with some embodiments, methods are described for achieving and optimizing high power transfer with such smali and/or thin coils with iow induction values and describe several techniques for control and regulation of this power in real world power applications. While this technology is generally described for any type of power supply using such inductors, in accordance with a particular embodiment the two coiis in the transformer are separated, with the primary being in an inductive charger and the receiver embedded in a device, battery, casing, skin, or other part of an electronic or electric device. In this case, a wireless charger or power suppiy can be created which is especially useful for charging or powering mobile electronic or electric devices or batteries.

[00196] The advantages of use of ZVS geometry in general, and in particular for coiis with small inductance and no magnetic cores, has been described above. However, another important aspect of power supply design is the Control and Regulation Circuitry that is impiemented. Regulation of the power to a load can be achieved by a linear or switching regulator at the output stage. However, if the regulation of the power is achieved in this way and constant power is supplied from the primary coil, under light load conditions (such as when a battery is fully charged or a device is on stand-by, then the power generated and transmitted by the primary is mostly wasted leading to a low efficiency power supply. A better solution is achieved by adjusting the power into the primary coil under different load conditions, to maintain high efficiency during different load conditions or battery charging stages.

[00197] In accordance with an embodiment, such control of output power in a ZVS power supply can be achieved by changing the frequency of the operation. In this embodiment, the output power is inversely proportional to the operating frequency and control can be achieved by an appropriate contra! circuit.

[00198] Figure 27 shows how the output voltage to the load is monitored and with changes in the load condition, a chip or a Micro Controiler Unit (MCU) varies the frequency or the duty cycle of the FET driver to achieve optimum operation and controlled output voltage with a changing load. As shown in Figure 27, a digital controi 600 for operation is shown. However, analog operation can also be achieved and may be simpler and faster in response time to load changes and preferable in some applications. In the implementation shown, the primary (Control Circuit, Clock, FET Driver, FET, primary coil etc.) and the receiver (secondary coil, rectifier, capacitor, other circuitry, etc.) arB able to communicate through a wired connection.

Switching Wlode Power Supply with Wireless Com munseat!on

[00199] In accordance with an embodiment that includes a charger or power supply wherein the charger or power supply and the receiver are separable from each other (wireless or inductive charging or supply of power to devices), the charger or power suppiy can contain the basic control and switching functions while the receiver contains the rectifier diode and capacitor for smoothing of the output voltage and additional circuitry. In this embodiment the two parts need to communicate with each other wirelessly.

[00200] Figure 28 shows an implementation of a more sophisticated charger or power supply. According to this embodiment, where the primary stage and the secondary (receiver) stage communicate wireiessly. In the geometry shown in Figure 28, a digital control scheme is implemented. The primary (charger or power supply) 620 is controlled by a Micro Controi Unit (MCU 1) that receives signals from a Current Sensor in series with the coil. The communication between the charger and the receiver 630 is achieved through the same coil as the power transfer. However, these functions can be separated.

[00201] In the geometry shown, the secondary (receiver) contains circuitry that enables this part to modulate the load as seen by the primary. In accordance with an embodiment this is achieved through modulation of switch Q2 by an MCU2 in the receiver. This can be a very small Programmable IC (PiC) and can easily fit into very small form factors. As the primary charger or power supply sends power to the secondary receiver, the circuit in the receiver turns on. The power received is rectified and filtered by rectifier D1 and Capacitor C2 respectively. Since MCU2 requires constant voltage input at all times, a small, low current regulator (Voltage Regulator) for powering MCU2 only is incorporated. This can

be a linear or switching regulator. Since the power usage of MCU2 is very small and the unit can also be put into hibernation between tasks, use of this reguiator does not affect the overall efficiency much. The output of the rectified stage is input to a device or Charge Management iC for the case of a battery charger configuration. This Charge Management sc is integrated into most Origina! Equipment Manufacturer (OEM) mobile devices that operate by rechargeable batteries or can be integrated into or on a rechargeable battery to directly charge the battery when the battery is in proximity to the charger. The Charge Management IC typically, for a fully drained battery, will pass on the maximum input current to the battery b enabie rapid charging when the battery is at Sow voltage. This presents a Sow impedance load to the power supply circuit and requires the power supply to sustain the voltage at the required value while supplying the current. The Charge Management IC is in communication with the MCU2 which also monitors the output voltage (Vout) and tries to maintain this Vouf within a pre-programmed range. This is achieved by MCU2 sending a digital signal to Q2 to modulate the switch. This modulation is prior to the rectifier stage and is at high frequency so the rectified and smoothed Vout is not affected. However, this modulation of the impedance of the secondary stage affects the current through the primary coil stage and can be βasϋy detected by the Current Sense circuit in the primary.

[00202] In accordance with an embodiment the Current Sense circuit can comprise a small resistor in parallel to a voltage amplifier, a Hal! sensor, etc. The output of the Current Sensor is connected to MCU 1 and the digital sequence is detected by an A/D converter. The firmware in MCU1 determines whether the output voltage is too high or too low and then executes the appropriate step to adjust accordingly by sending a signal to a clock to adjust the frequency of the FET drive to bring the output of the power supply to within acceptable range. Higher drive frequency corresponds to lower output power by shortening the time for integration of power in the resonant ZVS cycle and lower frequency corresponds to higher output power.

[00203] In accordance with an embodiment, one method for implementing the variable frequency is to use a variable frequency source whose output frequency changes with change in the voltage to its input. Using a programmable resistor and changing this resistor value by varying a voltage signal from MCU 1, the frequency for driving FET 1 can be changed. Other methods for achieving this change are also possible.

[00204] As an example of the method for control, in a typical application, the operating frequency of the circuit can be 1-2 MHz and the data transmission for control is at 14.4 kbits/sec. If the full output power range is achieved by moving the frequency in the 1.2-1.4 MHz, this range is broken into 256 steps. In one implementation, the receiver sends a digital code corresponding to the output voltage and MCU 1 compares this to the earlier output

voltage value and makes a determination about which direction and by how many steps to move the frequency. The frequency is then changed accordingiy. In another implementation, MCU2 sends one of 2 values corresponding to a voltage high or low condition. If the voltage is within range, MCU2 does not communicate with the primary, When a voltage high signal is received, MCU1 , takes a pre-determined step towards higher frequency to lower the output power and the process is repeated until output voltage is within required range. A voltage low signal has the opposite effect. Many variations of these basic methods are possible to allow rapid, efficient locking of the output voltage. Proportional-integral- Derivative (PID) techniques, etc. can aiso be used. Depending on the geometry, the circuit may aiso use a switch Q3 in series with the load. This optional switch may be opened during communication to create a better signal to noise ratio. Since communication occurs in several msec, opening and closing Q3 rapidly does not have a large impact on charging time of a load battery that can be in many hours.

[00205] In accordance with an embodiment, as the battery charges and its terminal voltage rises, the Charge Management IC throttles the incoming current back, and switches to a mode where the voltage across the battery tβrminaS is maintained at or near its final value. The supply will sense a higher output impedance and MCU2 and MCU 1 work in concert to keep the output within range throughout the charging cycle. At the end of the charge cycle, the Charge Management sc can signa! end of charge cycle to MCLJ2 which sends a pre-determined code to MCU 1 to shut down the charger, move to hibernation mode or take some other pre-determined step.

[00206] It is important to note that, in the embodiment, the voltage regulator in the receiver does not regulate the output voltage to the ioad itseif. If the reguiator was performing this function, then the controi and regulation described here would not be necessary. However, the overall system efficiency is much lower and, with a constant power going into the receiver, some fraction of this power is wasted as the battery reached a full charge or as the ioad became lighter and less power was required. This wasted energy can heat up the receiver, the ioad, or the device battery depending on the geometry. All of these cases are undesirable. In the geometry described here, the primary can in these cases adjust to send less power to the receiver, thereby maintaining high efficiency regardless of load condition.

Verification and Data Transmission

[00207] In accordance with an embodiment, the digital transmission process described here is bi~directionai, and can be used for verification process at start of charge or power transfer to ensure that the right kind of device is present and about to be charged, or to

inform the charger or power supply about the voltage/power requirements of the device or battery to be charged or powered. In accordance with an embodiment, this bi-directional data transfer can also be used for actual data communication between a device and a charger or power suppiy. For example, the charger or power suppiy can be powered by the USB outlet of a laptop and simultaneously receive data from the laptop to be transferred to a mobile device. When a mobile device or battery is on the charger or power supply, it can be charged or powered, and its data can also be synchronized simultaneously through this channel.

Extension to Other Geometries

[00208] WNIe the above discussion has focused on one implementation of the control with a Zero Voltage Switching power supply, the basic concepts for the control, verification, and data transmission are applicable to other geometries and topologies, and can be implemented in a similar manner. in accordance with some embodiments, the Charge Management Circuit is optional and is only used when a battery is present at the load. For exampie, as shown in Figure 28, If Vout is used to directly operate a load, the Charge Management Circuit is not used and Vout is directly connected to the load.

Fully Regulated Switching Mode Supply with Wireless Communication

£00209] Figure 28, described above, shows the basic building blocks for a digitally controlled wireless control circuit for a Zero Voltage Switching (ZVS) circuit were described. The geometry shown in Figure 28 can regulate the output power through a wide range. However, as a battery charges or the load condition changes to require very low output powers, the accuracy required for control of the Vout may require many finer steps or not be possible with the geometry of Figure 28 alone.

[00210] Figure 29 shows an embodiment that includes an enhancement that can be used to address the ZVS issue.

[00211] In the fully regulated power suppiy shown in Figure 29, a voltage regulator (Voltage Regulator 1) that can switch the input voltage between 2 values or more is used. In normal operation, Q2 is closed and the Voltage Regulator 1 is shut down though its enable pin. Therefore, the input voltage is directly available for the Coil L1 and is regulated as described earlier. However, if the output requires extremely low powers (such as *end* of charge stage for batteries), and the charger determines that a switch to a different range is required, Q2 is opened, and Voltage Regulator 1 is switched on to change the input to Coil 1 to a lower voltage value. Regulation is maintained at this range by shifting to the appropriate

frequency to achieve required output power. For example, if Vin is 5 V, this lower voltage level may be 3 V. Multiple voltage levels are also possible.

[00212] Since for most cases, and in high power conditions, Q2 is open and Voltage Reguiator 1 is turned off, high overall system efficiency can be achieved. Only during the lowest current conditions, the input voltage is changed by switching this VoStage Regulator 1 on and regulating at this level. Depending on the type of regulator used, some efficiency loss can be expected in this regime. However, this occurs at very low output power levels only. Voltage Regulator 1 can be a high efficiency Switching DC-DC suppiy or a lower frequency, less complicated and less costiy itnβar reguiator depending on efficiency/cost trade-offs.

Regulated Switching Mode Power Supply with Opto-Coupfer Feedback

[00213] The geometries described above use a digital method for transmission of information between a primary and receiver circuit. However, in some cases, the load changes instantaneously. Examples are when in a iaptop computer, the screen or the hard drive start or shut down, etc. To handle these cases, the feedback loop has to be extremely fast to avoid having severe and rapid voitage overshoots and undershoots. This becomes especiaily important for high power appiications.

[00214] Figure 30 shows an embodiment in which instead of a digital feedback circuit, an analog circuit based on coupiing between an LED and a light detector can be used.

[00215] In this case, the output voltage, Vout is continuousiy compared to a reference voltage and the intensity of Sight from a diode changes rapidly in proportion to the voltage value. A detector in the charger stage provides a voitage value to a frequency controlier that controls the FET drive. An MCU in the charger, IvICU1 also monitors the process and can switch on an optional lower voitage input to the primary coil (through Q2 and Voltage Regulator} if necessary. It can also sense the end of charge or perform verification or other tasks.

[00216] In some embodiments a high power completely wireless inductive charger for a laptop requiring up to 90 W continuously can be implemented with this scheme. In accordance with an embodiment the transformer coiis are PCB spiral coils that have 4" or more diameters and comprise 7 turns with a total inductance of 1 micro Henry. The rapid response time of the analog circuit allows maintaining of the output voltage with rapid swings in the ioad. The charger or power supply comprises a pad where the charger or power supply circuitry and a flat spiral PCB coii are integrated into and the receiver comprises circuitry and a similar coii integrated into the bottom of a laptop. The optical components are mounted such that the Sight from the transmitter is detected by the receiver in the charger or power supply.

[00217] Digital communication through the optical parts is also possible to achieve this result, but requires a higher bandwidth and high speed processing.

[00218] It will be evident that these features, or any other geometry described here, can be combined to achieve the desired results. For example, white the control process for regulation may be through the opto-coupler feedback described here, a separate digital data link through the coil can be established for data transmission or verification of the charger, power supply, or vice versa.

Regulated Switching Mode Power Supply with Isolated Transformer Feedback

[00219] In accordance with an embodiment, another geometry for the regulation uses a similar analog feedback technique with the feedback information being transferred through a separate isoiated transformer.

[00220] **Figure 31** shows an embodiment in which the opfo-coupSer is replaced by a Voltage Controlled Oscillator (VCO) and FET and in the primary, the signal is sent to adjust a frequency controller to provide optimum output voltage. An optional voitage regulator and switch Q2 can also be used to provide precise control at low output powers. Similarly, this communication can be implemented digitally, and also requires a high bandwidth to allow for rapid response. Since the circuit in **Figure** 31 is completely wireless and does not require optical components, it may be preferable in cases where an optically transmissive window in the charger or power supply or the receiver may not be possible.

Regulated Switching Mode Power Supply with RF Feedback Regulation

|00221J In accordance with another embodiment, the information between the charger and the receiver can be exchanged through a wireless link in the two parts. The advantage with this embodiment compared to the optical case is that the two parts do not need to be optically transmissive. In addition, compared to the earlier-described versions (optical and through a transformer), the relative alignment is not as important. However, in most practical application, the charger or power supply and the receiver coil will be aligned for power transfer, so an alignment of some degree will occur and with the right geometry, can enable transformer or optical feedback alignment and regulation to be implemented.

[00222] **Figure** 32 shows an embodiment in which the wireless link can be analog or digital (requires higher bandwidth and complexity) or can be integrated into the device to take advantage of existing wireless links in the device (Bluetooth, WIFi, Wireless USB. **WiMax,** etc.).

[00223] **Figure 33** shows a basic schematic for an inductive single coil charging system in accordance with an embodiment. As shown therein, the coil inductor in the

charger pad is switched by Switch T which is typicaily a FET transistor. A capacitor in paraiiel with the FET may be used to improve performance. The receiver in the right hand side comprises a similar coil, rectifying diode, and a capacitor to provide DC output to a load R_L.

[00224] Figure 34 shows the main components of a more advanced wireless power/charging system. Charge Management IC in the receiver aiso controls the charging of the battery to ensure appropriate charging. The MCU1 and current sense chips in the charger and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The optionai voltage regulator in the receiver is used to provide a constant low current voltage to MCU2 and is not reguiating the power into the battery. The Receiver is integrated into or on a mobile or eiectronic device or a rechargeabie battery. Points A, B and C are described later and can be used for placement of switching circuits. Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00225] An embodiment of the system incorporates a MicroControl Unit (MCU1) that can enable or disable the FET driver. This system also uses a Charge Management IC in the receiver which controls the charging of the battery to ensure appropriate charging profile is followed and the battery is not overcharged. Most mobile devices today aiready include a Charge Management IC in their power circuit between the input power jack and the rechargeable battery of the device to control charging of their internal battery. This chip can be incorporated into the receiver circuitry to enable a battery to directly receive power from an inductive source as shown in Figure 34.

[00226J Figure 34 also shows a Zβner diode (Z1) incorporated at the receiver. This Zener is used to ensure that the output voltage from the rectifier does not exceed a pre-determined value. In some instances this may be important, since the output of the receiver is fed into a Charge Management IC that may have a finite turn-on time. At the beginning of charging (when a device is placed on a pad first), the Charge Management IC may seem like a high impedance load. Without the Zener diode, such a load may cause the voltage the input to the Charge Management Circuit to increase to high values, potentially exceeding its safe operating conditions. A fast Zener diode can clamp the voltage under this or other unusual conditions and may be incorporated into the receiver. Depending on the architecture, other methods for avoiding such conditions may be incorporated. incorporating a Zener Diode is an effective, and inexpensive method for dealing with these potential issues.

[00227] In accordance with an embodiment, the receiver may aiso incorporate a voltage regulator just to provide a constant voitage (or voltage in the acceptable range for

operation) to MCU2. This voltage regulator just provides the iow power necessary for this and is not in the path of the main power going into the battery. Any power loss due to this regulator is small, because it is very Sow power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained.

[00228] The MCU 1 receives input from another sensor mechanism that provides information that it can use to decide whether a device or battery is nearby, what voitage the device or battery requires, and/or to authenticate the device or battery to be charged or powered. Several examples of the mechanisms for providing this information are:

[00229] The MCU1 periodically starts the FET driver. The current through the FET is monitored through a current sensing method. The inductance of L1 is highly dependent on the presence of objects nearby that affect its magnetic field. These objects Include metaliic objects or another nearby coil such as L2. Switching L1 at high frequency (100 kHz to several MHz) through a Field Effect Transistor (FET) such as Q1, the value of current being drawn is highly dependent on the L1 Value. This property can be used to sense the presence of nearby devices or batteries capable of drawing power and also to enable bi-directional communication if desired. Severa! methods for this are possible:

- A small resistor can be placed in series with the FET to ground contact. The voltage across this resistor can be measured by a current sensor chip such as Linear Technology Current Sense Amplifier part number LT1787.
- A Hall sensor such as Sentron CSA-1A that measures the current from a wire running under it can be piaced on top of the PCB Sine from the FET to the ground to measure the current without any electrical connection to the circuit. The advantage of this approach is that no extra resistor in series with this portion of the circuit is necessary reducing the impedance.
- Other techniques can be used to measure the current.
- By monitoring the current and comparing it to a baseline measurement taken at power *up,* and periodically with no devices nearby, MCU 1 can determine whether a device or battery is near the coil and drawing power. This provides a first level verification of an object capable of drawing power being nearby. However, there may be a possibility of false starts with metallic objects or wires in any electronic device or battery drawing power. A second level of verification may be desirable.

[00230] To enable a more secure verification, in accordance with an embodiment the MCU 1 can periodically start the FET driver. If current is being drawn, MCU 1 may activate the Q1 in a predetermined state (for example, this may be a iow power state). This can provide a first level indication that a receiver may be nearby. If there is a genuine receiver

nearby (versus, say, a metallic object, electronic device, or a non-approved receiver), the emitted power from L1 will power the receiver circuit. The charge control circuit in the figure or another chip in the Receiver circuit can be pre-programmed so that on power-up, it draws current in a pre-programmed manner. An example of this is the integration of the MCU2 and chip model number 10F220 Programmable IC by Microchip Inc. or another inexpensive microcontroller that upon power-up, executes a predetermined program that modulates the current being drawn in the receiver in a predetermined code (which can be encrypted). This receiver modulation can be detected as a current modulation in the current through the L1 by the charger or power supply current sensor in **Figure 34**.

[00231] After the initial handshake and verification, the MCU1 and current sense chips in the charger or power supply and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The system can also regulate the power and voltage received at the Charge Control Circuit to insure overvoltage conditions do not occur. As shown in **Figure 34,** switch Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00232] If the handshake and verification between the charger or power supply and the receiver is not successful, the MCU1 will assume that the device drawing power is not an appropriate receiver and will terminate powering it. This process invalidates false starts due to objects being accidentally placed on the pad, and also provides protection against counterfeit or non approved receivers. An RFID, Near-Field Communication (NFC) or other wireless data transmission method reader that can detect an RFID, NFC, or other tag included with the receiver circuit and antenna (i.e. device or battery to be charged). The information on the tag can be detected to identify the voltage for the receiver required, and to authenticate the circuit to be genuine or under license.

[00233] The information on the tag can be encrypted to provide further security. Once a device containing the tag is near the charger or power supply pad, the tag reader is activated, the system reads the information on the tag memory, and compares it with a table to determine authenticity/voltage required or other info. In some embodiments, this information table can also reside on the MCU1 memory. Once the information is read and verified, the MCU1 can enable the FET driver to start driving the coil on the pad and to energize the receiver.

A Hall sensor or a Reed switch can sense a magnetic field. If a small magnet is placed inside the receiver unit of the system, a Hall sensor or Reed switch can be used to sense presence of the magnet and can be used as a signal to start the FET.

Other capacitance, optica!, magnetic, or weight, etc, sensors can be incorporated to sense the presence of a receiver and to begin the energy transfer process.

[00234] The methods for verification and communication between the charger or power supply and the receiver are provided above by way of example, and in accordance with various embodiments, in practice a combination or a variation on the above methods may be used. it will aiso be evident that different embodiments can use different verification techniques, in addition to or instead of those described above, and various combinations of such.

Efficiency Enhancements through Latera! Offset Between Coils

[00235] Figure **35** shows a typical experimental curve for power transferred and Power Transfer Efficiency through a pair of circular spirai coils as a function of iateral offset between the center of the coiis. The power transferred is shown at the receiver after rectification and other eiectronics, and is the DC power availabie for charging/powering a device. Power Transfer Efficiency is defined as the DC Power out from the receiver divided by DC power into the charger or power supply circuit; so it includes any power consumed by the FET driver, the FET, rectifier diode, and other electronics. This efficiency includes ail losses (electronics, coil to coil losses, rectifier, etc.) and is a more practical number for efficiency than the ratio of AC power out of a receiver coil to AC power into a charger or power suppiy coil commonly used. It can be seen that very efficient power transfer efficiency can be obtained with inductive methods. In accordance with the example shown, the coiis can be identical and 1.25" in diameter and comprise 10 turns.

[00236J As can be seen from **Figure 35,** for the coil geometries used here, at an offset between the center of coiis of half the radius, the power transferred can be 75% of the maximum value. Improvements in flatness of the curve may be possible with changing the design of the coii to overlap more of the field on the outer areas of the coii or by using hybrid coils.

[00237] However, it is important to note that while the transferred power decreases with offset between the coil centers due to reduced overlap of the coii areas, the power transfer efficiency (ratio of DC power out from receiver to DC power into charger or power supply) remains relatively constant in the range of offset < 3r/4. This is a more critical factor in design of an efficient system. If one assumes that a system can be designed such that the coil offset is never larger than r/2, then in a wireless charging or power transfer system, then, one can design the system such that the power transferred at this maximum possible offset is equai or greater than the maximum transferred power necessary.

[00238] For example, if Figure 35 represents the maximum power transfer possible given the particular coi! type, size, and geometry and the switching circuit (FET) and circuit design, then 3 W or more power can be transferred depending on the offset between the coils assuming that the coil offset is always sma‖er or equai to r/2. For a power suppSy application where regulated, constant power to a device is necessary, using regulation of the output power or a feedback to the charger or power supply to change the frequency or duty cycle, etc. to keep the power constant can insure that the received power to a device is independent of the offset between the cσiSs. For example in this case, using regulation, one can ensure that up to a maximum power of 3 W can *be* provided to a load independent of coi! offset (up to the maximum allowable offset - assumed to be r/2 here). in this case, the 3 W is sufficient for most mobile devices (mobile phones, cameras, Bluetooth headsets, etc.). Again, if is noted that the overall efficiency of the system remains high in all cases, since the offset (within the range of possible offset values) and regulation of the power (if it is performed at the charger or power supply by changing duty cycle, etc.) do not have a large impact on efficiency.

Position Independence using Layers

[00239] From the discussion above, one can achieve the goals of high efficiency and position independence if a method is found wherein the offset between the charger or power supply and receiver coils is always kept equal or iess than r/2. In the case of hexagonal spirals with side = r, the maximai diameter is 2r (similar to a circle with radius r). So for a given hexagon with side ≃ r, the same relation holds. As described herein, several methods of achieving this are proposed.

|00240] Figure 36 shows *&n* embodiment in which a coi! mosaic is used to cover the surface area of the pad. The circuitry can include means of sensing the presence of a receiver coi! to start the appropriate driver to provide power. The drive and sense circuits and other electronics are shown here as components in the perimeter of the coi! area but can be located anywhere. The approximate Effective Area is also shown. !f the center of a receiver coi! is placed anywhere within the effective area, the receiver will receive the specified power with only one appropriate coil in the charger or power supply activated.

[00241] in the geometry described here, each coil is driven by its own drive circuit. A sensing mechanism senses the presence of a receiver coi! on top or close to a charger or power supply coi! and starts the drive circuit to power the appropriate coi!. The sensing mechanism can be a current sense mechanism. Each coil drive circuit can periodically start driving the coi! at an appropriate frequency and a current sense circuit can monitor the drawn current to sense when a receiver is nearby thereby affecting the inductance of the charger or

power supply coil. Driving the charger or power supply coil circuit at an appropriate frequency determined by the inductances of the charger or power supply and receiver coiSs and the capacitance of the load, can provide very high sensitivity to this change in the inductance,

[00242] Additional verification can be obtained by exchanging a verification code through the coils or by exchange of information through a second wireless data communication link (such as RFSD, NFC, WiFi, etc) between the pad and the device(s) to be charged. The code exchange can also provide information to the charger or power supply coil regarding the necessary voltage, power, temperature, or other diagnostic information for achieving reliable charging.

[00243] The approximate Effective Area is shown in Figure 36. Any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within half a width or less of the center of at least one charger or power supply coil. If the system is designed such that moving the receiver coil within half the width of the center of any given activated coil provides at minimum the maximum output required (i.e. 3 W in the earlier example), the Effective Area has the property that a receiver coil with its center anywhere within this area can receive the necessary maximum output power or more with only one appropriate charger or power supply coil activated.

[00244] For the geometry shown in Figure 36 comprising 75 hexagonal coils with side = r in 3 layers, the effective area is approximately 12 r wide and 6 mr high where mr is the minimal radius of the hexagon = √3 r. The total area is approximately 62r. In accordance with an embodiment, the Coverage Efficiency (CE) is defined as the Effective Area in units of coil radius (for circular coils) or length of side (for Hexagonal coils) divided by the number of Coils used. CE ~ 0.83 in this example.

[0024S] To consider an example, one can take the maximum offset between the receiver and charger or power supply coil to achieve sufficient output power to be half the width of a coil (assuming symmetrical coils). Using coils with different width or radii (in the case of circular coils) or other geometries would change this value, it can be shown that a hybrid coil with a PCB coil and a wound wire coil are placed on top of each other is shown to have a more flat power transfer efficiency curve as a function of offset between the charger or power supply and receiver coil offsets. The general results and the operating principles for the embodiments discussed herein are valid regardless of what type of coil, geometry, or regulation is used to allow larger (or smaller) insensitivity to charger or power supply/receiver coil offset.

[00246] For the remaining portions of this document, embodiments are generally described which use half the width of the charger or power supply coil as the maximum

allowable offset between the charger or power supply and receiver coil before the transferred power becomes Sower than the desired maximum transferred power value.

[00247] The sense and control mechanism in the Configuration shown In Figure 38 may be shared between a number of dnve circuits to reduce parts count or may be integrated with each drive section. A number of other sense mechanism such as magnetic, optical, or capacitance sensors may also be used.

[00248] Figure 3? shows an alternative embodiment in which the number of drive (and sensing) circuits may be reduced by using 1XN electrical or electronic switches. In this embodiment, a number (N) of coils are connected to a 1XN switch that is on the other side connected to a coil drive and sense circuitry. The switch periodically switches each of the coils in rotation to the coil drive and sense circuitry. Once an appropriate receiver coil in the vicinity of a charger or power supply coil is detected, that coil may be interrogated further to verify a chargeable device is nearby and then charging or powering of the device begins.

[00249] One drawback of this scheme is that since each drive electronics module can at most only be connected to 1 coil out of N coils in each segment, 2 devices placed on 2 different coils in that segment may not be powered or charged simultaneously. In practice, since each device to be charged will cover a certain amount of area on the surface, by appropriately segmenting the pad and choosing the size of charger or power supply and receiver coils, one can minimize the impact of this effect.

[00250] For an extreme case that N= NC (i.e. the number of coils in the pad), one can use a single drive and sense electronics module to monitor and power any coil in the pad thus greatly simplifying the architecture and potentially the cost of the charger or power supply. However, only one receiver coil, and hence only one device may be powered up or charged at any given time. The desirable characteristics of the 1XN switch are:

- Low ON resistance: This would reduce wasted power in the form of heat at the switch.
- High current capability: For power charging applications, depending on application and device to be charged, 0.5 A and higher, up to several Amps of current may be carried in ON state.
- High reliability: Failure of a switch would render the related segment dysfunctional.

Fortunately, the switching speed of the 1 X N switch is not critical for this application. For example, if it is desired for the pad to have a 1 second response time (time it takes for the pad to sense a device and begin charging), the switch must be able to disconnect and establish a new connection in under 1/N seconds (ignoring the time it takes for the sense and control circuitry to work which can be extremely fast). As an example, for N=10, this switch

disconnect and connect time is under 100 msec, which is quite achievable. Even lower switching speeds are acceptable for longer response times.

[00251] In accordance with an embodiment, the 1 X N switches may be implemented by eiectronics circuits or SPOT or DPDT iC switches, relays, MOSFETs, or ivlicro-Electro-Mechanical Systems (MEMS) switches. Other methods for switching may also be employed.

[00252] As an example of a an IC switch for this application, a series of Single Pole Double Throw (SPDT) switches with relativeiy low R_{ds} of 80 mΩ that can be used in this application. An example of the SPDT is available in a Quad (four switches) pack and is capable of carrying 500 mA which is sufficient for most low power applications. If larger current carrying capability is desired, two or more of the switches may be used in parallel. This particular IC also incorporates over current, short circuit, and temperature sense circuitry which provides additional safety features for a system. A 1XN switch can be created by connecting several of such switches.

£00253] In accordance with one embodiment, the surface of a charging pad is divided into segments where within each segment, a significant Effective Area wherein the center of a receiving coil can be placed to receive power is created.

[00204] Figure **38** shows a case where a three-coil layer PCB is arranged to provide a cluster for uniform power in an area using only one coil powered at any given time. In this case, layer 1 comprises six coils arranged around a central coil for a totai of seven coils. The second and third layers comprise six coils totai. in total, nineteen coils exist in the three layers of the PCB.

[0020S] Figure 39 shows the coils are arranged such that by powering only one of the coils in the cluster, any receiver coil (for the receiver) placed with a center within any location in the effective area receive the specified power if the appropriate charger or power supply coil is activated. When the three layers are stacked together, seen from above, the structure is as shown in Figure 39. As described above, any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within haif a width of the center of at least one charger or power supply ∞ is. Therefore, it can receive the necessary minimum power or more with only one appropriate charger or power supply coil activated.

[00256] For the case shown in Figure 38 with nineteen distinct coils, five of the quad SPDT chips mentioned above can provide the necessary Switching capability to allow a single drive and sense circuit to sense the presence or absence of a receiver coil near each coil. In accordance with an embodiment, the sequence can be:.

- The switches are set so that the coil 1 in Layer 1 shown as (1,1) in Figure 38 is connected to a switching and sense circuitry similar to the left side of Figure 34 (i.e. the charger or power supply in Figure 34).
- MCU 1 gives a command to the FET driver to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- If a receiver coil is nearby, it begins drawing power from the charger or power supply coil. This can be sensed as a higher than normal current draw in the current sense circuit of the charger or power supply.
- AdditionaSly, the charger or power suppSy and receiver coii can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified,
- At this point, the amount of current through the sense circuit is digitized by MCU 1 and saved in its memory,
- Alternateiy, the receiver circuit can note the amount of voltage or power being received and report back to the charger or power supply. This information can be encoded by modulating the input impedance of the receiver circuit by MCU2. This information is then sensed by the charger or power supply sense circuitry, digitized by MCU1 and saved.
- The FET driver and therefore the FET are disabled.
- The switches are configured to connect the drive and sense circuitry to the next coil (Coil (1,2) in this example).
- Commands 2 through 8 are executed untii ail coils have been activated and tested.
- MCU 1 compares the values received for sense currents and determines which coil has the highest sense current when turned on. This is the closest charger or power supply coil to the receiver coil. If additionai circuitry for confirmation of valid receiver through exchange of code is implemented, the closest coil has to aiso pass this test
- The appropriate coii is turned on and charging starts. An additional verification can be performed prior to start of charge.
- The charging continues in open or closed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00257] Depending on the characteristics desired and cost/performance tradeoffs, it may be decided that for each cluster, 2 or more drive and sense circuits and a smaller number of switches are used.

[00258] Figure 40 shows one configuration wherein the number of switches required is reduced to three to switch to any of the 20 coils in Figure 39. The first switch connects the Vc to one of the ports (outside or inside contact point of the spiral coil) on every coil in one of

the three layers. The other ports of groups of three of coils from different layers are connected together and input into the switches 2 & 3 as shown in the figure. The outputs of Switch 2 & 3 *ar&* connected together, and connect to the FET for switching. The center coil (1,7) is connected to the poles of the switches by itself. This coil is often the most iikeSy coil for the receiver coil to be adjacent to since it is central. Comparing **Figure** 40 with **Figure** 34 shows that using this scheme,, any one of the coils in the system can be connected by the switches to be driven by the FET.

[00259] Depending on cost/performance trade-offs involved, it may be advantageous to cut the number of switches by schemes such as shown in Figure 40. Such a scheme can aiso be used to cut down the number of switches in a Sarger array. For example, the array in Figure 36 comprising 75 coiis would require 19 Quad SPDT ICs to implement However, by using one Switch to choose one of the 3 iayers and 7 switches to choose one of the 25 coiis in each layer, one can achieve the same results with 8 totai switches.

[00260] With further cascading of switching layers, it is possible to further reduce this number. However, it must be noted that cascading of switching iayers increases the Series Resistance along the current path of the charger or power suppiy coil which is undesirable.

[00261] In the exampies given above, the switching is shown for Point A in Figure 34 prior to the coils. However, Point B can also be used for this purpose.

[00262] The associated electronics are shown on the perimeter of the coiis but can be piaced in other iocations too.

[00263] Figure 41 shows a multi-charger or power suppiy pad that incorporates four of the dusters shown in Figure 39. A device to be charged or powered wouid have to be piaced such that the center of the receiver coii is within one of the effective areas in one of the clusters or segments. As an example, if the duster is made of hexagons with side lengths r, a hexagonai Effective Area in the center of the cluster with a maximal diameter of 5 r is created. The Effective Area ~ 19r achieved with 19 coils giving a Coverage Efficiency = Effective Area (in coil radius or side length Units)/Number of Coils = 1.

[00264] For a typical coil of r =0.625" side, this leads to a maxima! diameter of 3.125". Such an almost circuiar Effective Area with a diameter of over 3" can be marked on the surface of the charger or power suppiy pad and aSlows the user b easiiy place the receiver coil inside (or on) a mobile device such as camera, mobiie phone, batteries, game piayers, etc. in the right iocation for charging without much alignment and effort. Each of the dusters in the configuration shown in Figure 41 can have their own coil drive and sense circuits or may share this circuitry through muStipiexing with switches.

[00265] In this way, a practical system for providing a large Effective Area in each charging area (i.e. segment) while maintaining high power transfer efficiency is developed. A significant advantage is also that simuitaneous charging of multiple devices can be achieved.

[00266] It should be noted that the charger or power supply coils can be designed to be larger than the receiver coils. By doing so, one can obtain an even larger effective area and insensitivity to placement of the receiver coil. The Effective Area has a maxima! diameter of 3r. Other combination of coiS patterns to achieve Socai position independence with a number of coils can be constructed.

[00267] Figure 42 shows a cluster of 2 layers of 3 coils and a central coil (total 7 coils) that can create an effective area of 3r. In practice, such an area may be sufficient for many applications. It will be noted that while Hexagonal coils are shown in many of these figures, a combination of Hexagons and/or circles, or other shapes can be combined to provide the best efficiency/position independence performance. Similarly, the size and shape of the receiver can be non-Hexagonal.

[00268] For example, in Figure 42, the central and the receiver coil can instead be circular (spiral coil) and the central charger or power supply coil is the most likely charger or power supply coil for the receiver coil to be on top of. If the receiver coil is placed on any other position, a hexagonal coil is the closest coil and be powered. In accordance with other embodiments, the centra! coil in Figure 16 can be larger than the receiver coil and cover most of the likely central area. The remainder of the coils would only be used if the receiver is placed in extreme outside locations.

[00269] It must be noted that the foregoing description describes the situation wherein the transmitted power drops to acceptable levels when the coil centers are offset by half the radius. In practice, this value can be different and by using a combination of coil patterns and sizes and regulation of the transmitted power, uniform power transmission across an area can be maintained.

[00270] While the use of IC switching elements has been discussed above, other switching mechanisms such as IVIEIVIS, relays, etc. can be used to achieve the results. In accordance with other embodiments, the switching may be implemented by creating a deformabie layer under the coii layers to act as the switch. Each spiral coil discussed here has 2 ports with one at the outside diameter wherein the coil starts and one at the center wherein the coil terminates.

[00271] Figure 43 shows a mosaic of hexagonal coils with the central port to each coil shown as circles. In accordance with an embodiment, one of the ports of all of the coils in the 3 layers (in this case, the outside port) is connected to a common point, called here P1. The other port of each coii (shown as the centra! one here) in the mosaic pattern of Figure 42

is brought down through vias to a common layer at the bottom of the multi-layer PCB and connected to a copper pad with a certain surface area. Such a pattern seen from above (the same side as Figure 43} is shown in Figure 44.

[00272] Figure **44** shows the fop view seen from the same side. The side view of the pad has integrated MEMS switch for contacting individual coil contact pads,

[00273] In an earlier US patent application 11/869,113, the use of attracting magnets placed at the centers of an inductive charger or power supply's PC8 coil and the center of the receive coil to align and center the 2 parts conveniently has been described. Such techniques were used in the charger or power supply for mobile device or battery alignment.

[00274] In accordance with a present embodiment, a planar conductive layer or conductive traces patterned with conductive pads similar to the coil port pattern shown in Top part of Figure 44 and al! connected to a common point (called P2 here) is created on a flexible materia! film. Examples of the material for the flexible film are mylar, polyimide, fiexibie PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a small magnet or ferromagnetic material is attached to the other side of the fiim. Alternatively, a layer of ferromagnetic materia! is deposited and patterned to have a pattern similar to Figure 45 top so that only material with a pattern similar to the PCB port pad remains. The flexible film is attached to the bottom of the PCB such that a smaS! gap between the top iayer of the film and the bottom of the PCB is created by a spacer. The side view of the MEMS charger or power supply pad is shown in Figure 44.

[00275] The entire package shown in the bottom of Figure 44 has 2 electricai connection points. One from the PCB, called P1 that is connected to one of the ports of all of the coils in the 3 layers of the PCB (in this case the edge port). The other connection is to the common pads on the flexible film. This is called P2. Looking at Figure 34, the entire package can be treated as 11, and connect P1 to point A in this circuit and P2 to point C.

[00276] Ordinarily, none of the coii center ports are connected to the contact pads on the flexible film and therefore the circuit is not completed. If a receiver coil with a magnet attached to the back of its PCS coil and the magnet oriented with correct polarity is brought close to the pad, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest charger or power supply coii and at the bottom of the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the center port of the appropriate coil and close the circuit. In this way, current can flow only through the appropriate coil and then activate it.

[00277] In accordance with an embodiment, to avoid oxidation of the contact pads at the bottom of the PC8 and the flexible fiim contacts, these surfaces can be protected by deposition of additional layers such as gold or other material on top of the copper. Such

processes are often used in PCB manufacture to protect exposed contacts, In addition, the PCB pad package can be hermetically sealed to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with an inert gas such as nitrogen.

[00278] By optimizing the surface area of the contact pad and the flexibie film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of materia! used.

[00279] The configuration above is provided by way of example, In accordance with other embodiments, it is possible to connect the components in a different manner, or to piace in an external drive circuit in a different configuration to achieve the desired result. A 3 layer board has also been used to demonstrate this approach. Simpler constructions with 1 or 2 layers or configurations wherein the coils in the different layers have different functions or sizes and provide different power levels can also be implemented. The advantages of this approach are:

1- High efficiency: Only the appropriate coil for high coil overlap is activated.

2- Position Independence: The receiver coil can be placed anywhere with its center in the Effective Area and achieve specified power transfer.

3- Low cost: The pad does not use any IC switching elements for connecting to the appropriate coil.

As described above, in accordance with an embodiment the entire package in Figure 44 is connected between points A and C in the circuit of Figure 34. One example of the operation of the system is described in more detail here:

- MCU 1 gives a command to the FET driver periodically to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- Ordinarily, none of the coils is connected to point C in Figure 34. Therefore, no current is sensed in the current sense circuit.
- If a receiver coil is placed on the pad, it will cause the appropriate charger or power supply coil center port to contact the pad on the flexible film and therefore the appropriate coil is contacted to points A and C in Figure 34.
- The receiver coil begins drawing power from the charger or power supply coil. This can be sensed as a higher than norma! current draw in the current sense circuit of the charger or power supply.
- Additionally, the charger or power supply and receiver coil can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified.

* Once MCU1 determines that an appropriate receiver coil is on the pad and ready to draw power, the FET is turned on and charging starts. An additional verification can be performed.

♦ The charging continues in open or ciosed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00280] The description provided above describes what happens when the activation of the MEMS switch occurs through magnetic attraction. In accordance with some embodiments, the switch can be designed such that it closes at the appropriate location due to static attraction, pressure, temperature change, or other mechanism.

[00281] In the MEMS system described above, a disk or other magnet in the receiver coil attracts a magnet or patterned ferromagnetic layer attached or deposited under the flexibie fiim to dose the contact beneath the appropriate charger or power supply coil to the FET. However, in other embodiments a ferromagnetic layer can aiso be used in the middle of the receiver coil (on the front of the PCB, its back or separate layer from the coi! layer) and use either permanent magnets or deposit or sputter, etc. a patterned ferromagnetic layer that is permanently magnetized behind the flexible Sayer film. in this way, the charger or power supply pad would contain multiple magnetic points corresponding to the centers of the coils. When a ferromagnetic material is brought close to the pad, the appropriate coi! is activated. To avoid false starts with metallic objects placed on the pad, secondary verification techniques, as described above, can be used, inciuding in some embodiments an exchange of code between the charger or power supply and receiver coil.

[00282] Examples of metals that can be used are Ni, Fe, Co_1 or various commonly used alloys. These can be deposited on a flexible film in a variety of ways such as sputtering, evaporation, e-beam, plating, etc.

[00283] The system shown in Figure 44 is mostly designed to operate with a single FET and allow charging of a single device somewhere on the pad. If 2 devices are placed on the pad and 2 coils are connected to the pad, the power transferred may not reach the full specified power and it may not be clear which device is sending or receiving the control signals during charging.

[00284] In accordance with an embodiment, to overcome these issues, a segmented pad where dusters of charger or power supply coils are attached to individual drive and sense circuits and are independent of each other can be used.

[00285] The X-Y area is divided into segments (in this case 4 shown). One coil in each section can be driven by an appropriate FET and sense Circuit for that segment. Top: The pattern for contact pads at the bottom Sayer of the PC8. Each pad is connected to the centra! port of a cot! in one of the 3 iayers above. The top view is shown here. Bottom; The side view of the pad with integrated MEMS switch for contacting individual coi! contact pads. Spacers at the edges and the waüs of the segment areas keep the flexible fiim at a pre¬determined distance from the bottom layer of the PCB.

[00286] Figure 45 shows the architecture of the segmented MEMS charger or power suppiy pad in accordance with an embodiment. Each segment comprising a number of cotis is connected to points A and C of a different driver and sense circuit. Thus, devices piaced inside each segment can be driven with their own driver and are independent. In this way, severa! (in this case 4) devices can be charged or powered simultaneously.

[00287] In Figure 45, additional spacers are piaced at the boundaries of the segments. These spacers may help with keeping the flexibie film/PCB gap constant and operation of the flexibie fiim uniform aiong the X and Y direction. Such spacers interspersed in the X-Y piane between the PCB and flexible film iayer may be used regardiess of whether the pad is segmented eiectrically or not.

[00288] In accordance with some embodiments, the MEMS switching method described here can also be appiied to the duster geometry shown in Figure 41 or any other geometry.

Conductive *M*ulti -Charger or Power Supply Surface

[00289J As discussed above, in accordance with some embodiments, another method for charging or powering rnultspie devices on a common charger or power supply surface is to incorporate a number of connector points or strips into the pad. The user can p!ace a device with an appropriate connector on a pad or similar object and receive power through matching contacts on the pad. Figure 46 shows a genera! diagram for this approach is shown in. in this approach, one or more reguiated power supplies are connected to the charger or power suppiy pad. The pad comprises an array of contacts or strips of exposed connector.

[00290] Figure 47 shows an array of contacts on the surface of a pad. in Figure 47, each position comprises a Voitage and Ground contact. in this picture, the connector is shown as a recessed circSe similar to a washer where one contact is in the middle and the other contact is in the body or outside of the circie. Other connector geometries are possibie,

[00291] A device with an appropriate mating connector at its bottom or in a plug-in unit for after-market appücations can be placed on the pad and the connectors on the device make appropriate contacts to the pad contacts if piaced on one of the contact points. in

accordance with an embodiment, the connectors on the surface of the charger or power supply pad are connected to a number of switches which are connected to regulated power supplies and sense circuits as shown through switch arrays as shown in Figure 48. MCU1 periodically turns ON one of the regulated power supplies. The switches are set such that a connection is made to the 2 contacts of a contact point in the pad. The sense circuit detects any possible flow of current. if a current flow is detected, the system may verify the presence of a valid receiver through exchange of information through the contact with a MCU2 in the receiver. If no current is being drawn or the verification process fails, the MCU1 reconnects the supply to the next contact position. By rastering the entire pad periodically, contact to several devices on the pad for charging or power can be established, A diode D1 can be used for protection against reverse voltage, a Capacitor (C1) to filter any potential noise on the regulated power supply output, and MCU2 to enable communication between the Charger or power supply and the Receiver are shown. The receiver may also incorporate a voltage regulator to provide a constant voitage (or voltage in the acceptable range for operation) to MCU2. This voltage regulator just provides the low power necessary for this, and is not in the path of the main power going into the battery. Any power loss *due* to this regulator is small because it is very low power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained. However, these components are optional and may not be present depending on the architecture used. The description provided herein does not depend on use of these components for operation,

[00292] If the ground (through a sense circuit) contact for all positions is connected together, then Switch Array 2 can be eliminated. Care must be taken to interpret the received signals in interpreting the current sense values since it is the sum of currents from ail devices being charged.

[00293] The switching arrangements discussed above for the Inductive cases can be modified and used for this type of conductive switching as well. In addition, the MEMS based approach shown above are applicable to this application.

[00294] An embodiment for a universal charging pad using conduction is shown in Figure 48. In this case, one of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (Ground through the sense circuit in this case). The other contacts are brought through the charger or power supply surface to the bottom of the surface and contact pads are formed.

[00295] Top: The pattern for contact pads at the layer below the connectors. One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (through Sense circuit to Ground in this

case). Bottom: Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges keep the flexible film at a pre¬determined distance from the bottom layer of the PCB.

[00296] In accordance with an embodiment, a planar conductive iayer or conductive traces patterned with conductive pads similar to the charger or power supply surface contact pattern shown in Top part of Figure 48 and all connected to a common point {called P2 here) is created on a flexible materia! film. Examples of the materia! for the flexible film are mylar, polyimide, flexible PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a smaii magnet or ferromagnetic material is attached to the other side of the fiim. Alternatively, a layer of ferromagnetic material is deposited and patterned b have a pattern similar to the Top in Figure 47 so that it only materia! with a pattern similar to the charger or power supply surface pad pattern remains. The flexible film is attached to the bottom of the charger or power supply surface such that a small gap between the top layer of the film and the bottom of the charger or power supply surface is created by a spacer.

[00297] Figure 48 shows the side view of the MEMS conductive charger or power supply pad. Using the MEMS conductive charger or power supply pad eliminates the need for switching arrays.

[00298] In accordance with an embodiment, the entire package shown in the bottom of Figure 48 has two electrical connection points. One from the top surface, called P1 that is connected to one of the connector points of aii of the connector positions on the charger or power supply surface (Ground in this case). The other connection is to the common pads on the flexible fiim. This is called P2, and is connected to the other position in the circuit. For example, for the geometry discussed here, P1 can be connected to Point B in Figure 49 and P2 connected to Point A. Figure 49 is a generalized biock diagram of a charger or power supply pad with multiple regulated power supplies.

[00299] The case discussed here and the pad in Figure 48 enable connection of one regulated supply to one or more devices placed on the pad. However in the case of multiple devices on the pad, the voltage characteristics of the device would have to be identical to the first one and the sum of powers being drawn from the supply not exceed the maximum rating of the power supply. A more generalized approach wherein different voltages/power can be supplied to different devices is discussed in further detail below

£00300] Ordinarily, none of the connectors are connected to the contact pads on the flexible film and therefore the circuit is not completed, in accordance with an embodiment, if a receiver with a magnet attached to the back or perimeter of the connector and the magnet oriented with correct polarity is brought close to the charging surface, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest contact pad and at the bottom of

the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the contact pad for the appropriate connector at the bottom of the charger or power supply surface and close the circuit. In this way, current can flow only through the appropriate connector into the receiver circuit and the device to be charged.

[00301] As described above, to avoid oxidation of the contact pads at the bottom of the charger or power supply surface and the flexible film contacts, these surfaces can be protected by deposition of additional layers such as gold on top of the Copper. Such processes are common to protect exposed contacts. In addition, the pad package can be hermetically seated to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with *an* inert gas such as nitrogen.

[00302] By optimizing the surface area of the contact pad and the flexible film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of materia! used.

[00303] Top- The pattern for contact pads at the layer below the connectors One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad to form contact point P1. Bottom; Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges and the walls of the segment areas keep the flexible film at a pre-determined distance from the bottom layer of the PCB. The contact pads in each segment of the flexible film are connected together to form contact P2 for each segment.

[00304] Figure 49 shows another embodiment where several regulated power supplies provide power to the pad. This allows charging of several devices simultaneously.

[0030S] Figure 50 shows an alternative embodiment using a segmented surface. The operation of this is similar to previously described except that the top and bottom contact points for each segment P1 and P2 are connected to the appropriate positions in B and A in Figure 49 so that each regulated power supply is connected to one of the segments in the charger or power supply surface when the circuit is closed. In this way, a device placed on each of the segments can be powered by the regulated power supply at its required voltage and power level.

Electromagnetic Shielding

[0030S] Electromagnetic Interference (EMI) is an important aspect of performance of any electronic device. Any device to be sold commercially requires adherence to regulation in different countries or regions in terms of radiated power from it.

[00307] For an inductive charger or power supply comprising a number of coils and electronics switches and control circuitry, the main sources of noise include:

• Any potential radiated noise from switching FETS, drivers, etc. or sense and control circuitry. This noise can be at higher frequency than the **fundamental** drive frequency of the coils and can be emitted away from the charger or power supply because of the frequency. This noise can be minimized by optimizing the drive circuit to avoid sharp edges in the drive waveform and associated noise.

• Noise from copper traces with ac signals. This noise can also be at higher frequency and emit away from the charger or power supply. The length of these paths must be minimized.

• EM emission from the switched coil For coils described here and driven in the tOQ's of kHz up to severai MHz, the waveiength of the Electromagnetic (EM) field generated can be in the hundreds of meters Given the smaSi length of the coils windings (often 1 m or less), the coils used are not efficient far-field transmitters of the EM field and the generated EfV! fiβid is in genera! highly contained near the coil surface. The magnetic flux pattern from a PCB coil is highly contained in the area of a coil and does not emit efficiently away from the coil.

[00308] Care must be taken when designing the current paths, and in some embodiments shielding of the FETs or other ICs or electronics components may be necessary. in addition, switching the coils with waveforms that have higher frequency components, gives rise to noise at higher frequencies. In any of the above geometries described, incorporation of conductive layers and/or ferromagnetic layers in the system can shield the outside environment from any potential radiative fields. The conductive layers may be incorporated in the PCB to eliminate the need for additional separate shielding layers.

[00309] In the examples provided above, while the 3 coil layers can be incorporated into PCB layers, the electronics components can be placed on the lower most surface of the PCB to allow a flat surface on the top and allow receiver coils to get as ciose as possible to the charger or power supply coils. One possible arrangement for the location of the electronics components at the bottom surface of the total PCB stack is shown. In this case, in some or all of the layers above, the PCB layers can incorporate Copper sections in the areas shown in black in this figure. By appropriately grounding these sections and providing additional conductive and/or magnetic layers below the electronics components, the EMI can be significantly reduced.

[00310] In accordance with an embodiment, another method for minimizing the effect of the copper traces in the PCB is to sandwich them between layers of conductors in the PCB. in a muiti-layer PCB, the copper trances and connections to all the components and coils can be for example, be in a middle layer and the necessary connections to the iCs or other layers be made through vias. Given that the magnetic flux is highly contained within

the coil area, the layer containing the coil or another layer below or above can contain a substantially continuous layer of copper covering everything except the area of the flux generated by the PCB (very cfose to the outside ring of the coil). By having two or more conductive PCB layers for shielding sandwiching the signal and current paths, most of the noise generated can be shielded very dose to the source. Since the noise from the PCB is minima! and does not radiate, the remaining source of noise, the electronics, FETS, etc. can be shielded by covering the section with these devices with a metallic cover or shield.

[00311] Similar types of judicious incorporation of grounded Copper layers in the PCB layers in any of the designs above can significantly reduce any potential EMI issues without requiring additional shielding iayers.

[00312] Figure 51 shows a standard used within the European Union for measuring emissions from a product. in this case, the emissions from a product are measured at 10 m distance. This test {EN 55022) looks for emissions from 30 MHz to 1 GHz. Limits for Class A and Class B certification are shown in the Figure.

[00313] Figure 51 shows a typical scan of emissions from an inductive multi-charger or power supply pad. As discussed above, the radiation at the fundamental operating frequency (10G's of kHz to several MHz), can be self-contained within the coil area. However, noise at higher frequencies (such as the test range of 30 MHz to 1 GHz) must be reduced to avoid interference with other nearby electronic devices

[00314] Mβtailic and/or Ferromagnetic layers are often included in eiectronic devices to reduce their EM emission. An example of such iayers is described in U.S. Patent Nos. 6,888,438, and 6,501,364, In these instances, PCB coils are formed on two sides of a PCB, and ferromagnetic and copper iayers are placed on each side of the PCB to iimit emissions from a package containing such a transformer,

Frequency Selective Electromagnetic Shielding

[00315] In accordance with some embodiments of the inductive universa! charger or power supply pad described herein, the inclusion of metallic and/or Ferromagnetic layers at areas that are potential sources of emission such as FETs, etc. may be beneficial. However, a method that would wholly cover the charger or power supply pad package to βiiminate potentia! for escaping Elvl fields may provide benefits.

[0031 6] Given that the inductive charger or power supply pad operates by generating an oscillating magnetic field, such an approach does not seem feasible as it would block such a field from being sensed by the receiver coil.

[00317] In accordance with an embodiment, a method is described herein that allows the inductive pad to emit EM waves efficiently for operation while simultaneously providing

shielding to high frequency EM fields. Such operation is achieved by taking advantage of the skin effect in conductors.

[00318] The skin effect is the tendency of an alternating electric current {AC} to distribute itself wtthin a conductor so that the current density near the surface of the conductor is greater than inside the material. That is, the electric current tends to flow at the "skin" of the conductor.

[00319] The skin effect causes the effective resistance of a conductor to increase with the frequency of the current and has practical consequences in the design of radio-frequency and microwave circuits.

[00320] The current density j in an infinitely thick plane conductor decreases exponentially with depth δ from the surface, as shown below;

$$J^{T} = J_{S}^{T} e^{-\delta/d}$$

where d is a constant caiied the "skin depth". This is defined as the depth below the surface of the conductor at which the current density decays to 1/e (about 0.37} of the current density at the surface. It is given by:

$$d = \sqrt{\frac{2p}{\omega\mu}}$$

Where;

p ~ resistivity of conductor

ω = angular frequency of current = 2τr × frequency

μ = absolute magnetic permeability of conductor = $\mu_0 \cdot \mu_r$, where μ_0 is the permeabiiity of free space and μ, is the reiativa permeability of the conductor.

It is important to note that d decreases rapidly with frequency. The magnetic and electric field similarly get attenuated traveling through a sheet of a conductor. Using the values for conductivity of copper (5.8x10^7 Siemens/m), the absorption going through a single layer of copper with various thickness can be calculated.

[00321] Figure 52 shows the absorption through a copper layer of 70 m and 7 m. While the 70 m layer provides very high attenuation in the region of interest (30 MHz to 1

GHz), the attenuation is excessive in most cases and is only needed in extraordinarily noisy circumstances.

[00322] As described herein, the transmitted power is considered through a very thin conductive layer,

[00323] Figure **53** shows how the attenuation values are shown for Copper and Aluminum (conductivity of $3.76x10^7$ for 99.99% A!) layers for several thicknesses.

[00324] For these calculations, the placement of the layer with respect to the source of the EM field needs to be included. In these calculations, the source is assumed to be 0.5 mm under the layer. This is similar to placing the layer essentially directly on the source of the field.

[00325] It will be noted that, for very thin layers of Copper and Aluminum, down to 1 micron thickness, very high attenuation values at frequencies over 1 MHz are obtained. The attenuation of 1 ¬m layers of Copper and Aluminum at 10^6 Hz are respectively 32 dB and 28 dB and are comparable. However, at 1 MHz or below, the attenuation in either material for such a thin layer is minima!. In accordance with some embodiments, this behavior or characteristic can be exploited.

[00326] Figure 54 shows Transmitted EM Power through Copper and Aluminum layers of varying thickness for an incident EM fieid at 1 MHz which is a typical operating frequency for the type of inductive universal charger or power suppSy described herein. Below 5 J v.im thickness, the transmitted power exceeds 95%. Aluminum in particular (due to its lower conductivity), has a wide range of thicknesses that allows a 1 MHz radiation to transmit through without much attenuation.

[00327] As discussed above, in some embodiments of the inductive charger or power supply device described herein, the generated EM field at the operating frequency of the charger or power supply (typically ~ 1 MHz), is generated by an inefficient PCB coil antenna and is mostly confined b the area immediately near the coil (to be picked up by the receiver coil). However, any noise generated by driving the coil at this fundamental frequency (due to nonlinearities at the components, non-sinusoidal signal, or at the FET or the FET driver) or any noise generated at any other location in the charger or power supply device current paths or components or the receiver (including noise generated at the receiver rectifier), can have components that are much higher in frequency. It is desirable to suppress such noise to the extent possible.

[00328] In accordance with an embodiment, a very thin layer of a conductor (such as Copper or Al, organic conductors, nanotech materials, nanotubes, or other material), covering ali or part of the charger or power supply and/or receiver circuit can be used to aliow the desired low frequency components (Several MHz or below) to travel through without

attenuation while severely reducing the higher frequency noise, In accordance with some embodiments, the entire inside or outside surface of the charger or power supply and/or receiver package circuitry or part of it is covered to achieve this frequency selective shielding without dramatically affecting the fundamental operation of the device.

[00329] In one embodiment, the entire inside or outside of the package for the inductive charger or power supply and /or the receiver for such a charger or power supply is covered by a thin layer of a conductor (15 ¨rn thick or less or preferably less than 5 ¨m thick}. The conductor can be metallic as discussed above, rneta! alloys, organic, nanotech materials, nanotubes, etc. At high frequencies, such a layer reduces the emitted EM power considerably (greater than 20 dB or even 30 dB) while allowing most (>90%) of the fundamental operating frequency power to transmit through the layer. The conductive layer can be directly deposited on the parts. To avoid shorting of any electronics or connectors, contacts, a dielectric layer, paint or other material must be first deposited. Alternatively, the conductive parts can be masked off so as not to contact the EM shielding conductive layer.

[00330] The deposition of the conductive material can be done in a variety of manners (sputtering, evaporation, electroplating, coating through dipping, Langmuir Biodgett, painting, etc.) for different materials. Recently, an inexpensive method (Ecoplate) for conformally coating any materia! with metallic or metal alloy layers at room temperature has been developed. In this process, a spray of moiten metal at controlled temperature and velocity instantaneously cools on incidence with a substrate and forms a conformal layer covering the entire or part of a part.

The EM conductive shield can also be deposited onto a substrate such as a polymer (e.g. mylar, polyimide, polyurethane, plastics, etc.), rubber, etc. and the conductive iayer coated polymer be applied to the inside or outside of the part. Anti-static bags *&r&* an example of a metaiized polymer material. Aluminum is commonly used for this application.

[00331] In another embodiment, the PCB boards, electronics components, and the coils in the charger or power supply and/or the receiver are covered by a nonconductive layer (such as a dielectric, paint, etc.) and then covered completely or locaiiy by a conductive iayer of appropriate thickness either directly deposited on the board and the electronics or indirectly with a polymer or similar backing (as described above).

[00332] The optimum thickness of the conductive materia! is highly dependent on its conductivity. By choosing the materia! composition and thickness, one can obtain the desired combination of Elvl noise suppression and transmission of fundamental frequency,

[00333] It is also possible to combine conductive layer materials and thicknesses to construct a more tailored frequency response. Such an approach is commonly taken in the optical domain to fabricate wavelength dependent filters.

[00334] In those embodiments wherein the conductive layer covers the charger or power supply and/or receiver cot!, it may be desirable to generate an EM field with a charger or power supply coil and then, after passing the emitted field through such a conductive layer, turn it back to DC power through the receiver coil and rectification. Since the conductive layer is a frequency dependent filter, in this process, this removes or weaken any higher frequency signals and enables the receiver to receive a cleaner, and depending on the design, more sinusoidal signal. Such high frequency noise is often related to not-only EIVIS disturbance and lack of signal to noise ratio in the electronic device b be charged. In addition, the higher frequency noise causes non-optimum operation of the receiver and possibly heating of the receiver or other components. By removing the generated noise, electrical and thermal/en vironr πental performance of the charger or power supply and receiver system may be improved,

[00335] Such a physical filtering of an electrical system is analogous to an optical signal being filtered in the wavelength domain (by an optical filter, grating, etc.) before reaching a receiver. The SNR and efficiency of the system is improved in this way.

Use of Magnets for Alignment of the CoUs

[00336] Figure 55 shows a method for obtaining local alignment independence between the coils in the charger or power supply and the receiver are shown therein. In accordance with an embodiment, by using small magnets behind (on the side opposite to the side facing the surface of the charger or power supply) the center of each coil in the charger or power supply, and behind (on the side opposite to the side facing the surface of the charger or power supply) the coil in the receiver, such that the magnets attract each other, a charger or power supply system can be provided wherein the user can easily find the location where the charger or power supply coil is located, without providing any physical features and/or marking on the surface of the charger or power supply. This may be advantageous in enabling charger or power supplies which can be used with any device to be charged without need for special alignment or size features. This allows charging of any si2e and shape device and/or battery. In this geometry, shown in Figure 55, the magnets can be thin flat or other shape magnets placed at the center of the coil and allow the device or battery to be charged to be rotated around the charger or power supply coil with no effect.

[00337J As described above, by enabling the coil in the charger or power supply to move laterally (and somewhat vertically) in the plane of the charger or power supply surface, automatic alignment of the charger or power supply and device and/or battery coil can be achieved when a device and/or battery is laterally brought close to the center of the charger or power supply coil.

[00338] If magnets used for this application are electrically conductive, then some of the field generated by the coil will generate currents in the magnet and heat the magnet, decreasing the efficiency of the system and generating unwanted heat. This effect especially becomes important as the field strength of the cotl is increased for higher powers,

[00339] In accordance with some embodiments, methods for dealing with this problem can be included, such as:

- Since the currents are created by eddy currents generated in the magnets, use of non-conductive and/or low conductivity magnetic material can improve this condition.
- The magnet can be constructed of thin flat magnet material with laminate in between the layers to decrease the current flow and loss of power.

[00340] Figure 56 show an embodiment in which the magnets can be broken or divided into sections, such as semi-circles with a gap or non-conductive material in-between to avoid current circulation. By having each set of magnets behind a coil to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In this figure, each set of magnets behind a coil are made of semi-circular magnets. The poles of the magnet are aligned with the South or North pole facing the surface of the charger or power supply. The magnet in the device or battery have the opposite polarity so that the magnets of the charger or power supply and the device and/or battery attract. By having each set of magnets behind a coil to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In Figure 58, each set of magnets behind a coil are made of two semt-circular magnets.

[00341] Figure 57 shows an embodiment in which one or more alignment magnets can be used behind each coil. However, in accordance with an embodiment the magnets are placed such that each magnet does not cover an area extending beyond the center of the coil. In other words, the surface of the magnet does not cover the center of the coil and thereby does not allow circular currents to be set up in the magnet as effectively. In this way, the eddy currents set up are much weaker and much smaller power dissipation in the magnets occurs. Alignment magnets at center of charger or power supply and device and/or battery coils for alignment of the two coiis are attached to the back of the coils in such a way that the area of the magnet does not extend beyond the center of the coil. In this way, the eddy currents created are much weaker and much less power is lost to the magnets. In this figure, two magnets are shown per back of each coil (four total for a pair of charger or power supply and receiver magnets). However, any number of magnets from one to many can be used.

Additional Applications - Charger/Power Supply with Se5f-Powered Operation

[00342] Figure 58 shows an illustration of a device for inductive power charging that includes an interna! battery for self-powered operation, in accordance with an embodiment. As shown in Figure 58, an inductive charging unit such as an inductive pad 360 includes a rechargeabie battery 364, The unit is normally operated with, or is occasionally coupled to, power input from an electrical outlet, or from a dc source such as a standard automobile 12 volt dc outlet, or from an outlet in an airplane or an external dc source, or from another power source such as the USB outlet from a computer or other device. Aiternattveiy, the power can come from a mechanical source such as a windmill, or a human-powered crank handle. The unit can include coils 362 that are energized to transfer power to receiver coiSs in mobile electronics devices such as mobiie phones, MP3 piayers, radios, cd players, PDAs, and notebook computers. At the same time, the input power charges the rechargeable battery inside the unit itself. When the external power source to the unit is disconnected, or when no input power is provided, the unit automatically switches its operation from its charged internal battery. Alternatively, the unit's operation can be switch-operated by user. in this way, users can continue to charge their devices by placement on the unit without any outside power source. This use can continue until the external power is restored or until the internal battery is completely discharged.

£00343] The ability of the unit to continue charging depends on the capacity of the battery included. Thus, for example, with a 1500 mAH interna! battery, the unit is able to charge a mobile phone with a 1000 mAH battery completely if the losses due to conversion efficiency, operation of the circuitry in the unit, and other losses are up to 500 mAH.

|00344] In other embodiments of an embodiment, the unit can be powered by other power sources such as a fuel cell that generates power from methanol or other sources. The unit can also be connected to the electric grid through an outlet or to an external DC power source such as power from an outlet in a car or airplane or be itself charged or powered inductively by another unit. However, when not connected to outside power, the unit can be powered by its internal power generator from the fuel cell and can charge devices placed on it inductively.

[00345] Figure 59 shows an illustration of art alternate embodiment of art inductive charger or power supply unit or pad 370 with a solar cell power source for self powered operation, in accordance with an embodiment. As shown in Figure 20. the surface of the unit can be covered by a solar panel or solar ceil 378. In normal operation, the unit can be powβrβd-up or charged by connection to an electric outlet or external DC source. But without external electric power, the pane! generates electric power that is used to power the charger

or power supply which in turn can charge devices placed on if through the inductors in the unit. In some embodiments the unit can also include a rechargeable battery 374 that can be charged when the unit is either connected to externa! electric power or charged by the solar cells on the surface of the unit. This battery can then operate the unit when the unit is either not connected to external electric power or the solar eel! is not generating enough power to run the unit such as during operation at night.

[00346] **Figure 60** shows an illustration of an inductive charger or power suppiy unit with an incorporated communications and/or storage unit, in accordance with an embodiment. As shown in Figure 21, in accordance with some embodiments the charger or power supply, including for example the regular charger or power supply 380, and the solar-cell powered charger or power supply 382, can further comprise an optional communications and/or storage unit, for storage of data and transmission of data to and from a mobile device being charged. Examples of components that can be incorporated include Bluetooth, Near-field Communications (NFC), WiFi, WiMax, wireless USB, and proprietary communications capabilities, including means of connecting to the Internet.

Additional Appiications - Inductive Charger Applications and Kiosk

[00347] The technology described herein may also be used for other appiications. in some applications, it may be desirabie to buiid the inductive (as described above) or wire free charger or power supply into a case for an electronic device, a briefcase, or other carrier such as a box, holder, or container in a car or other wise. An example can be a brief case, hand bag, or back pack where the bottom part or the outside surface has an integrated charger or power suppiy. Any device enabled to receive power from such a charger or power supply (device containing coiis and the appropriate electronics to receive power or with appropriate contacts for wire free charging) can be placed on or inside such a briefcase and be charged. The charging circuitry can be powered by plugging the briefcase, handbag, or back pack into an outlet power or having internal batteries that can be charged through power from a wai! plug or by themselves being inductively charged when the briefcase, handbag, or backpack is placed on an another inductive or wire free charger or power suppiy. Uses can be applied to any bag, container, or object that can be used to essentially charge or power another device. This first object can itself be charged or powered through an outlet directly by wires or wirelessly through an inductive or wire free charging system. As an alternative, the first object (the charger or power suppiy) can be powered by solar cells, Fuei cells, mechanical methods (hand cranks, pendulums, etc.).

[00348] In ail of the above case, it is possible for the functions of the inductor or wire free charger or power supply and the power source for the charger or power supply (battery,

fuel cell, solar cell, etc.) to be separated. Furthermore, in some cases, the charger or power supply part can be separated from a portable power source to operate it (such as a rechargeable battery) which is in turn powered or charged by another source (power outlet, fuel ceil, solar cell, mechanical source, etc.). The three parts can be in the same enclosure or area or separate from each other.

[00349] An additional example may be an after market inductive or wire free charger or power supply for a car where the inductive or wire free charger or power supply or pad including a solar ceil on the pad or in another area and connected to the pad by wires is used to charge mobile devices. Such a device placed on the dashboard or tray between seats or a special compartment can be used to charge a number of devices such as phones, MP3 players, cameras, etc. Devices such as GPS navigation systems, radar detectors, etc. can also be powered from such a device. in another application, mugs, cups, or other containers with a receiver circuitry and means of heating or cooling the contents can be used in combination with the inductive charger or power supply to keep the contents hot or cold. A dial or buttons on the cup or container can set the temperature. The charging device or pad can also contain rechargeable batteries that allow the device or pad to store energy and operate in the absence of any external power if necessary.

[00350] Other applications of this technology include clothing, jackets, vests, etc. that have an integrated inductive charger or power supply such that a user can power or charge a device by simply placing it on or near a pocket or an area where wireless inductive power is available. The jacket or clothing can in turn be powered by solar cells, Fuel cells, batteries, or other forms of energy. It can also be powered by batteries that are recharged through solar cells sown onto the clothing or be recharged by placing or hanging the clothing item on a rack or location where it is recharged wirelessly or inductively. By using inductive charging, the user does not have to plug in devices into individual wires and connectors at the appropriate jacket pocket.

[00351] In some cases, it may be desirable to build the charger or power supply or the secondary part (receiver for a charger or power supply) into the protective case of another device. For example, many products exist today that are after-market or optional items such as a skin or case for a music player, phone, PDA, or notebook computer. In one implementation, the case or skin can contain the electronics and the coil necessary to allow the device to be charged or charge other devices or both. The charger or power supply can be powered by the device if is attached to or can receive power from a separate source such as a solar cell, fuel ceil, etc. that is integrated with the charger or power supply or in another location and electrically connected to the charger or power supply. For example, in a briefcase, while the charger or power supply is inside the briefcase and can charge devices

inside, the surface of the briefcase can have solar cells that power the charger or power supply inside. The briefcase can aiso contain rechargeable batteries that store power generated by the solar ceiSs and use them when necessary to charge devices inside. Similarly, the charger or power supply can be built on the outside or inside surface of the case and charge devices piaced on or near the surface.

[00352] It is also possible to provide a charger or power supply with modular components that allow other capabilities to be added later or simultaneously as an option. In one embodiment an inductive charging pad that contains a rechargeable battery can have a separate top surface module or ali around cover or skin that contains a solar cell array and simultaneously electricaiiy connect to the charger or power suppiy pad to enabie the battery internal to the unit to be charged without any externa! power input. It is also possible to have the cover or the outside skin to provide other capabilities such as communications, or simpiy provide a different look or texture so that the pad fits in with the user's taste or decor.

[00353] **Figure** 81 shows an iiiustration of a kiosk that incorporates an inductive charger or power supply unit in accordance with an embodiment. As shown in Figure 81, the kiosk 390 includes a control screen 392 and an inductive charging pad 394, to aiiow individuals to walk-up and purchase an occasionai charge for their mobile device. Currently, the usage mode! of typical mobile user consists of charging their most essential device (phone, MP3 player, Bluetooth headset, etc.) during the night or at the office or car. In cases where the user is outside their environment for a long time such as traveling, this may not be possible. A variety of public mobile device charging stations have appeared that allow the user to charge their device in a public setting by paying a fee. An inductive or wire free public charging station or kiosk would allow the user to place their mobile device that is 'enabled' (i.e. has the appropriate receiver or components to allow it to receive power from the charger or power supply) on or in the wire free or inductive charger or power suppiy station and charge the device. The customer can pay for the service or receive the service for free depending on the service providers' approach. The payment can be cash, credit card, debit card, or other methods.

[O03S4] In accordance with an embodiment, a single pad with multiple stations can charge multiplicity of devices simultaneously. The user may be asked to pay for the service before charging a device or the service may be for free. Alternatively, each charging station can be in a compartment and the device is secured by a door that can only be opened through a code given to the device owner when charging starts or payment occurs. The door can also be secured by a combination lock or physical key.

[00355] Alternatively, the charging station or kiosk can be open and not physically secure but when the user pays for the service, a code is issued. The user proceeds to place

their device to be charged but when the charging ends or the user wants to pick up the device, the code must be entered first. If no code is entered, an aiarm is sounded or the device is deactivated or some other warning occurs. In this way, a thief or the wrong user can not remove the device without attracting attention that may act as a deterrent, A combination of the above techniques may be used in implementing a public charging kiosk,

[0035S] Since a typical charging process can take up to 30 minutes or more, it is possible to aiso synchronize data, downioad songs, movies, etc. into the device during this time. Many of current mobile devices have Bluetooth or WiFi capability. Other communication protocols such as WtMax can increase the data rate further. By combining the charging and information transfer process, the service provider can charge for additional services. In addition, if a camera is being charged and has wireless capability, it can download the pictures or movies to a designated website or online storage area or be ©mailed to a designated email address while charging. In this way, a traveler can simultaneously charge a camera while downloading the contents of its memory to a location with larger memory. This would enable the traveler to free up limited memory space in their camera or other mobile device. Such a service would enable devices that have limited or short range wireless communication capabilities (such as mobile phones, MP3 players, cameras, etc.) to be able to connect to the internet and send or receive data indirectly. It is important to recognize that without the charging capability, a device conducting such downloading or synchronization through an intermediate device (Bluetooth to internet gateway for example) often run out of power due to the length of time this takes. In this manner the charging capability of the kiosk enables a more effective operation.

Additional Applications - Inductive Charger Applications and Kiosk

[00307] With increased functionality in mobile devices, there is an ever-increasing focus on maximizing the battery life. Currently, the rate of increase of power usage continues to outpace new and improved battery technologies. Given the desire to minimize mobile device size, the battery power limitation has required some mobile device manufacturers to begin shipping mobile devices with several batteries and a desktop charger to keep ail of those batteries regularly charged. The user is sometimes expected to change the batteries for the device during the day while using the device. Such a situation is not ideal and puts the burden on the user to carry multiple batteries, and to keep those batteries charged,

[003S8] Methods for extending the battery life in mobile devices, but which do not greatly increase the size and weight of the mobile device, are extremely useful for new power hungry enhanced multi-media mobile devices. By way of example, one solution that has

been proposed is described in U.S. Patent No. 6,184,854. However, such a technique and geometry is incompatible with the variety of mobile devices and connectors in use today, and requires the user to piug the device into a connector inside the holster whiie fastening it to hold it securely.

[00309] Described herein is a system and method for extending the battery life of mobiie devices by integrating a wireiess charger into the case, carrier, or holster for the device. The system and method has the advantage of keeping the size and weight of the mobile device iow while enabling the user to automatically recharge the device when placed in the case thereby dramatically increasing the device run time.

[00360] In one embodiment, the case recharges the mobile device inductively, and can itself be recharged by an inductive base charger. Various embodiments including additional integrated functionality such as data storage and communication in the case are aiso described herein.

[00361] Figure 62 illustrates some common regular (non-charger) mobile phone holders types, including a belt holder 1000 and case 1002.

Powering Mobile Devices and Inductive Charging Case

[00362] Mobile devices continue to converge and to combine multiple functions and protocols into ever-smaller packages While mobile TV, radio, high resolution cameras, GPS, etc. are becoming standard in many mobile phones, the power usage of the devices continues to rise. One solution that has been applied to several devices is the use of external battery packs.

[00363] Figure 63 illustrates various products for a music player, (e.g. an iPod or MP3 player) that include an external rechargeable battery pack.

[00364] As shown in, the external battery pack provides extra running power for the device when it is plugged into the music device and clipped to its back. by providing power through the battery pack's internal higher capacity batteries. However, this battery pack is expected to remain connected to the device at all times and increases the size and weight of the device considerably. This is very undesirable from the customer perspective and inhibits mobility/use and adoption.

[00365] In accordance with embodiments of an embodiment, the battery power of the mobile device is extended by providing a holster, case, pouch, bag, wallet, or an equivalent holding, carrying, or storage device (which for convenience are herein referred to as a "case") for the mobile device {e.g. mobile phone, Bluetooth headset, camera, laptop, PDA, MP3 player, game player, etc.). The case can incorporate one or more rechargeable batteries, and one or more inductive charger or power supplies. A mobile device can be

'enabled' to receive power inductively by providing a receiver (such as a coil, etc.), and circuitry integrated by the manufacturer, or by a battery with a built-in receiver, or by a plug-in unit to receive power, etc. A suitabiy enabled device can thus receive power when placed in the case, in accordance with some embodiments, the case can aiso incSude means of recognition of the device automatically by, for exampie, RFiD, Feiica, detection of coii from change in the case's coil's induction, or by verification using proprietary techniques, etc. in some embodiments, the system or coil can be enabled to turn on automatically as necessary and to begin charging the device. Alternatively, the case and/or coils can turn on when a device is placed in it by sensing the presence of a device through a magnetic, mechanical, or other form of switch. Alternatively, the case can include a mechanical or sensory switch that must be manually activated by a user to begin charging the device.

[00366] In accordance with some embodiments, the case can accommodate more than one device. For example, the case can include a location for a Bluetooth headset and a mobile phone. Either or both of these devices can be inductively charged by the case when placed inside the case. This enables the user to have a simple way to carry both parts or devices together, and to extend the battery capacity of both without needing them to be any larger, thus providing great advantages for the consumer.

[00367] In accordance with an embodiment, the batteries inside the inductive charger case can themselves be charged by either a regular charger/power supply, or through another inductive charger or power supply. For example, a desktop inductive charger can charge the inductive charger case, and simultaneously charge the mobile devices (mobile phone, Bluetooth headset, camera, etc.) or battery. Alternatively, the desktop charger or power supply or base can be designed so that it can also charge the mobile device directly when the device is placed on it (without any case present). As described above, the inductive case can aiso be designed so that it will charge its internal batteries, and the devices inside, when it is connected to a regular power supply/charger.

[00368] Some embodiments of the case can include data storage, communication or other capabilities (for exampie, GPS, WiFi, etc.).

[00369] Figure 64 illustrates a multi-function device that includes a hard drive, rechargeable battery, Bluetooth, and WIFi connectivity.

[00370] Typical multi-function devices such as that shown in Figure 64 are of the size of a credit card and about 10mm in thickness. The multifunction device allows a mobile phone user to store the majority of their digital data (pictures, movies, music, etc.), and to have that data available wirelessiy on their mobile devices. The mobile phone and multifunction device can also connect wireiessiy to a computer or laptop, for download or upload of information.

[00371] In accordance with an embodiment, a multifunction device such as that shown in Figure 3 can be integrated into the case, and can have a wireless charger or power supply built into it. Once a mobile device is placed into the case or on the modified multifunction device, it can establish communication, and/or can be charged simultaneously. Since a typical multifunction device already has internal rechargeable batteries, the same batteries can be used to power the charger for the mobile device. The multifunction device case can also be charged wirelessly (using an inductive charger or power supply pad or similar device), or through conventional means.

[00372] In other embodiments, the wireless charger or power supply case can be integrated into a compartment in a briefcase, handbag, backpack, carrier, clothing, automobile, airplane, or other transport vehicle, etc. Some of these are applications are described in further detail in copending U.S. Patent Application titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application No. 11/869,113, incorporated herein by reference.

[00373] Figure 65 illustrates a system for use with a charger or power supply case to inductively power or charge a mobile device. As shown therein, an inductive charger or power supply base or pad charges a case, holster, or other small, portable charger that in turn can charge or power a mobile device or battery placed in proximity to it. The second part (charger case) can be a stand-alone device or be integrated into another device, as in the case of the multifunction device example described above. In other embodiments, the charger or power supply case can be charged or powered through a conventional, wired charger or power supply, In accordance with an embodiment, the system comprises:

[00374] Inductive Charger or Power Supply Base; In accordance with an embodiment, this part can be a stand-alone charger or power supply or desktop charger or power supply that comprises a Field Effect Transistor (FET) that periodically turns the current through a coil on and off. In one embodiment, for a typical 9 turn PCB coil with 1" diameter, a drive frequency of 1-2 MHz is ideal, and the power transfer efficiency is increased when a capacitor of appropriate value is placed in parallel with the FET. When the circuit is driven at a resonant frequency, the amount of current through the FET can vary greatly by proximity of another coil (L2) to LI To allow the system to operate automatically, a current sensing system can be used to sense the secondary (L2) being in close proximity to the primary (L1). In other embodiments, a separate circuit for positive identification of a device to be charged being in proximity can be integrated. These can include wireless identification systems such as $RFID_1$ Felica, Bluetooth, WiFi, WiMax, etc. In another embodiment, the system of the charger or power supply case can be designed so that a chip in the charger or power supply case (near L2) senses an input voltage and modulates the current through L2 in a pre-

programmed manner. This results in a modulation in the current in 11 that can be sensed with the current sensor and positively identifies the charger or power supply case and initiates power transfer and operation if the pattern matches a pre-storβd pattern for verification. In some embodiments, the inductive charger or power supply base can *have* the shape of a formed piece that the inductive case would fit into, or a pad for placement of the inductive case and/or mobile devices or both.

[00375] Inductive case: In accordance with an embodiment, the case has means for receipt of power inductively (from the charger or power supply base} and charging another device (or number of devices) inductively. Alternatively, it may be possible for the case to be designed so that it operates by being charged or powered directly by a wired power supply/charger. The case has a receiver part that is connected to a battery charger circuit that charges one or more internal batteries and simultaneously, can also operate the circuitry in the charger or power supply case to charge a nearby mobile device or battery. The case has charger or power supply circuitry similar to the charger or power supply base that can be powered by its internal battery or the power from the charger or power supply base. The case can in turn recognize a nearby mobile device automatically or through mechanical or other means as described earlier and commence charging when a mobile device is placed in or near the case/holster. In another embodiment, the charger or power supply case may contain two or more charger or power supply sections so that several devices in the case (e.g. mobile phone and a headset) can be charged simultaneously. As described earlier, the circuitry/functions described here can be integrated into a device that also extends the functionality to storage, WIFi or Bluetooth connectivity, etc. In one embodiment, the batteries in the charger or power supply case are identical to the batteries used in the mobile device and are removable. In this case, the user may exchange the batteries between the charger or power supply case and the mobile device (such as a mobile phone) in an emergency to allow quick use of the mobile device without waiting for the charging of the mobile device to occur. This can provide an additional desirable feature for the user,

[00376] Mobile Device Receiver: In accordance with an embodiment, the mobile receiver part comprises a coil and circuitry that can be either integrated into a mobile device by the manufacturer (i.e. an OEM), integrated into a battery that can be swapped with the original battery to enable a mobile device to receive power inductively, or provided as a plug in unit that plugs into the existing power jack of a device and has the coil and the circuitry to enable the device to receive power inductively. Alternatively, the receiver can be built into a jacket or skin for a device that plugs info the device and allows the device to become 'enabled'. Variations of these are described in further detail in copending U.S. Patent Application titled INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application

No. 11/689,113, The above-referenced patent application also describes the use of attracting magnets placed at the center of an inductive charger or power supply's PCB coil, and the center of the receive coil, to align and center the two parts conveniently. Such techniques can be used in the base to case coil alignment, or the case to mobile device aiignment or both. In addition, the alignment can be achieved through visual or mechanical marks, indentation, or mechanical design of the parts to enable easy alignment.

Heat Reduction and Dissipation

[00377] In order to generate the magnetic field for an inductive charger and/or power supply, a coil made of wires or printed on PCB is typically used. Such a coil can be in a simple way, modeled by an inductive and resistive element in series. The resistance of the coil can be estimated by using the dimensions of the wire or PCB trace, its length, and the resistivity of the material used (such as copper). At higher frequencies, the resistance increases due to the skin effect whereby the electrical current travels near the surface of the wire or trace rather than throughout its cross section, thereby decreasing the wire's or trace's effective cross section. in order to obtain reasonable inductive values, several turns of wire or PCB trace are necessary.

[00378] For example, in a PCB spiral coii of **1.25"diametβr,** about 10 turns are necessary for a 1 micro Henry inductance value. To design a high efficiency inductive power transfer coii, the resistivity of the coii must be minimized while the resulting induction is kept at desired levels. it must be noted that any heat generated at the coil will increase the resistivity of the coil materia! in turn leading to higher heat generation and temperature increase. To avoid this positive feedback for heat generation, the main methods for reduction of temperature at the inductive coil include reduction of heat generated and dispersal of heat away from the coil.

[00379] In addition, electronic devices generally need to satisfy reguiatory and safety requirements which include the requirement not to interfere with the operation of nearby devices. For an inductive charger and/or power supply that creates a time varying magnetic field to transfer energy to a receiver, care must be taken to keep the level of interference to below allowed limits.

[00380] In general, the magnetic created by a small coil <~1"diameter) of several turns when it is driven by an electrical voitage at around 1 MHz, does not radiate more than severai mm beyond the coil and is confined to the near field. To reduce the effect of such radiation (for example, as provided in Near Field Power™ radiation devices) at higher frequencies, which are of bigger concern for most devices, the driving voitage of the circuit must be made to have weaker higher harmonics.

[00381] Another concern for generation of Electromagnetic interference (EMi) is the electronic circuitry and switching Field Effect Transistor (FET) incorporated in the circuit. Such components can be additional noise sources. Described herein are some ways of reducing the effect of above EMI sources.

[00382] Another important factor in efficient operation of an inductive charger/ power suppiy is the alignment of the charger/power supply coi! and the receiver coi! in the device to be charged/powered. Various methods of alignment of the coiis using magnets have been described in prior applications. in addition, also described are the use of moving coiis and other methods by which severai coils or dusters of coils can be used to provide position tolerance between the coils for efficient power transfer.

[00383] In accordance with an embodiment, to reduce the temperature increase at the inductive coil, severai methods can be used.

[00384] In accordance with an embodiment, the coil can be optimized by using the minimum number of turns necessary thereby decreasing the length and resistance of the coii. The diameter, thickness, or width of the wire or PCB trace can be optimized to provide optimum resistance.

[0038S] For coiis such as PCB coiis discussed above, the magnetic fieid created is strong inside the coil, and drops very rapidiy as the radial distance b the center of the coii exceeds the radius of the coil This dependence can be verified using electromagnetic modeling (such as described in Xun Liu; HuL S.Y., Optimal Design of a Hybrid Winding Structure for PSanar Contacfless Battery Charging Piatform, IEEE Transactions on Power Electronics, Volume 23, Issue 1, Jan. 2008 Page{s);455 - 463), and aiso by experimental means. The heat generated at the coii can be dispersed away from the coii by use of high heat conductivity PCB substrates or materia! for the coiis. Since the magnetic field is minima! in the area outside the coii, use of high conductivity metai iayers wil! not have a iarge effect on the fieid and wiii not create undesirable eddy currents. Therefore, the surface of the area surrounding the coii can be designed to have metal or other materia! that have high heat conductivity and remove the generated heat rapidly,

[00386] Figure 66 is an illustration that shows a geometry for an arrangement 1030 in which the area surrounding a PCB coil is designed b have meta! on the top, bottom or another layer of the PCB. As shown in Figure 66, the area surrounding a PCB coi! is designed to have meta! on the top, bottom or another layer of the PC8. The metal pattern can be incorporated at the same layer as the coii or a separate PCB layer. This metai layer can be continuous or have a gap in one area to avoid generation of eddy currents due to circulating eiectrons due to magnetic fields generated by the coii. in a typical PCS, the coil and the metai layer are made of copper. In this manner, any heat generated at the coii is

dispersed laterally rapidly and thus does not result in large temperature increase. In accordance with an embodiment, such a PCB can be itseSf the top layer of an inductive charger in which case, any heat carried away by the metal layer can be additionaiiy evaporated to the surrounding environment, Aiternativeiy, the heat can be further dispersed by removal to another area or surface or use of eSements such as fins or slits. Similarly, the receiver coil and the circuitry for receiving power that is integrated into a device,, battery, outside carrier of an electronics device,, etc. can have a similar geometry to enable dispersal of heat generated.

[00387] In accordance with an embodiment, for typical applications with a PCB, the metal layer can be made from copper materia! similar to that of the PCB coil itself, and it is desired to have sufficient thickness to provide a low thermal conductivity path for the heat. For example, a copper layer of several microns or even 10s of micrometers can be used.

[00388] Any such high thermal conductivity or metal layer may begin at the edge of the PCB coil or with a gap to the PCB coil. Since the layer is not covering the PCB coil, it may not cause eddy current loss in the layer. In those instances that eddy currents are generated, a gap in the metal iayer as shown in Figure 66 can be used to reduce the effect of circulating currents, and reduce the resultant heating and power draw. In accordance with an embodiment a metal layer can be used on top of the coil (with a thin non-conducting layer or dielectric in between) if its thickness is smaiS. For example, in previous applications as referenced above, the use of a thin iayer of metal (several micrometers) on top of a PCB coil was described to act as an EMI shield for high frequencies while transmitting low (around 1 MHz and below) frequencies of the inductive charger. Such a layer may also be used in addition to the metal iayer surrounding the coil to facilitate heat dispersal

[00389] Figure 6? is an illustration that shows, in a multi-charger or power supply where multiple coils are used, such a high heat conductivity iayer 1040 may be repeated around each coil or cover all areas between the multiple coils.

[00390] Figure **68** is an illustration that shows a similar method may be used for heat removal from wound coils of other shape and type 1050, 1058. in accordance with the geometry of this embodiment, to facilitate heat removal from a coil that may be a wound coil around a core, the coil may be attached to a high heat conductivity iayer or a metal layer. In the case of a metal layer, such a layer can be designed to be in the area surrounding the outside of the coil to avoid interference with the field generated inside the coil. Similarly, to avoid eddy currents, the metal layer or the core of the wound coil or both can have a gap or discontinuous portion to reduce circulating currents.

[00391] In above examples, a metal or high heat conductivity layer has been shown. Figure 69 shows an illustration of an embodiment 1060 in which the layer can be patterned to provide heat conductivity channels rather than a continuous layer if needed.

[00392] In accordance with any of the above geometries, additional means of heat removal such as use of fins, fans, additional surfaces, heat pipes, thermal grease, thermally conductive epoxies, etc. can be incorporated to facilitate heat removal. in addition, it is possible to incorporate heat conducting layers, such as ceramics or polymers can be incorporated below or above the main PCB to help in heat removal.

[00393] In the above discussion, round shape coils are generally shown. It will be evident that the techniques described herein are appiicabSβ to coils of other shape or multiple coils in a duster or separated to power or charge separate devices. In many instances, the increase of the temperature at the center of a PCB coil is largest. To remove this heat in accordance with an embodiment the surface of the charger or a layer behind the coil that contains high heat conductivity materia! can be used to disperse the generated heat laterally. An example of such a layer is ceramic material. High alumina ceramics can provide high heat conductivity and low electrical conductivity, which characteristics are important for this application.

Reduction of EMI from Jnducttve Charger and/or Power Supply

[00394] An advantage of the metal layers discussed above is that any EMI generated inside the inductive charger or power supply will be greatly shielded from the outside and will be attenuated outside the charger or power supply device by the metal layer,

[0039SJ Additionally, in the above geometries, the metal layer on the top layer can be made to contact electrically to other metal layers on the side and/or bottom of the charger and/or power supply, thereby forming a box or other enclosed shape where only the coil is not covered by metal. Such an enclosure will greatly attenuate EMI from the switching electronics or other parts in the charger. To reduce the effect of the potential eddy currents generated in the metal box due to the magnetic field, in some embodiments it is useful to eliminate use of metal directly below the coil area where magnetic fields may exist. In addition, to avoid generation of eddy currents in the walls of the metai box or similar outside surface, the wall can be cut in one or more location so that a continuous metal circuit or ring is not formed, and does not allow the electrons to circle unimpeded. This gap can be filled with a non-conductive material to provide rigidity.

[00396] In the geometries shown above, it is possible to use a PCB whereby the coi! is formed in one area and the electronics is on the same PCB. sn accordance with an embodiment, to provide shielding and heat dissipation discussed above, the metal layer

around the coil may be in a layer on fop (closer to the outside surface) of the PCB, For example, the coil may be formed on the top layer of the PCB aiong with the heat dissipation and/or EMI shield layer and the PCB electronic components may be on the bottom layer of the PCB, Alfernafiveiy, the metal layer can be in a separate layer in the middle or even the bottom layer with the PCB electronic components. However, the EM! shielding effects from the electronics components will be reduced if the metal layer surrounds the electronics area and does not provide an eiectrical barrier directly above it.

[00397] Figure 70 shows an illustration of the electronics for the PCB coil inductive charger and/or power supply or the inductive receiver as fabricated on the same PCB as the coil in accordance with various embodiments 1070, 1076. The electronics in this case may be at the bottom layer, whiie the coil and the metal layer surrounding the coil are on the top layer and shield any electronic noise generated by the electronics from the outside,

[00398] Any of the shapes and geometries discussed above are equally appropriate for incorporation into the charger and/or power supply coil or the receiver coil and for dispersal of heat and reduction of EM! from a device to be charged/powered inductively as well as the coil in the charger/power supply itself.

Magnetic Alignment of Coils

[00399] In accordance with an embodiment, to enable efficient power transfer in an inductive charger and/or power supply, the coiis in the charger and/or power supply and the receiver must generally be aiigned with on another.

[00400] Figure 71 shows an embodiment 1080 in which magnets placed at the center of a stationary coil or a moving, floating charger and/or power supply coil and the receiver coil can provide a method for alignment of the coils and to achieve this result.

[00401] A problem with this method is that, since the magnetic material is composed of electrically conductive materia!, eddy currents can be generated when the coils are operated to generate a time-varying magnetic field. This can cause lost power and can also cause heating in the magnets which is not beneficial

[00402] To address this problem, Figure 72 illustrates an embodiment 1090 in which two or more magnets that do not cross the center of the coil are used. This geometry reduces the eddy currents created greatly. in accordance with an embodiment, the system can use an alternative magnet geometry that provides a simple and inexpensive method for alignment of coiis. In addition, this method provides for a considerable amount of alignment tolerance when placing a device on the charger and/or power supply.

[00403] To provide alignment magnets that will not draw current due to eddy currents created in them when a magnetic field is applied, in accordance with an embodiment the magnets are piaced outside the PCB coil area.

[00404] **Figure 73** is an illustration of two embodiments 1094, 1098 that shows how the magnets may be placed outside the PCB coil area. The magnet shown in Figure 73 comprises a ring that surrounds the coil or overiaps each coil such that little effect on eddy current generation or loss is created. If any eddy current effects are observed, then in accordance with an embodiment gaps can be inserted in the magnet ring by cutting after manufacture or by inserting this separation dunng manufacture. In this manner the eddy currents can be significantiy reduced or eliminated. The magnet in the case shown is magnetized perpendicular to the surface of the ring. By attaching one magnet to around the charger and/or power supply coil and another magnet with opposing polarity to the receiver coil, the two coils can easily be aligned with minima! effort by the user.

£00405] In addition, the use of a ring has the advantage of allowing circularly symmetric operation so that the two coils can be rotated with respect to each other with no effect on charger/power supply operation or efficiency.

[00406] A typical geometry for the charger/power supply can comprise the PCB shown in Figure 8 such that the coil can be fabricated on the top surface of the PCB, and the magnetic ring is attached to the bottom side of the PCB where the eiectronics may be located. A similar receiver can have a magnet attached with opposing polarity so that whan the receiver is brought close to the charger/power supply, the two magnets can attract and puil the coils into alignment. TOIh this geometry, the magnetic field of the coils create attraction and alignment as long as the coils have any overlap.

[00407] For example for coils of 1.25" outside diameter and using ring magnets of 1.25" inner diameter, as long as the centers of the coils are less than 1.25" away laterally, the coils can be brought into alignment when the two magnets are vertically (distance in the axis perpendicular to the plane of the coil) brought close enough to allow the magnetic fields to sense each other. Thus in this case, if the user brings the center of the receiver coil to be within a circle of 1.25" radius of the center of the charger/power supply coil, the coils can attract and provide automatic alignment of the parts.

[00408] For most applications, this amount of alignment tolerance is sufficient. By using marks to outline the location for the coil on the surface, this degree of tolerance allows the user to piace a device or battery incorporating the receiver coil very easily into the right location.

[00409] Examples of magnets that can be used include those manufactured from various magnetic material such as Neodymium iron Boron, Samarium Cobalt, AINiCo,

ceramics, bonded magnetic material, etc. The magnetic strength can be designed to provide alignment or secure attachment without being too strong or difficult for separation.

[00410] Alternatively, the coils can be manufactured on the lower surface ciose to the magnet and the electronics or can be manufactured on another layer in between. Various geometries are possible. In any case, the magnets can be used to align the two coils for optimum operation.

[00411] In above description, ring shaped magnets are described. However, in many cases, size and spacing requirements may require use of a different geometry.

[00412] Figure 74 shows an embodiment 1100 in which magnetic arc shaped parts around a circular coii are used. This case may be combined with the matching magnet on the other coil having the same shape or a ring shape similar to Figure 73. For example, in a mobile battery application where the battery with an integrated inductive receiver is charged by placement on an inductive charger pad, the size of the coil determines the received power and may require the width of the battery to be equal or similar to the receiver coil. To allow attachment of alignment magnets, two arcs as shown in Figure 9 can be attached to the coil. In this case, the magnets can be placed in between the battery and the cos! PCB to allow the coil to be on the top surface and therefore closest to the charger coil. The matching magnet in the charger can be a ring or a similar set of arcs or another shape or size to facilitate alignment If a ring is used behind the charger coil, then central symmetry between the two parts is retained and the parts can be rotated with respect to each other while keeping alignment for optimum operation.

[00413] Other geometries are possible. For example, Figure 75 illustrates embodiments 1120, 1126 in which the use of bar magnets on or around the coil is shown. Such a geometry does not have the symmetry offered by a ring magnet. However, this may be useful if only one dimension of alignment insensitivity is desired,

[00414] In any of the above geometries, use of two magnets with opposing polarity to attract each other is described. However, in accordance with some embodiments it is preferable for one of the parts to be non-magnetized. This may be advantageous in cases where it is not desirable for the mobile device to attract metallic parts when not being charged or powered by the inductive charger/power supply. An example may be a mobile phone where it is not desirable for the phone to attract metallic objects during normal use. in this case, the charger and/or power supply can contain a magnetized part and the other matching part in the mobile device/battery, can be made of appropriate magnetic material but not magnetized. For example, the charger/power supply may contain a magnetized ring as described above and a mobile phone can have a matching ring or arc made of magnetic material but not magnetized.

[00415] In addition, it is possible for the charger and/or power supply magnet to be activated electrically and be normally non-magnetized. For example, a wire winding or PCB trace is placed around the perimeter of the power transfer coil and powered to create a DC magnetic field for alignment of the two coils for power transfer/charging. in this way, neither of the two alignment parts need to be normally magnetized and therefore eliminate any concerns regarding unintended attraction of metallic objects or effects on magnetically sensitive parts such as credit cards, etc. The generated magnetic field can be further strengthened by using a non-magnetized magnetic material on or near the alignment trace area.

[00416] As an example, a circular path around the main charger/power supply PCB coil can be powered by a DC current periodically or when a user desires to charge or power a mobile device. This can be done by the user or can also be activated automatically by a sensor that senses the approach of an appropriate device to be charged or powered through RF, optical, magnetic, or other methods. Once the magnetic field (such as a ring pattern as described above), is generated it wiSI attract and align a magnetic meta! part or magnet of appropriate shape in the mobile device or battery into the correct alignment and placement and help the user place the mobile device in the correct position. Once the device is placed in the right location, the DC magnetic field may no longer be necessary and can be shut down or reduced to save power. Thus only for a very brief period this alignment magnet may be needed. During other times, neither the charger and/or power supply or the mobile device can be designed to have any magnetic field around them or contain weaker magnets.

[00417] The use of magnets as described above is especially useful for cases where movement between the power suppiy and/or charger and the device or battery to be charged or powered may occur. As an example, in an automobile environment, it is desirable to keep a mobile device such as a phone from moving during charging. Thus the use of the magnets described above, in addition to the above benefits, can enable use in moving environments. In addition, in some cases, it may be beneficial to have the charger and/or power supply in a position that is not horizontal. For example, a charger can be installed vertically. In this case, the magnets can be designed to be strong enough to hold the mobile device or battery in piace vertically during the charging or powering process.

[00418] In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating the coil from low electrical conductivity materials or ceramics, layering the magnet into thin sheets to increase resistivity, using bonded materia! in an epoxy matrix, roughing the surface, cutting gaps in the material to reduce circular motion of electrons, or other common techniques to increase the resistivity. The magnet can also be manufactured from segments that are not

electrically connected to prevent electrons to be able to trave! around a circular path. For example, the ring magnet can be manufactured, formed or attached to the coils from two or four ring arcs that are not electrically in contact or attached to each other, using a non¬ conducting epoxy to form a full ring, or parts of a ring,

[00419] In addition, the coils shown above are generally circular. However, the methods and discussion above can be applied to coils of any shape and size as well as an array or cluster of coils and can provide in performance of any size and type of coil.

[00420] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical application, thereby enabling others skilled in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of an embodiment be defined by the following claims and their equivalence.

[00421] Some aspects of an embodiment may be conveniently implemented using a conventional genera! purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as wii! be apparent to those skilled in the art.

[00422] In some embodiments, an embodiment includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of an embodiment. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, *DVD,* CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROIvIs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00423] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. Particularly, whiie the embodiments of the systems and methods described above are described in the context of charging pads, it will be evident that the system and methods may be used with other types of charger or power supplies. Similarly, while the embodiments described above are described in the context of charging mobile devices, other types of devices can be used. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical

application, thereby enabling others skied in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particuiar use contemplated. s is intended that the scope of an embodiment be defined by the following claims and their equivalence.

Claims;

What is claimed is:

1. A system for inductive powering and charging of portable devices or batteries, comprising:

a base unit, including one or more primary coils composed of a non-ferrite materia! and shaped as planar spiral coils, which are capable of generating an inductive energy for use in powering or charging multiple devices or batteries simultaneously;

a receiver unit, including a receiver coil also composed of a non-ferrite materia! and shaped as a pianar spiral coil, which is coupled to or incorporated into a portable device or battery, wherein the secondary coil receives energy inductively from the primary coil and uses it to charge or power the portable device or battery;

means within the base unit for allowing a degree of position independence of the devices or batteries on the base unit and selectively activating the one or more primary coils; and

wherein the base unit can simultaneously charge or power additional portable devices or batteries with additional secondary coils.

2. The system of claim 1, wherein the charger or power supply includes a plurality of coils, and wherein the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery.

3. The system of claim 1, wherein the charger and a receiver in the device or battery both include microcontroller units, wherein the microcontroller unit in the charger monitors current flow, and wherein the microcontroller unit in the portable device or battery provides communication between the charger and the receiver for use in controlling charging.

4. The system of claim 1, wherein the charger or power supply includes an additional verification step prior to activating charging, to verify the identity or permissions of a device or battery.

5. The system of claim 1, wherein a plurality of coils are integrated into a pad-like charger or power supply and wherein the coils are used to form a coil mosaic and an effective area of charging or power that does not cover more than approximately 90% of pad surface.

6. The system of claim 1, wherein each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more

COilS,

7. The system of claim 1, wherein one or more coils includes a switch component, and wherein the microcontro üer unit periodically starts the switch components, monitors the current therein, and uses the current to sense the proximity of a receiver and device or battery to that coil and activate charging in that coil, or a selection of coils in that region.

8. The system of claim 1, wherein a plurality of iayers of coiis are layered upon one another to create an effective area, and so that powering any one or a seiection of the coiis ailows a receiver whose center is within the effective area to be charged.

9. A mobile device capable of being inductively powered or charged comprising;

a battery; and

a receiver for one of ind ʊctiveiy powering the device or charging the battery in the mobile device, and wherein the receiver is one of attached to or incorporated into the battery or the mobiie device.

10. The mobiie device charger or power supply of claim 9, wherein the coiis or wires are formed within a printed circuit board PCB iayer of at least two different sizes or shapes.

11. The mobile device charger or power supply of claim 9, wherein the charger or the power supply, and the mobile device, communicate with each other to transfer data,

12. The mobile device charger or power supply of claim 9, wherein the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply and/or wherein the charger or power supply stores charging or power requirements for mobile devices which can be charged or powered by the charger or power suppiy.

13. A system for use with a mobile device or battery for charging or powering the mobile device or battery inductively, comprising;

a base unit including one or more pnmary coiis therein, the primary coil having a generally pianar shape so that when a current is passed through the primary coil a magnetic field is generated in a direction substantialiy perpendicular to the plane of the primary coil; and

wherein the perpendicular magnetic field inductively generates a current in a matching receiver coil or coils within a mobile device or battery placed close to and aligned with the base unit, to charge or power the mobile device or battery.

14. The system of claim 13 wherein one or more of the coils are manufactured on printed circuit boards and are manufactured to have a !ow resistance.

15. The system of claim 13 further comprising a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an externa! power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time.

16. The system of claim 13 further comprising one of a soiar ceil coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface of the base unit or pad includes a decorative or non-slip surface,

17. The system of claim 13, wherein a plurality of modular chargers or power suppües can be interconnected to form a single unit

18. The system of claim 13, wherein the mobile device to be charged or powered includes a charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device or battery to a predetermined maximum voltage, and a switch means that includes a MOSFET and the circuit includes a capacitor connected in parallel to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the tviOSFET when the base unit detects a mobile device or battery placed close to or aligned with the primary coil.

19. The system of claim 13, further comprising means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power into the coils under different load conditions, to maintain high efficiency during different load conditions or charging stages.

20. The system of claim 19, wherein the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation.

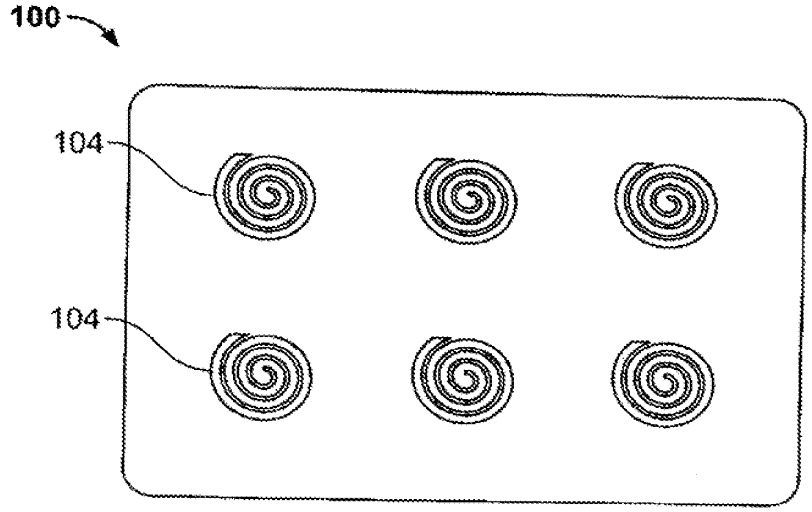

100
104
104

FIG. 1

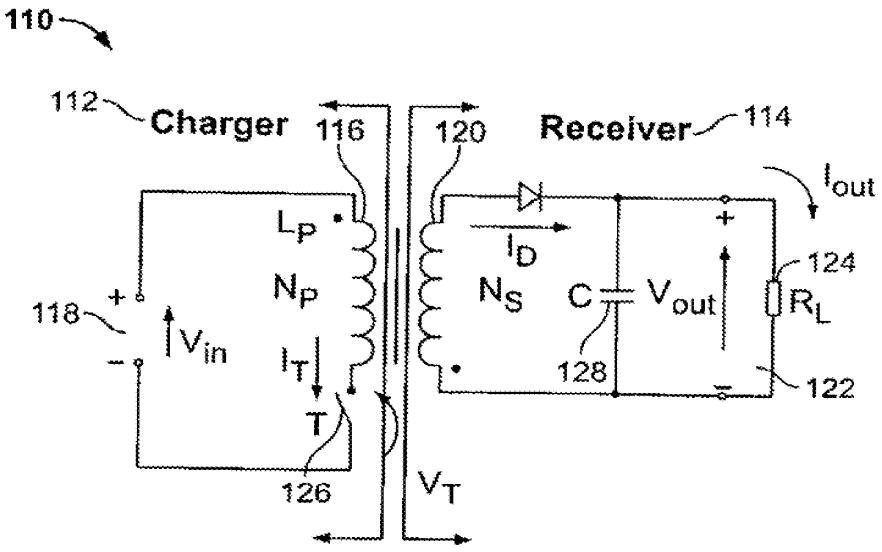

110
112
Charger
116
120
Receiver
114
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
124
R_L
118
+
V_{in}
−
I_T
T
128
122
126
V_T

FIG. 2

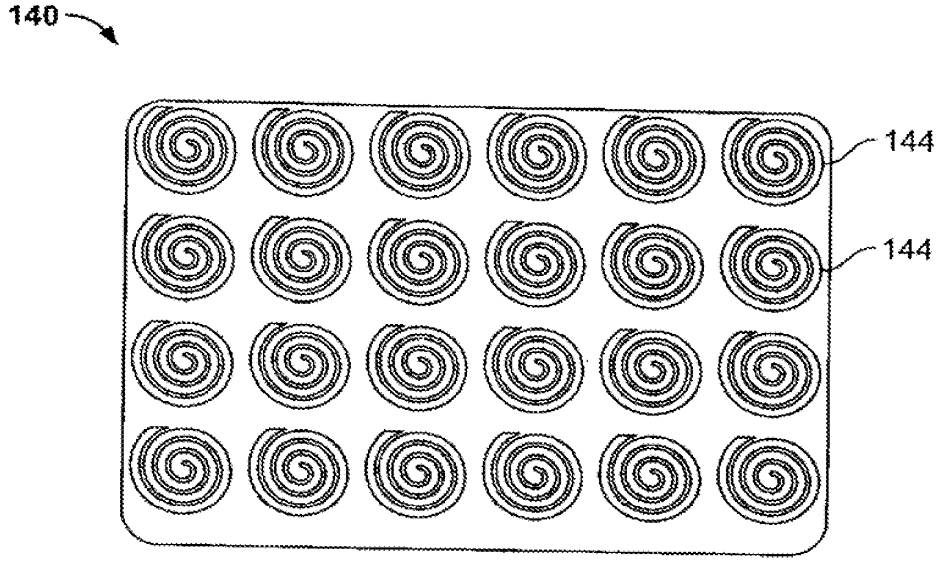


FIG. 3

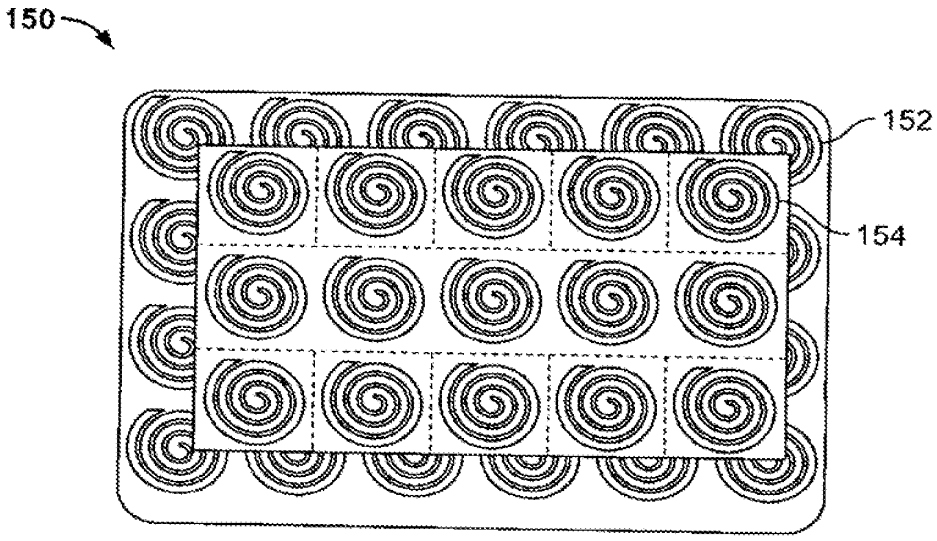


FIG. 4

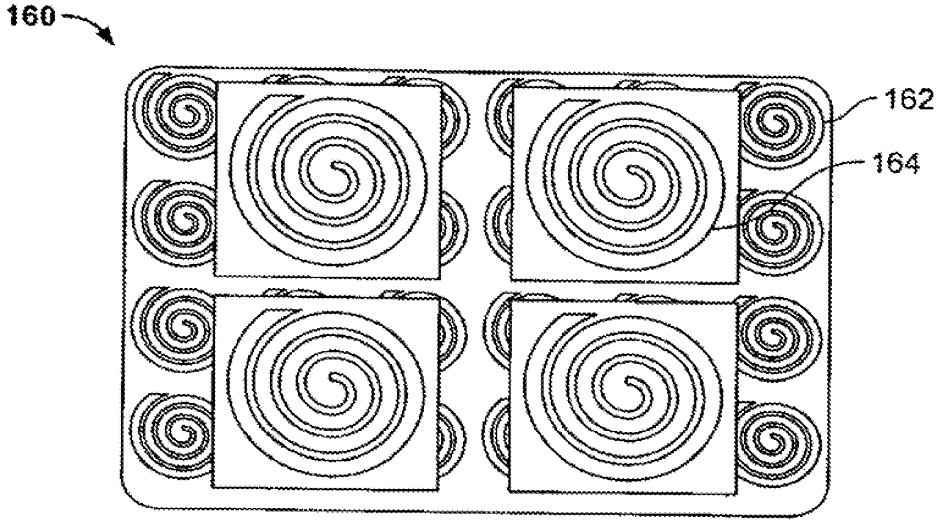

160
162
164

FIG. 5

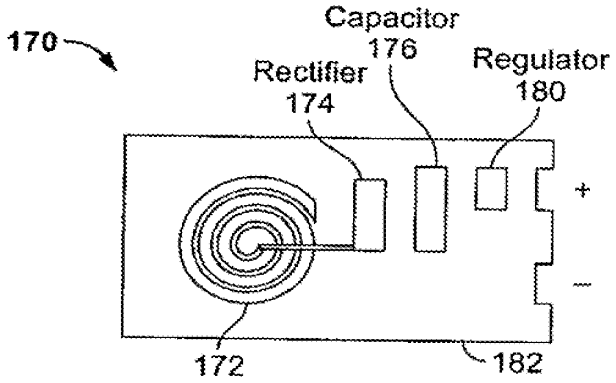

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

FIG. 6

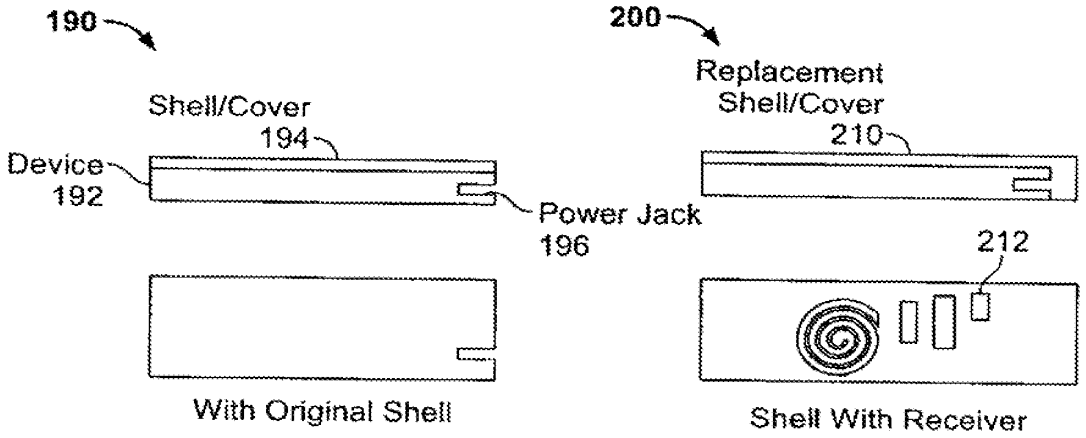

190
Shell/Cover
194
Device
192
With Original Shell
200
Replacement
Shell/Cover
210
Power Jack
196
212
Shell With Receiver

FIG. 7

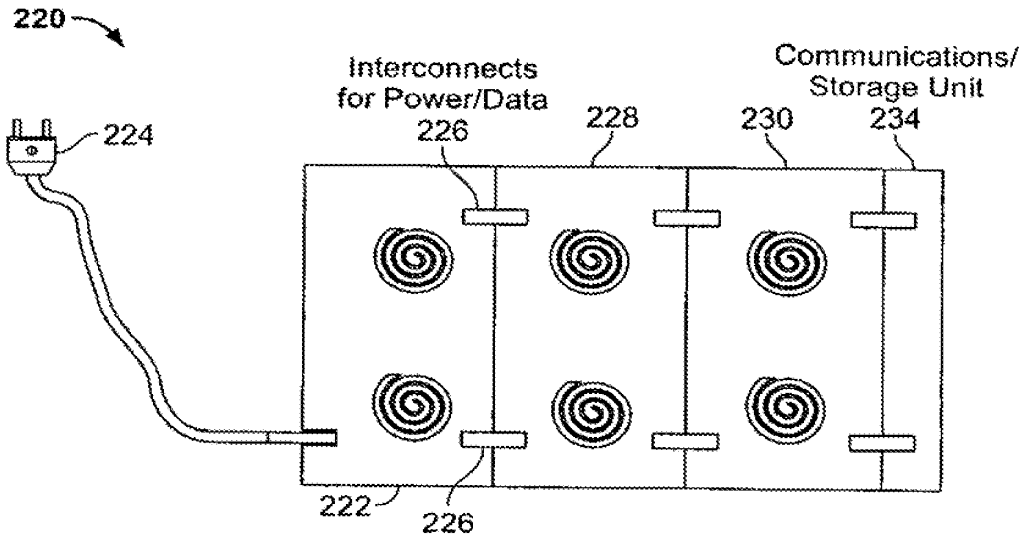

220
224
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
222
226

FIG. 8

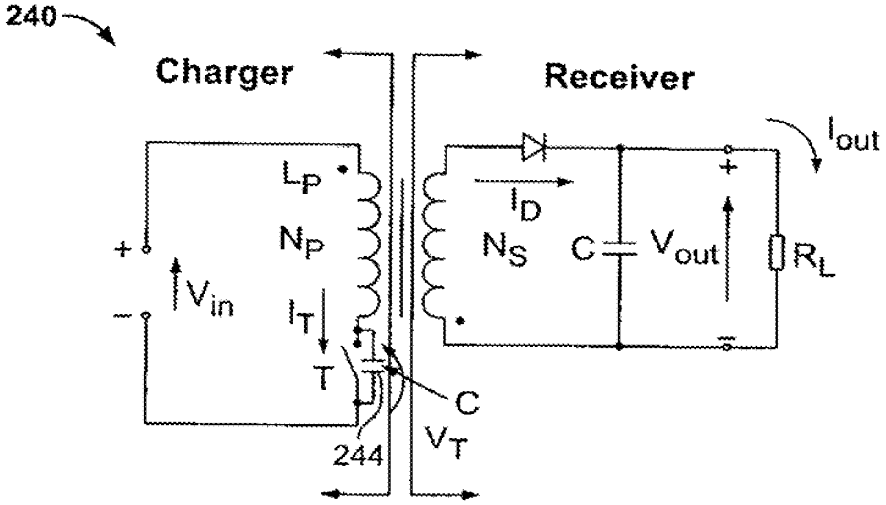

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
V_T
244

FIG. 9

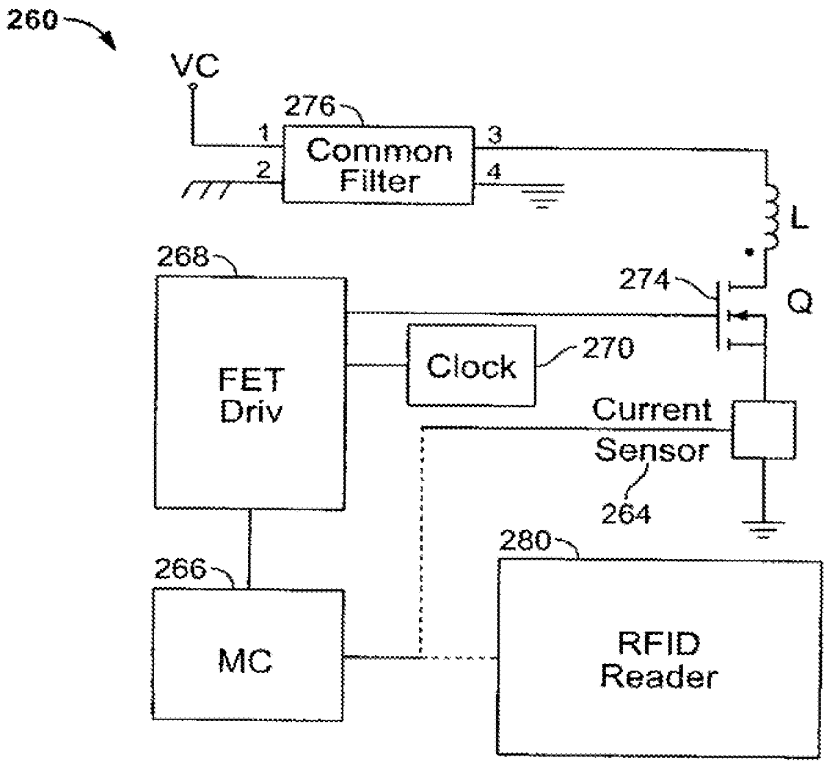

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

FIG. 10

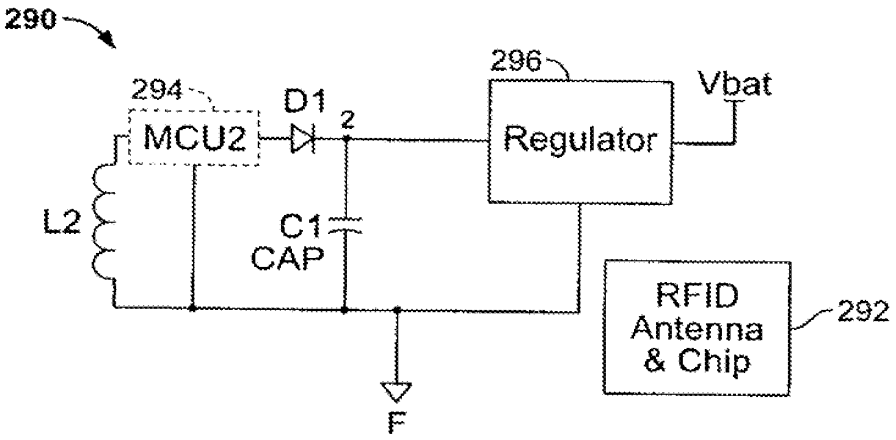

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

FIG. 11

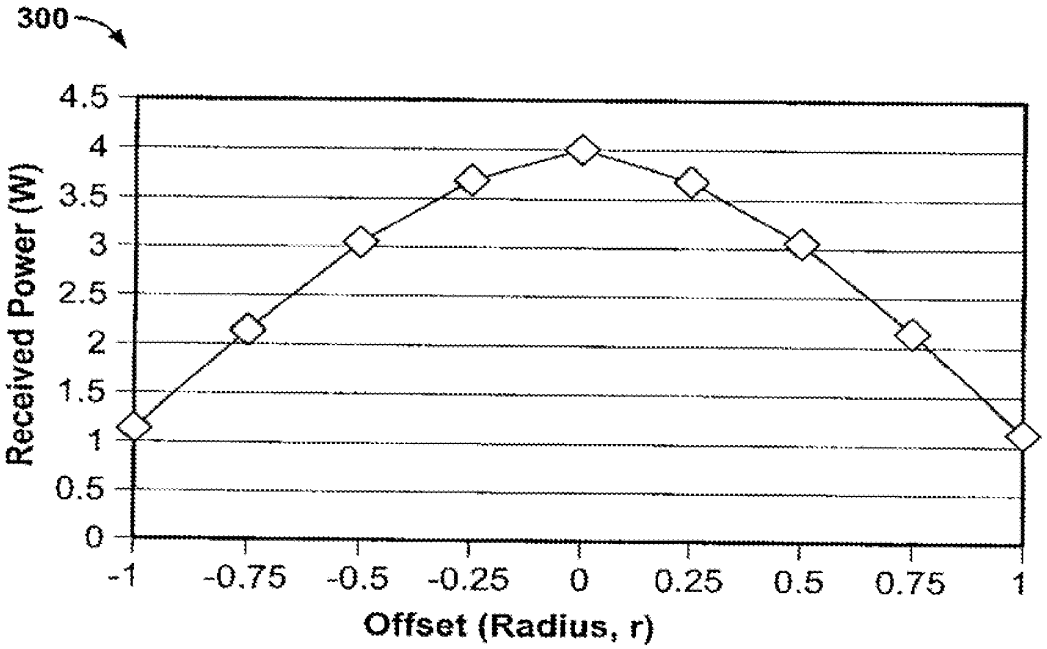

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

FIG. 12

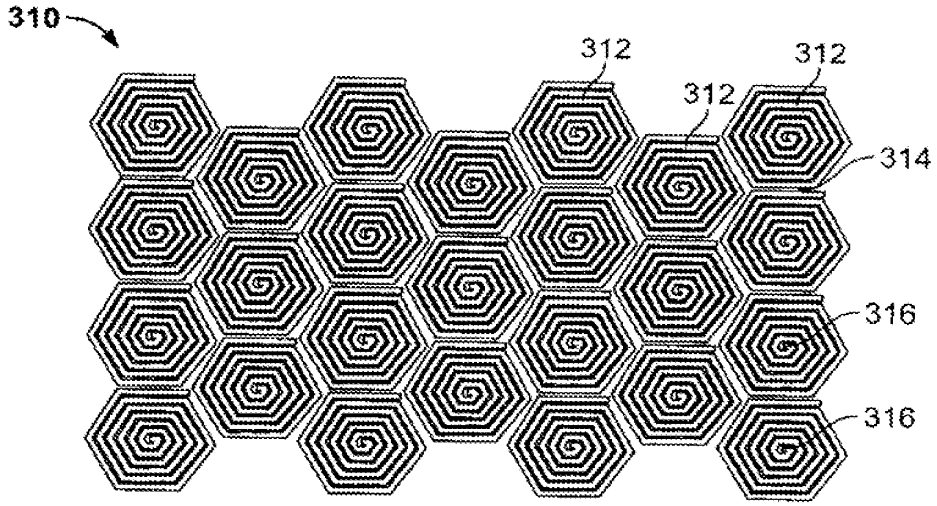


FIG. 13

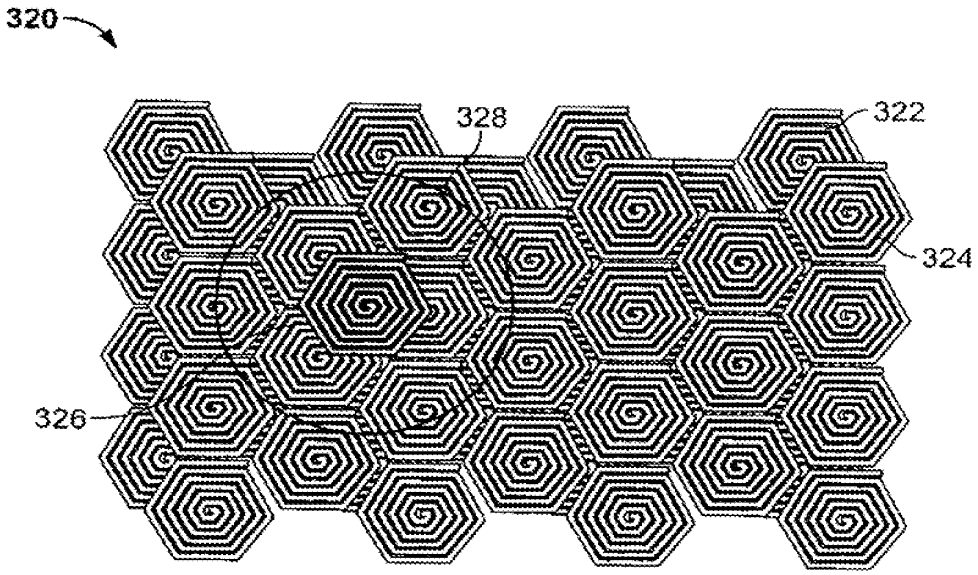


FIG. 14

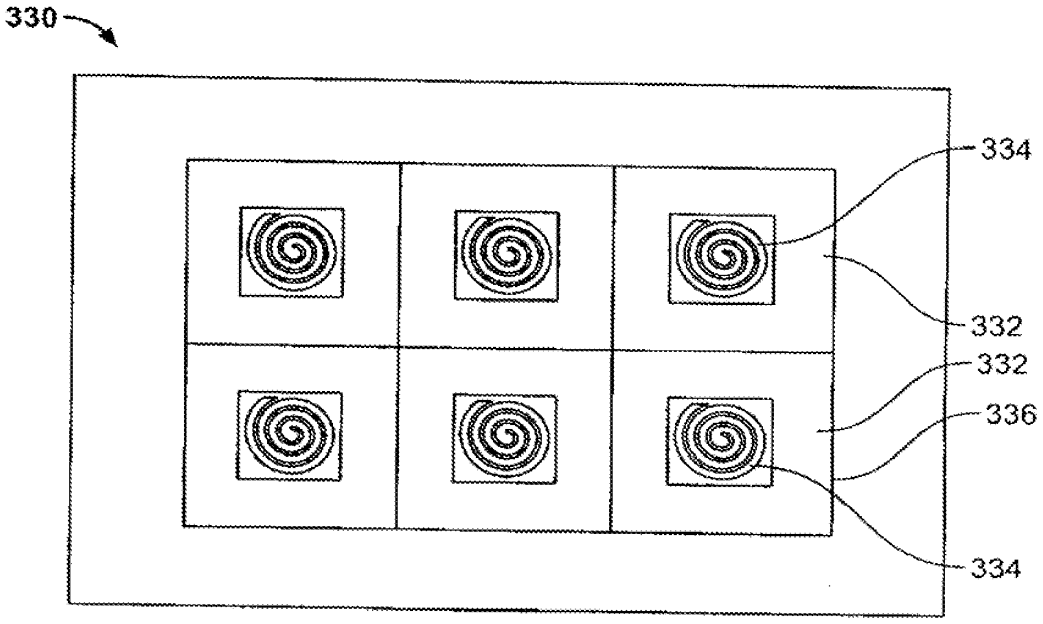


FIG. 15

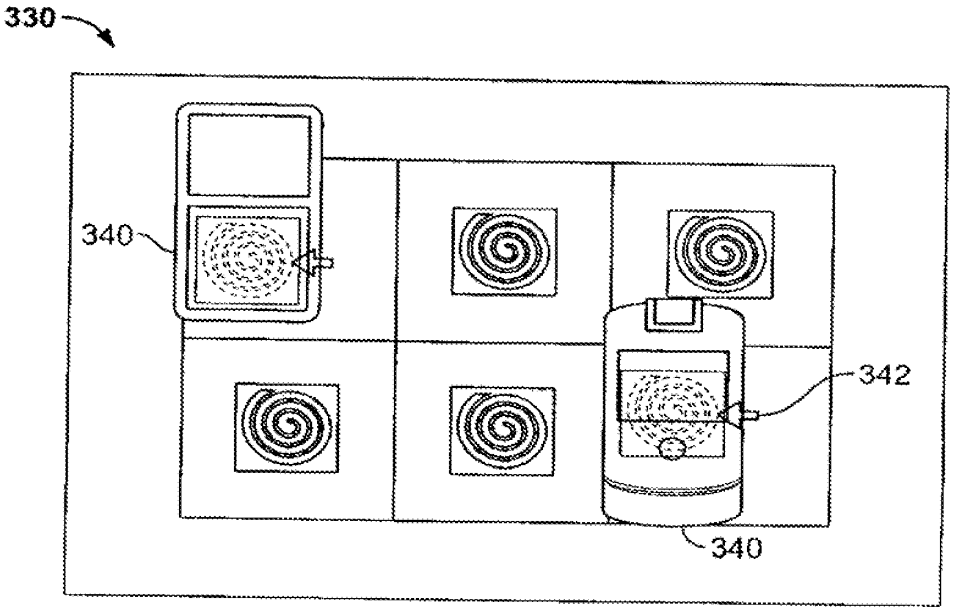


FIG. 16

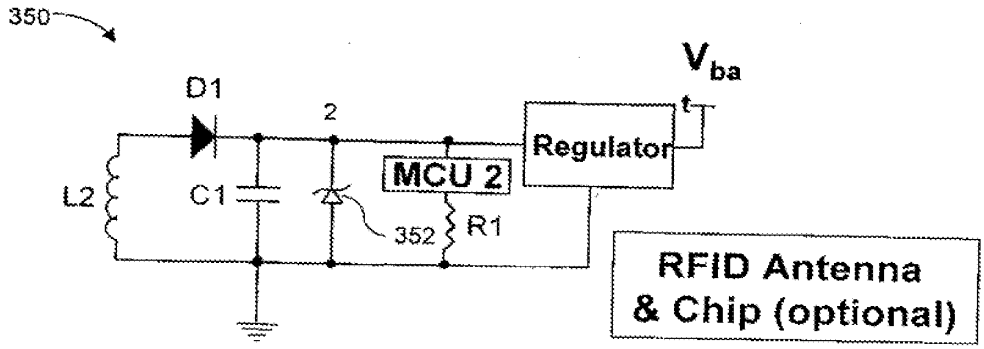

350
D1
2
V_{ba}
Regulator
MCU 2
L2
C1
352
R1
RFID Antenna
& Chip (optional)

FIG. 17

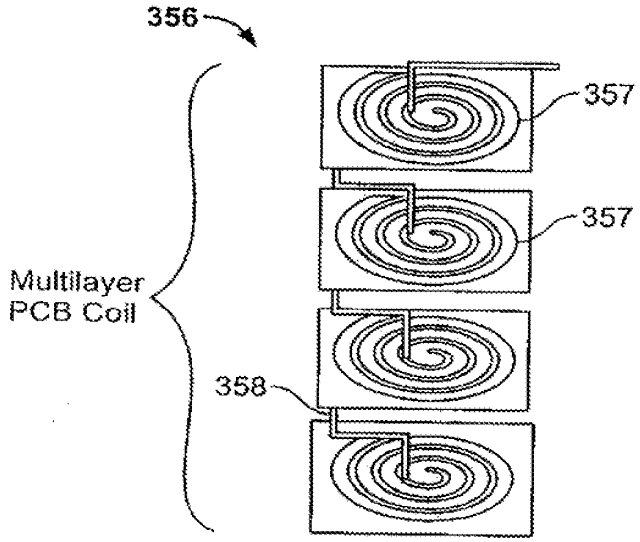

356
357
357
Multilayer
PCB Coil
358

FIG.18

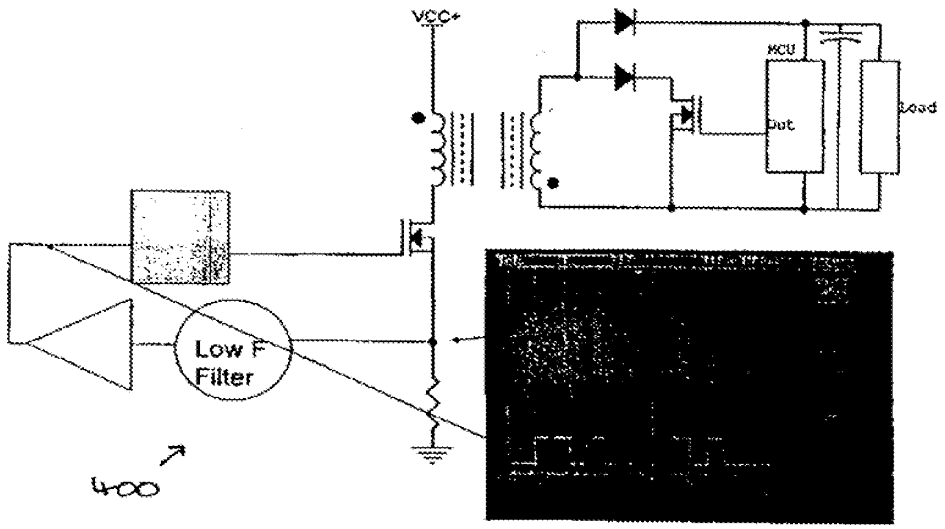


FIG. 19

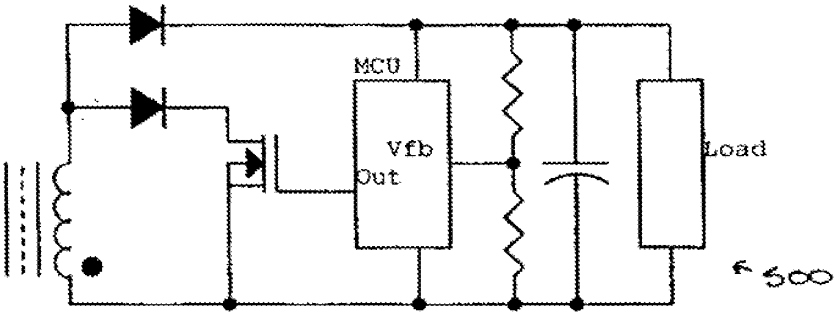


FIG. 23

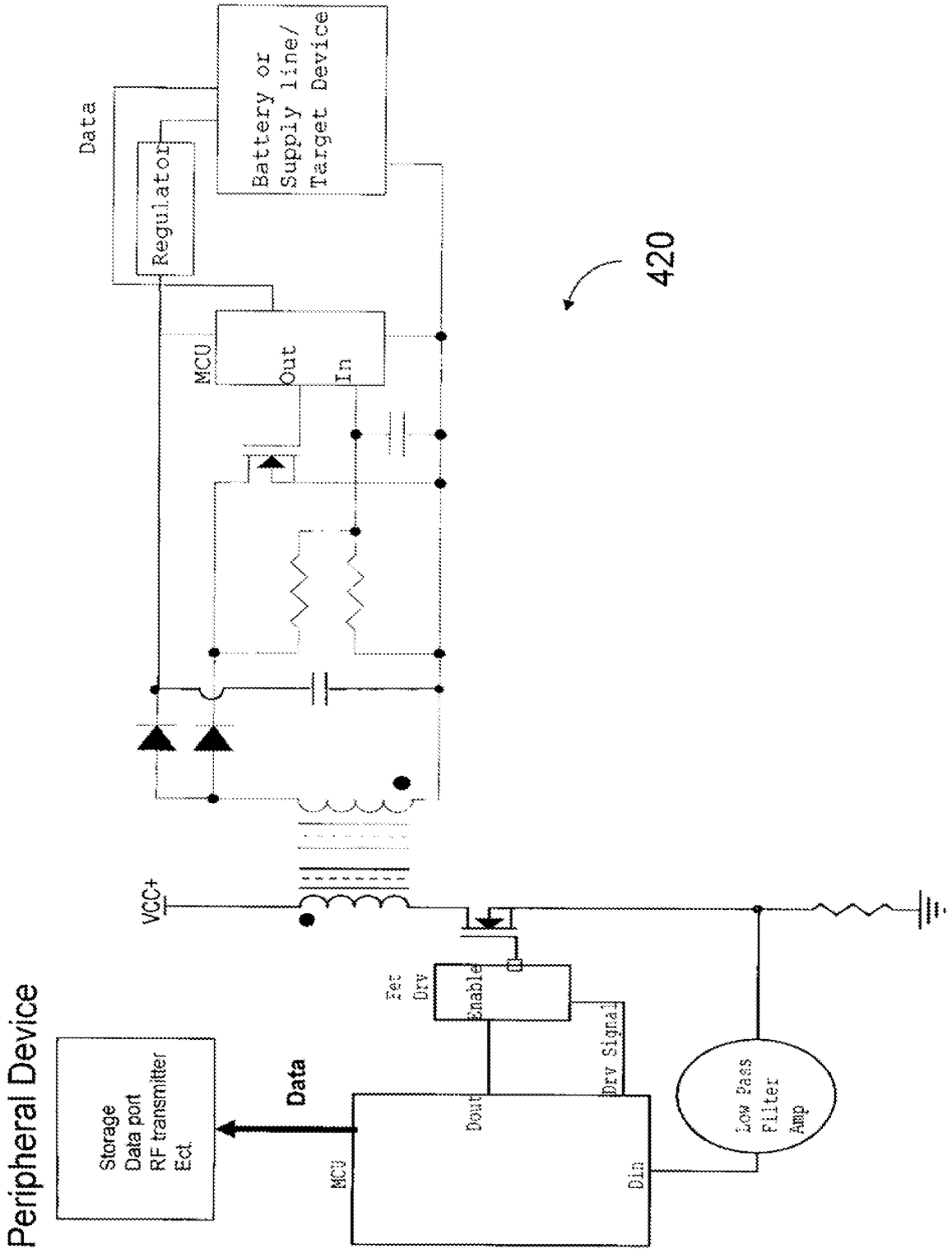

Peripheral Device
Storage
Data port
RF transmitter
Ect
Data
MCU
Dout
Din
Drv Signal
Enable
Rec
Drv
Low Pass
Filter
Amp
VCC+
MCU
Out
In
Regulator
Data
Battery or
Supply line/
Target Device
420

Figure 20

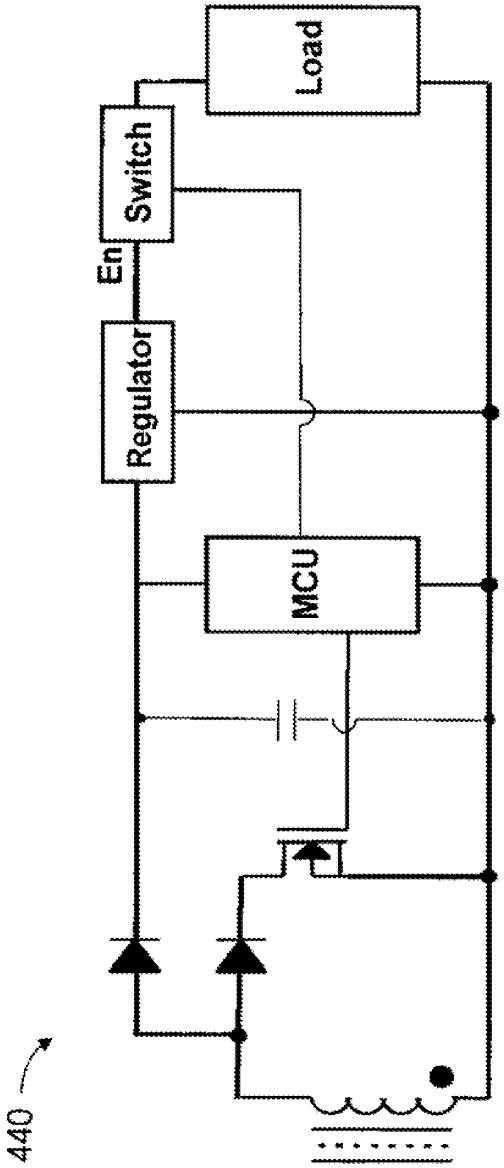


Figure 21

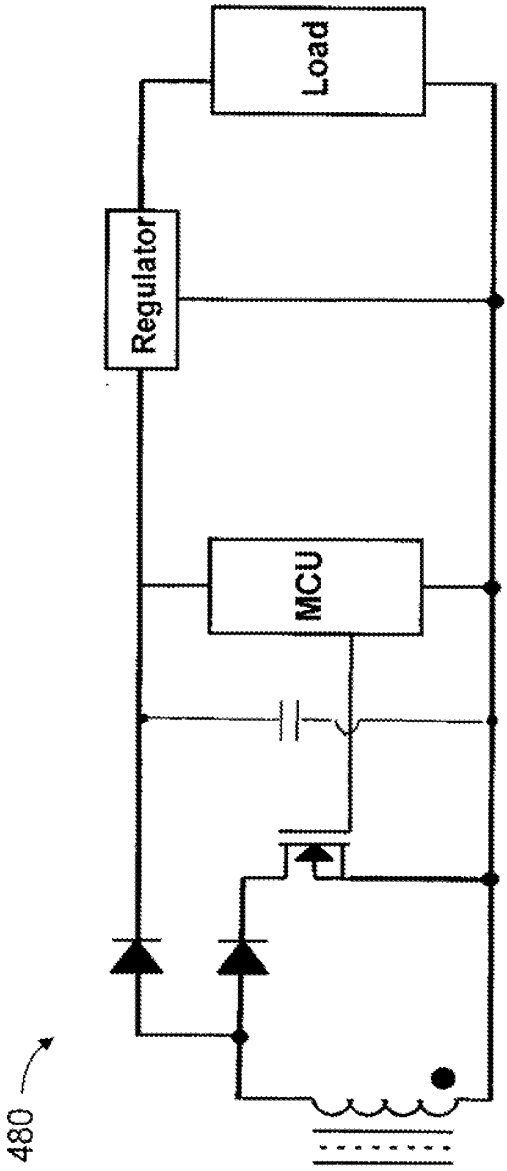


Figure 22

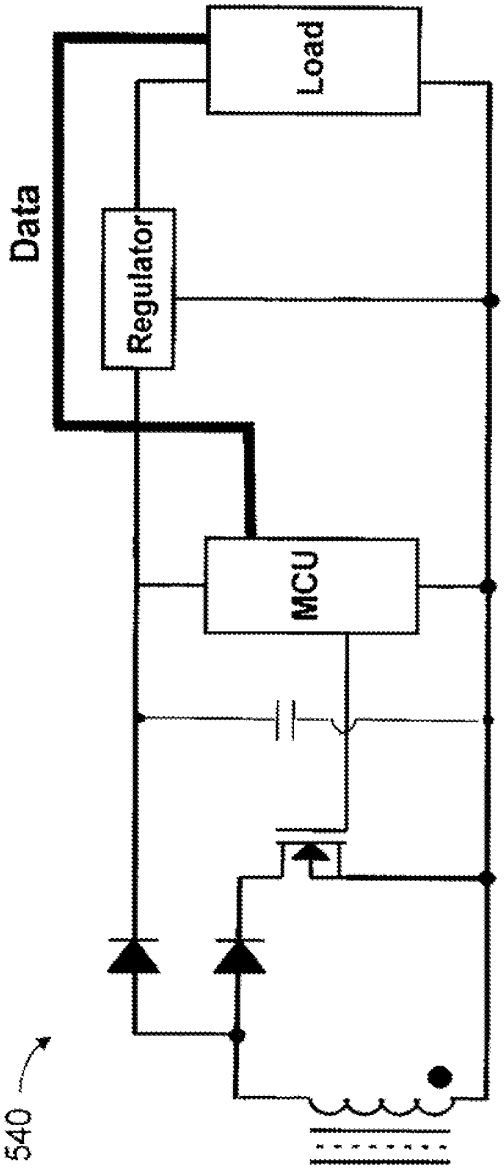


Figure 24

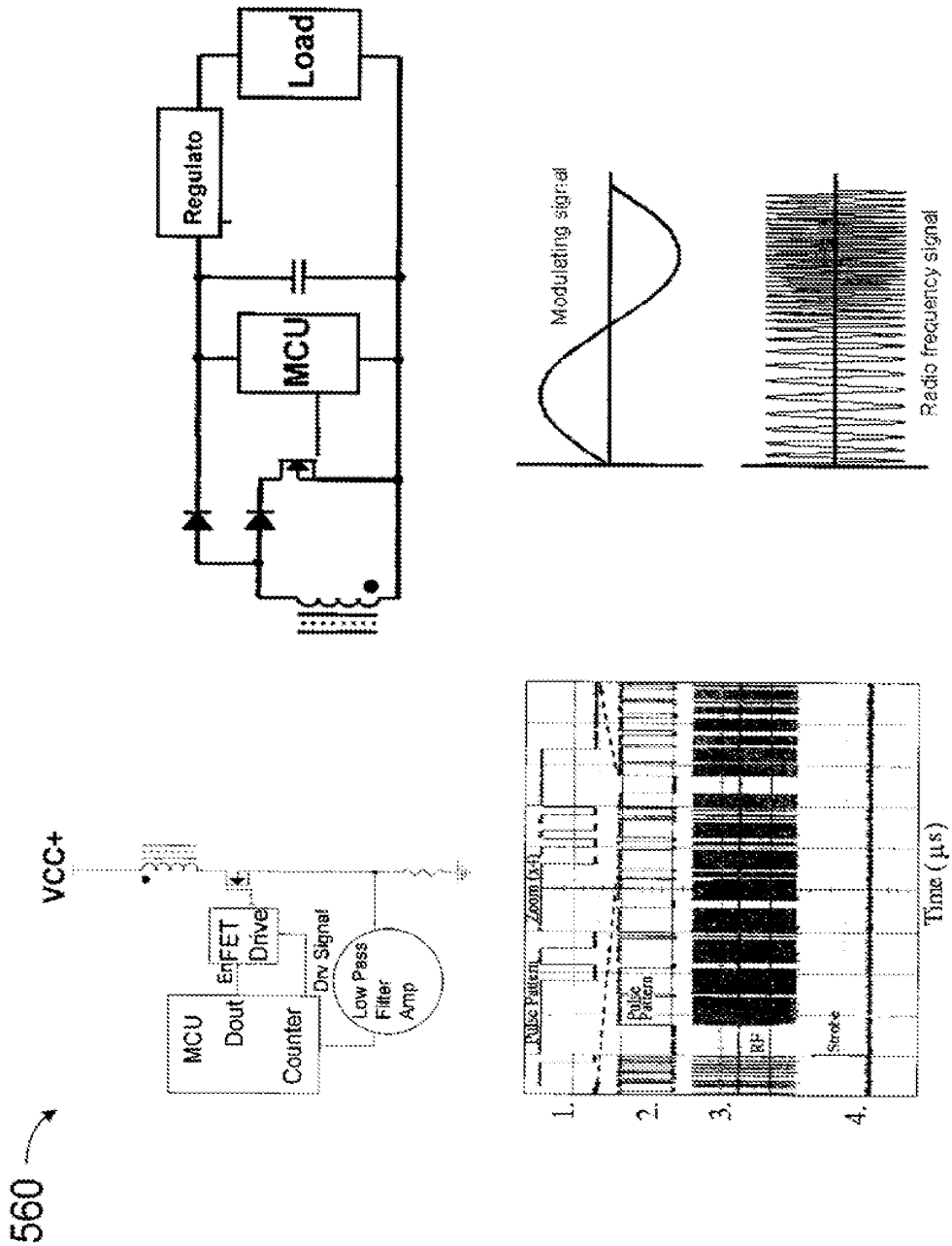

Load
Regulato
MCU
Modulating signal
Radio frequency signal
VCC+
EnFET
Drive
Dout
MCU
Counter
Drv Signal
Low Pass
Filter
Amp
560
Pulse Pattern
Zoom (x1)
Pulse Pattern
RF
Stroke
1.
2.
3.
4.
Time (µs)

Figure 25

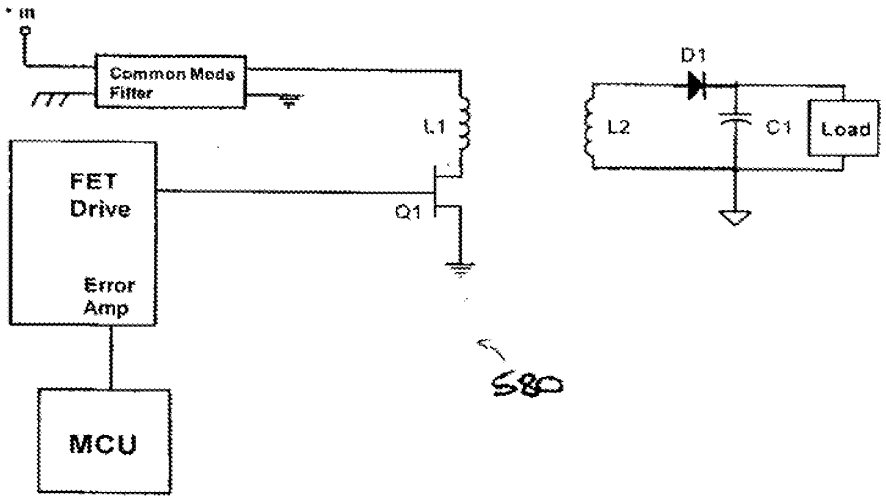

Common Mode Filter
L1
FET Drive
Q1
Error Amp
MCU
D1
L2
C1
Load
580

FIG. 26

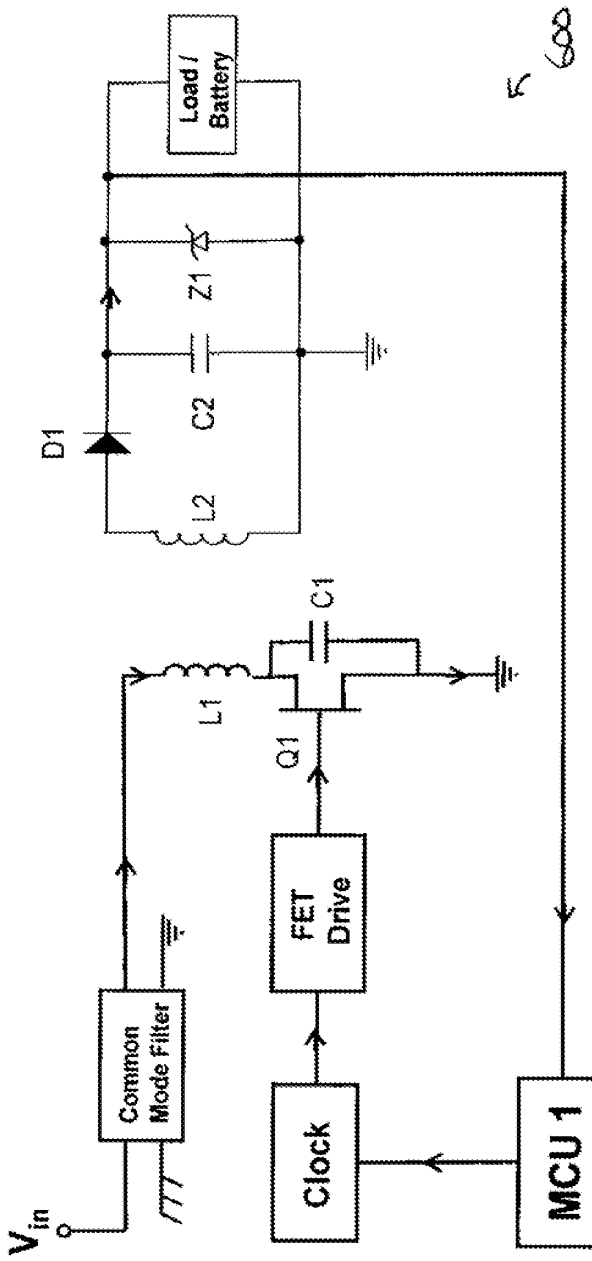

Load / Battery
600
Z1
C2
D1
L2
C1
L1
Q1
FET Drive
Common Mode Filter
Clock
MCU 1
V_{in}

Figure 27

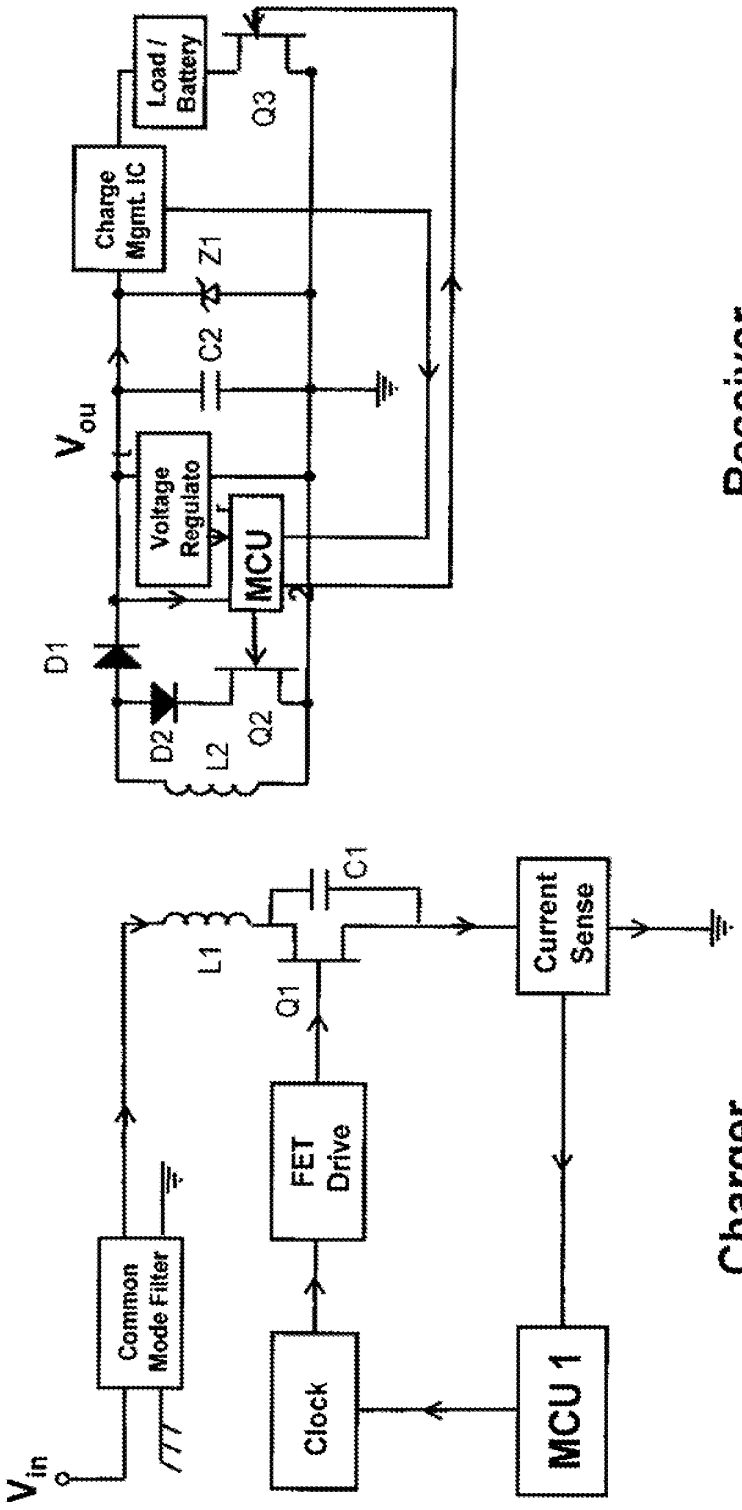

Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
Vou
Voltage Regulato
MCU
D1
D2
L2
Q2
Receiver
630
C1
L1
Q1
Current Sense
FET Drive
Common Mode Filter
Vin
Clock
MCU 1
Charger
620

Figure 28

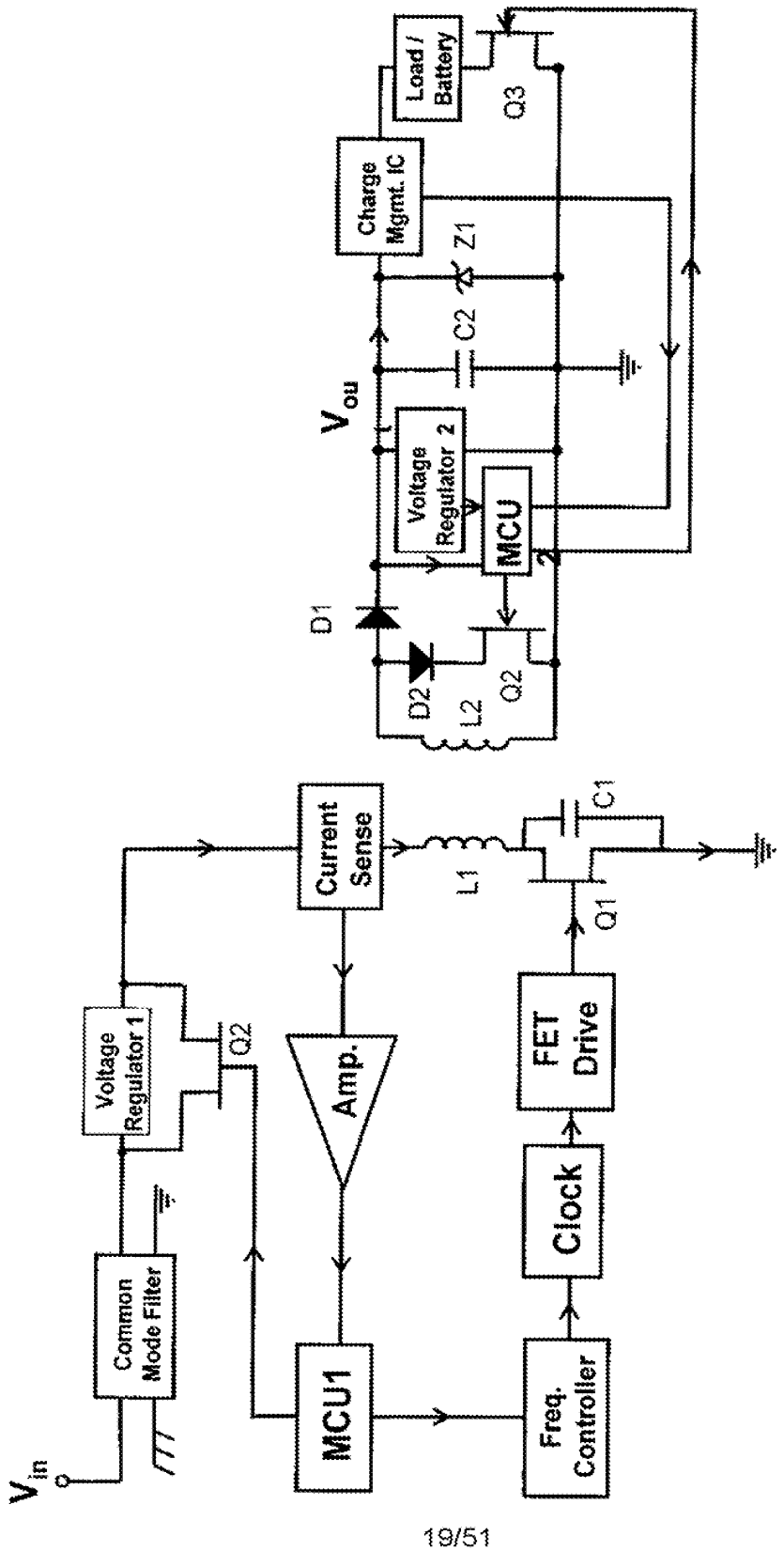

Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
V_{out}
Voltage Regulator 2
MCU
D1
D2
L2
Q2
Receiver
640
Current Sense
L1
C1
Q1
Voltage Regulator 1
Q2
Amp.
FET Drive
Clock
Common Mode Filter
MCU1
Freq. Controller
V_{in}
Charger

Figure 29

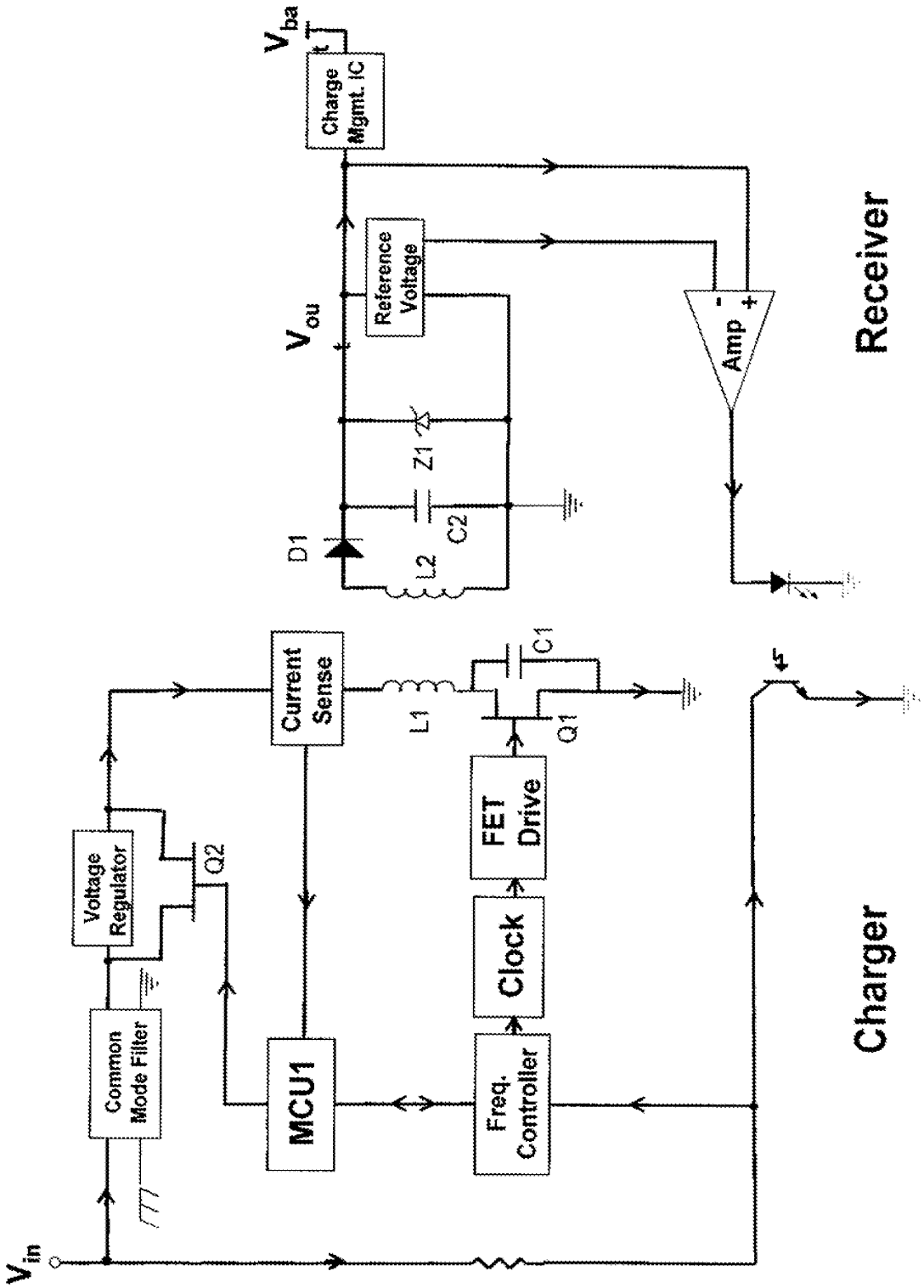

V_{ba}
Charge Mgmt. IC
V_{ou}
Reference Voltage
Amp
Receiver
650
Z1
C2
D1
L2
Current Sense
L1
C1
Q1
FET Drive
Clock
Voltage Regulator
Q2
Common Mode Filter
MCU1
Freq. Controller
Charger
V_{in}

Figure 30

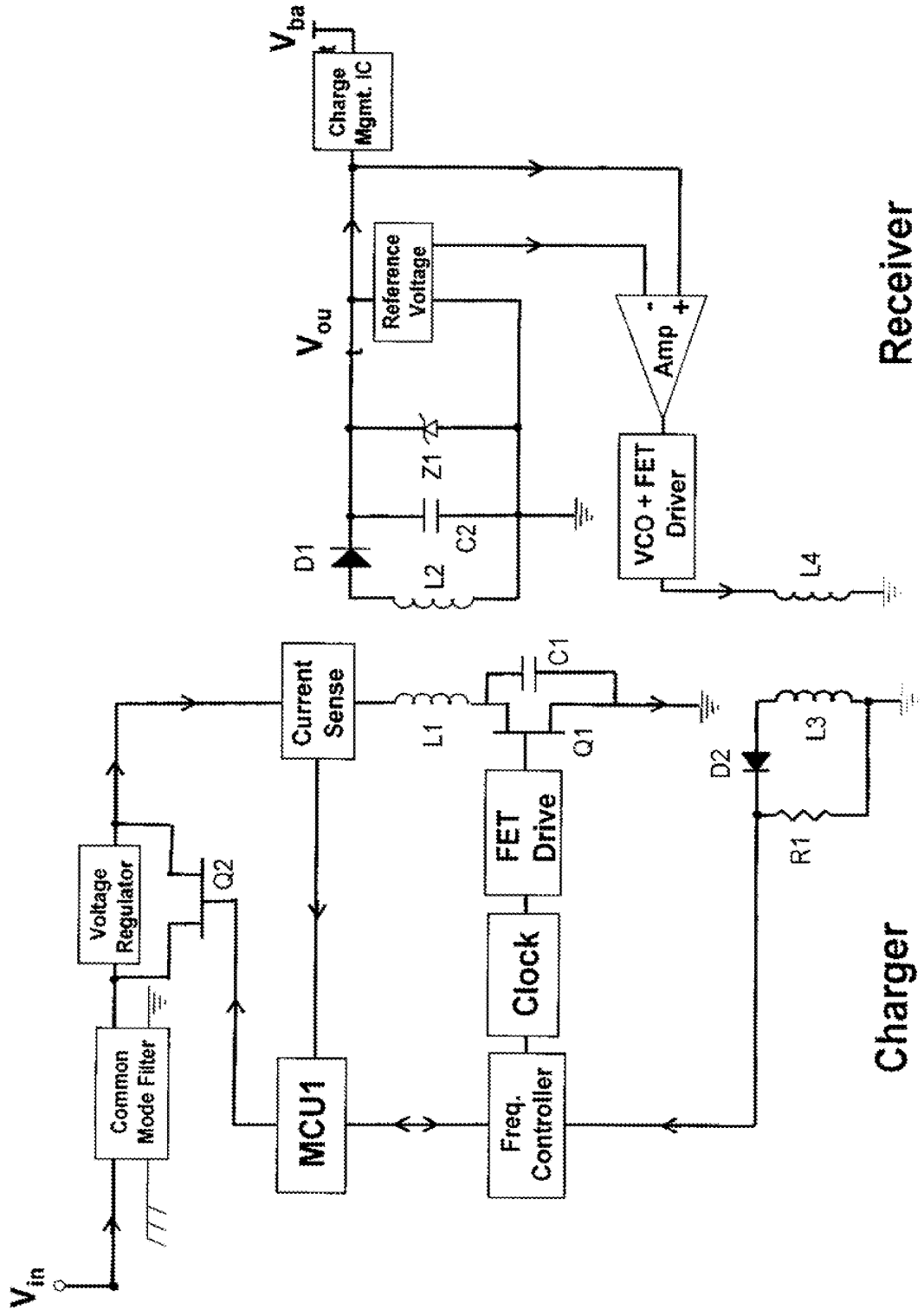

V_ba
Charge Mgmt. IC
V_ou
Reference Voltage
Amp
Receiver
Z1
C2
D1
L2
VCO + FET Driver
L4
660
Current Sense
L1
C1
Q1
D2
L3
R1
FET Drive
Clock
Freq. Controller
MCU1
Voltage Regulator
Q2
Common Mode Filter
V_in
Charger

Figure 31

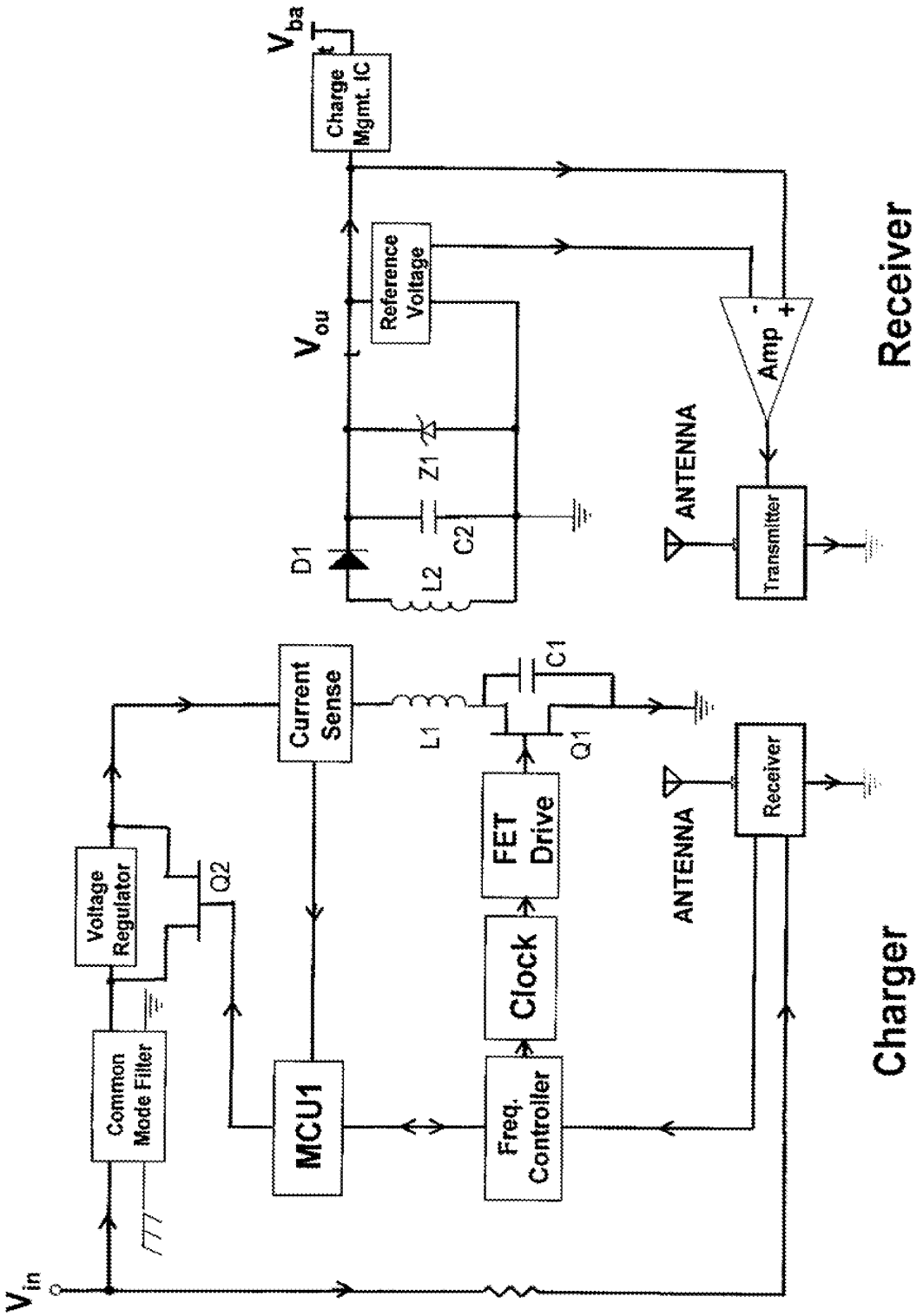

Receiver
Charger
V_{ba}
Charge Mgmt. IC
V_{ou}
Reference Voltage
Amp
ANTENNA
Transmitter
Z1
C2
D1
L2
Current Sense
L1
C1
Q1
FET Drive
Clock
Freq. Controller
MCU1
Voltage Regulator
Q2
Common Mode Filter
V_{in}
ANTENNA
Receiver
670

Figure 32

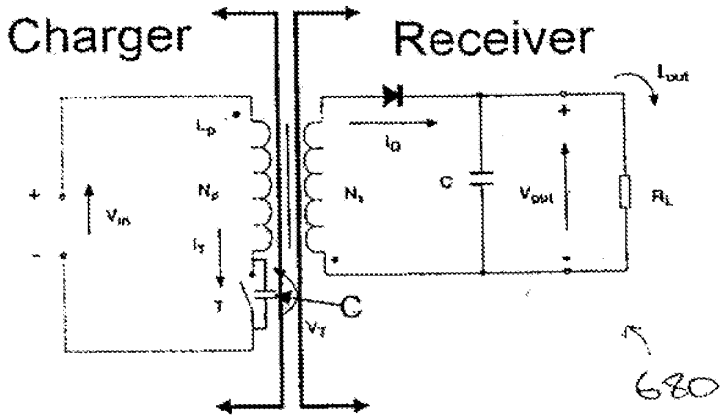


FIG. 33

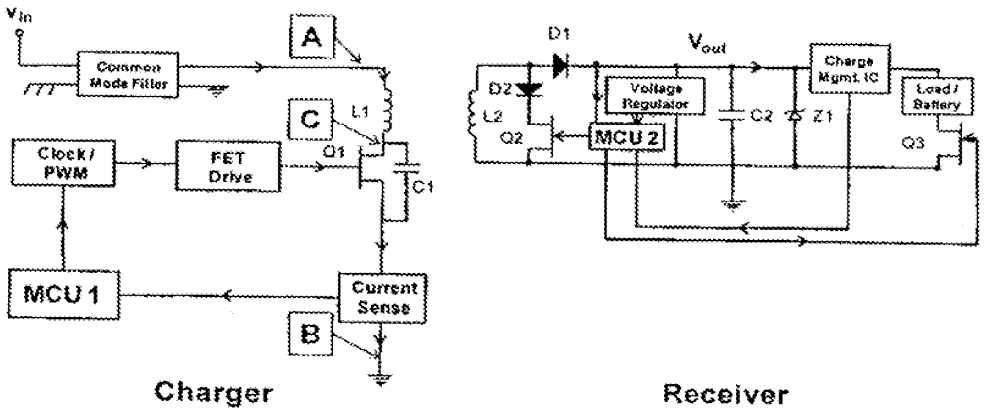


FIG. 34

700

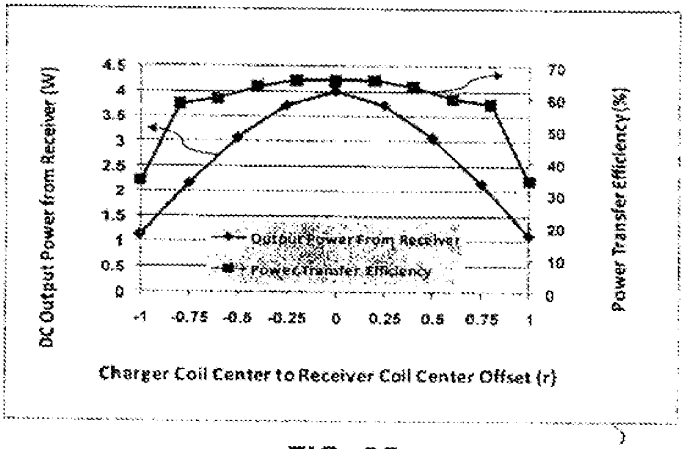


FIG. 35

720

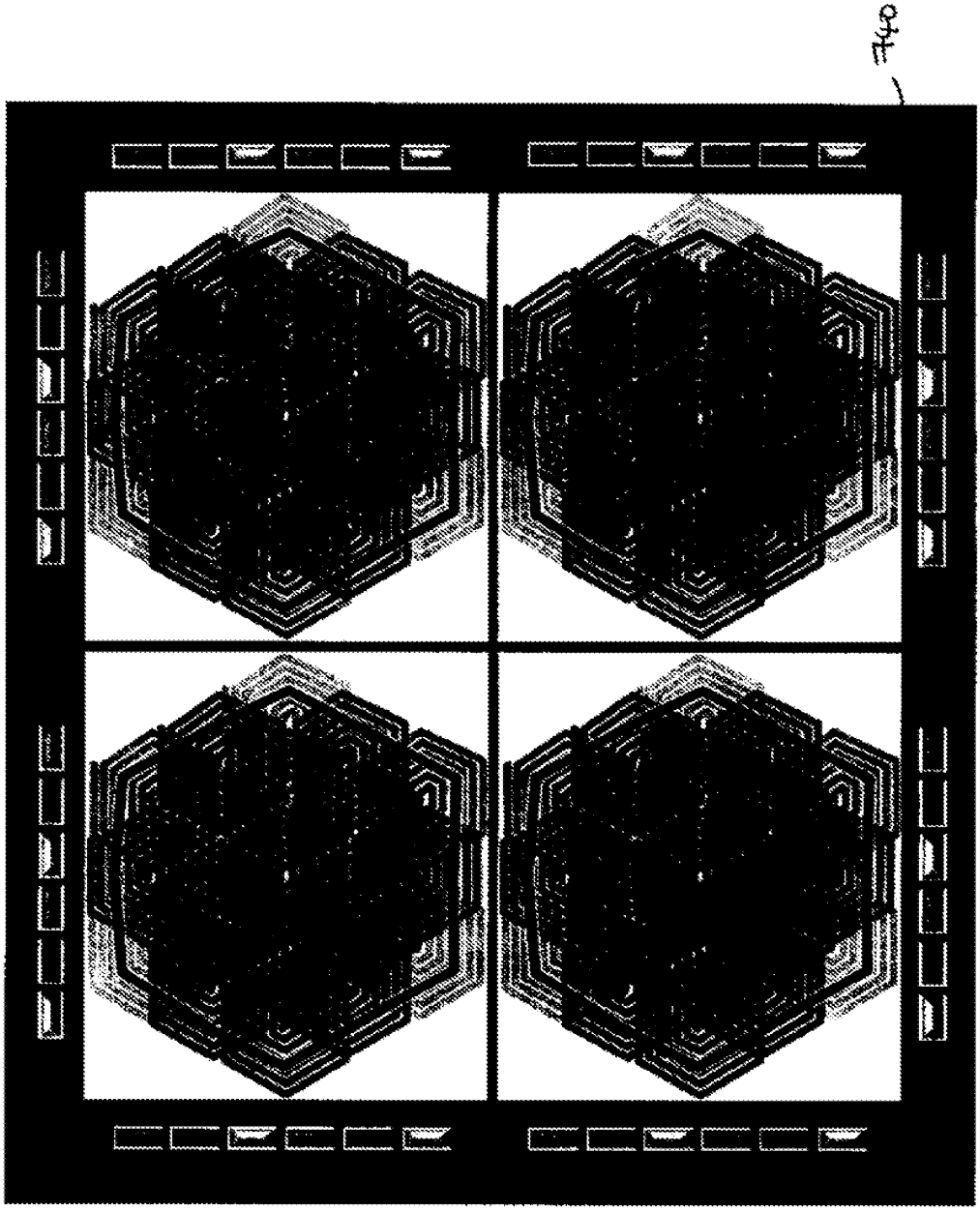


Figure 36

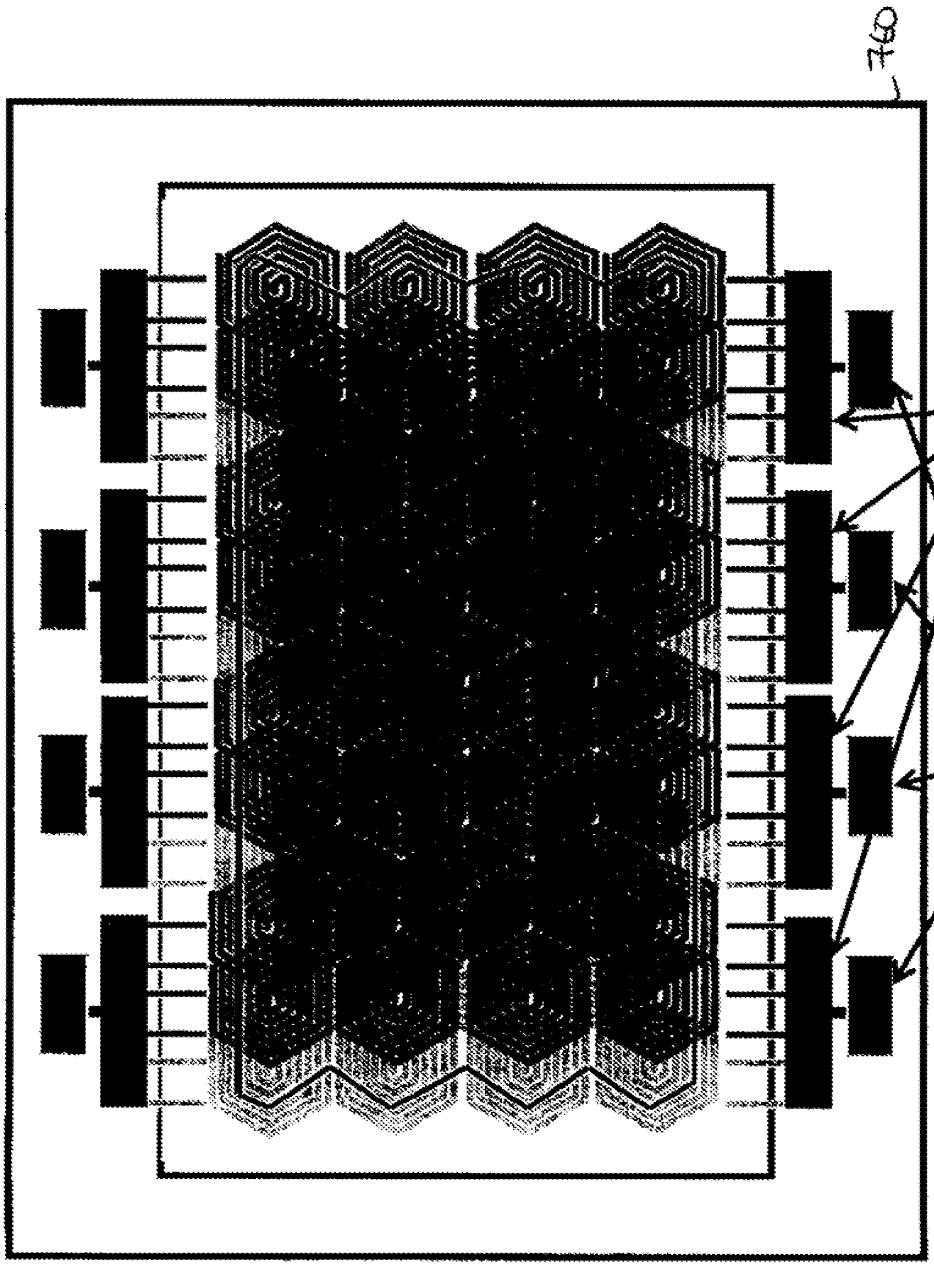


Figure 37

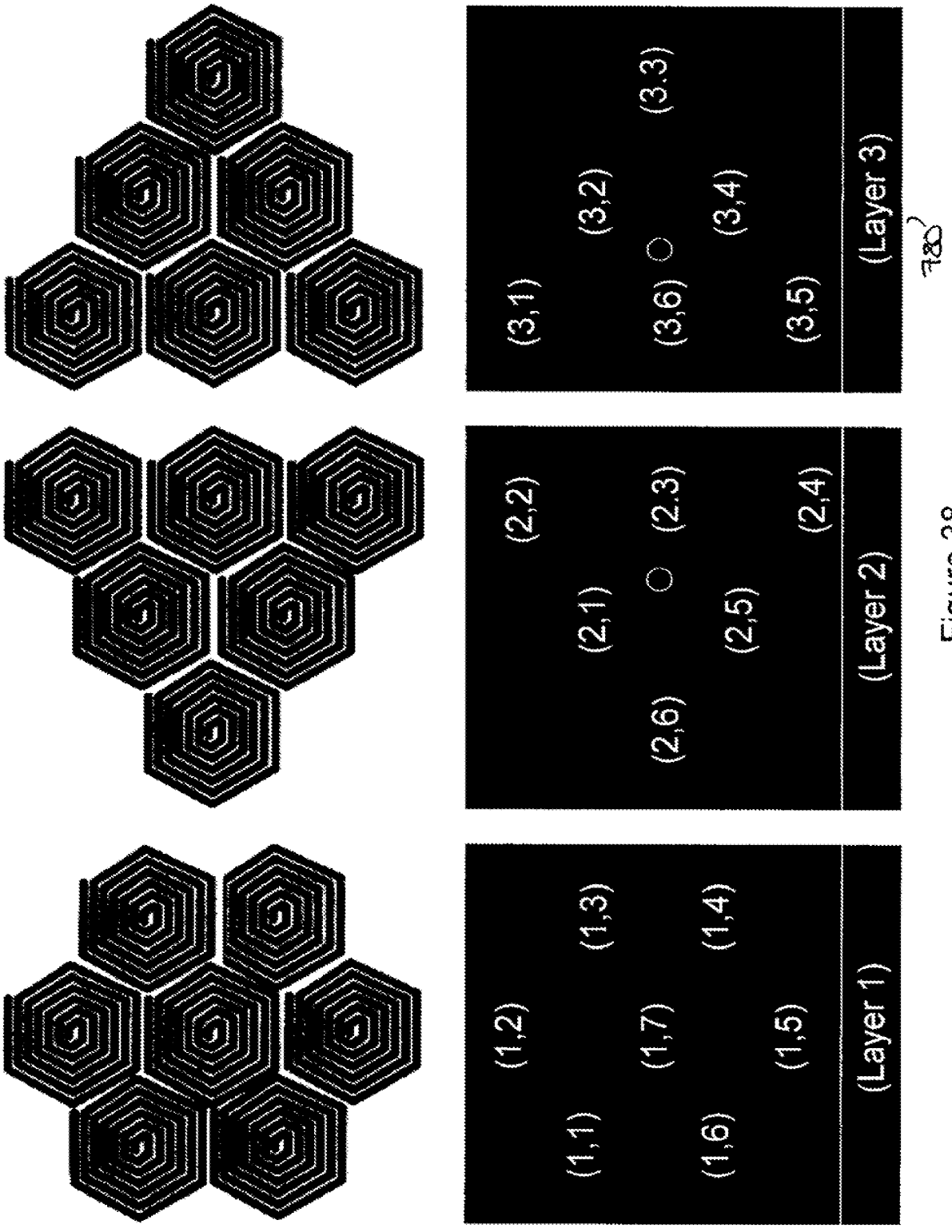

(1,1)
(1,2)
(1,3)
(1,4)
(1,5)
(1,6)
(1,7)
(Layer 1)
(2,1)
(2,2)
(2,3)
(2,4)
(2,5)
(2,6)
(Layer 2)
(3,1)
(3,2)
(3,3)
(3,4)
(3,5)
(3,6)
(Layer 3)
780

Figure 38

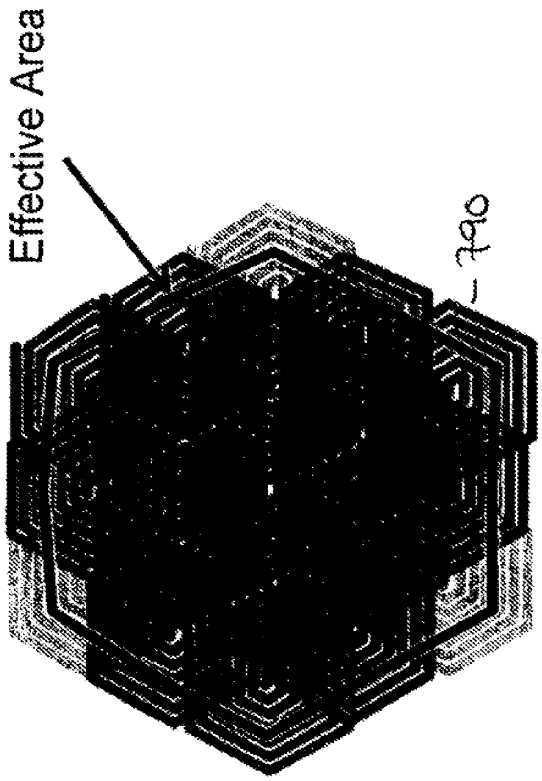


Figure 39

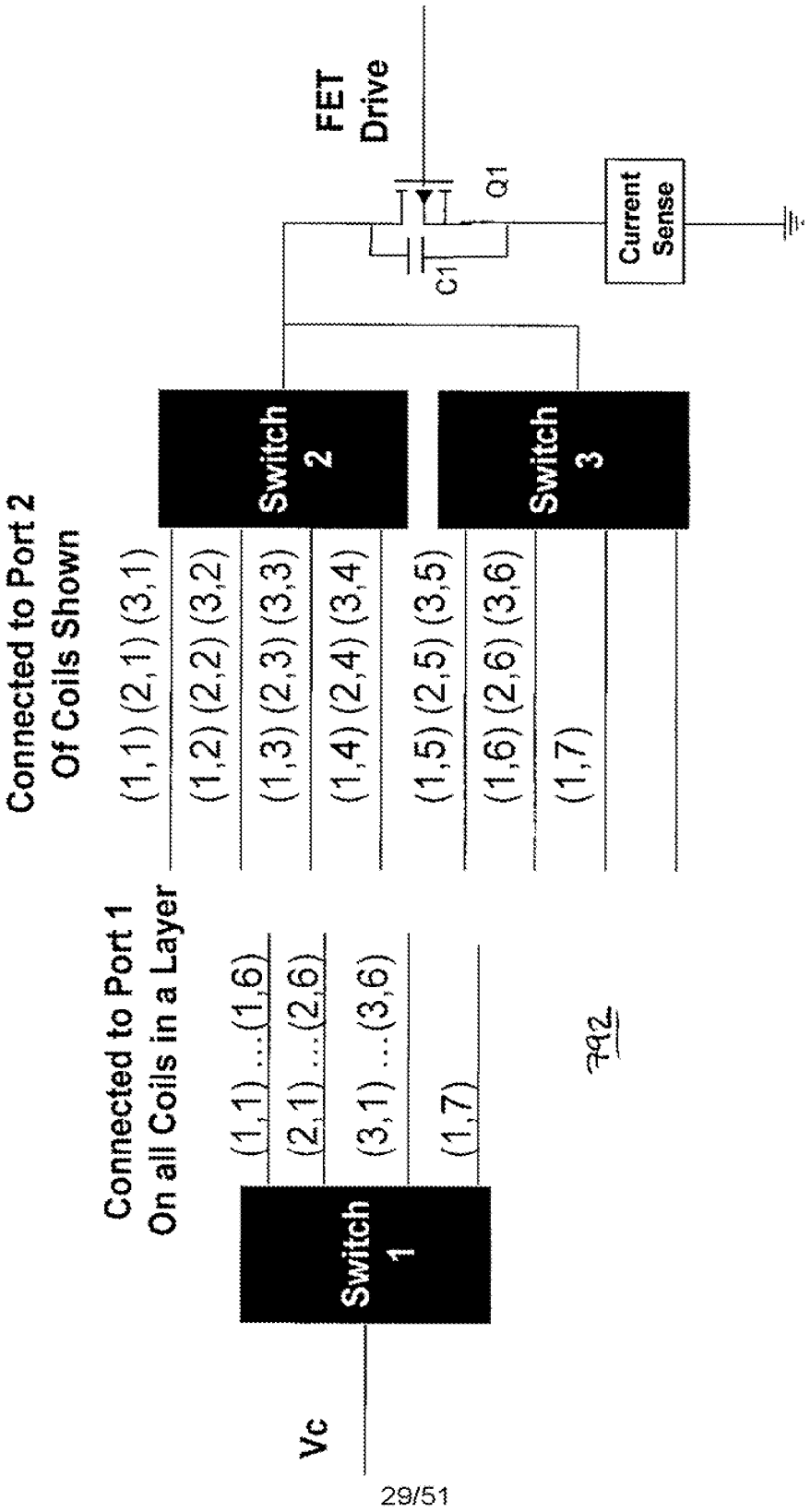

FET Drive
Q1
C1
Current Sense
Switch 2
Switch 3
Switch 1
Connected to Port 2
Of Coils Shown
(1,1) (2,1) (3,1)
(1,2) (2,2) (3,2)
(1,3) (2,3) (3,3)
(1,4) (2,4) (3,4)
(1,5) (2,5) (3,5)
(1,6) (2,6) (3,6)
(1,7)
Connected to Port 1
On all Coils in a Layer
(1,1) ...(1,6)
(2,1) ...(2,6)
(3,1) ...(3,6)
(1,7)
792
Vc

Figure 40

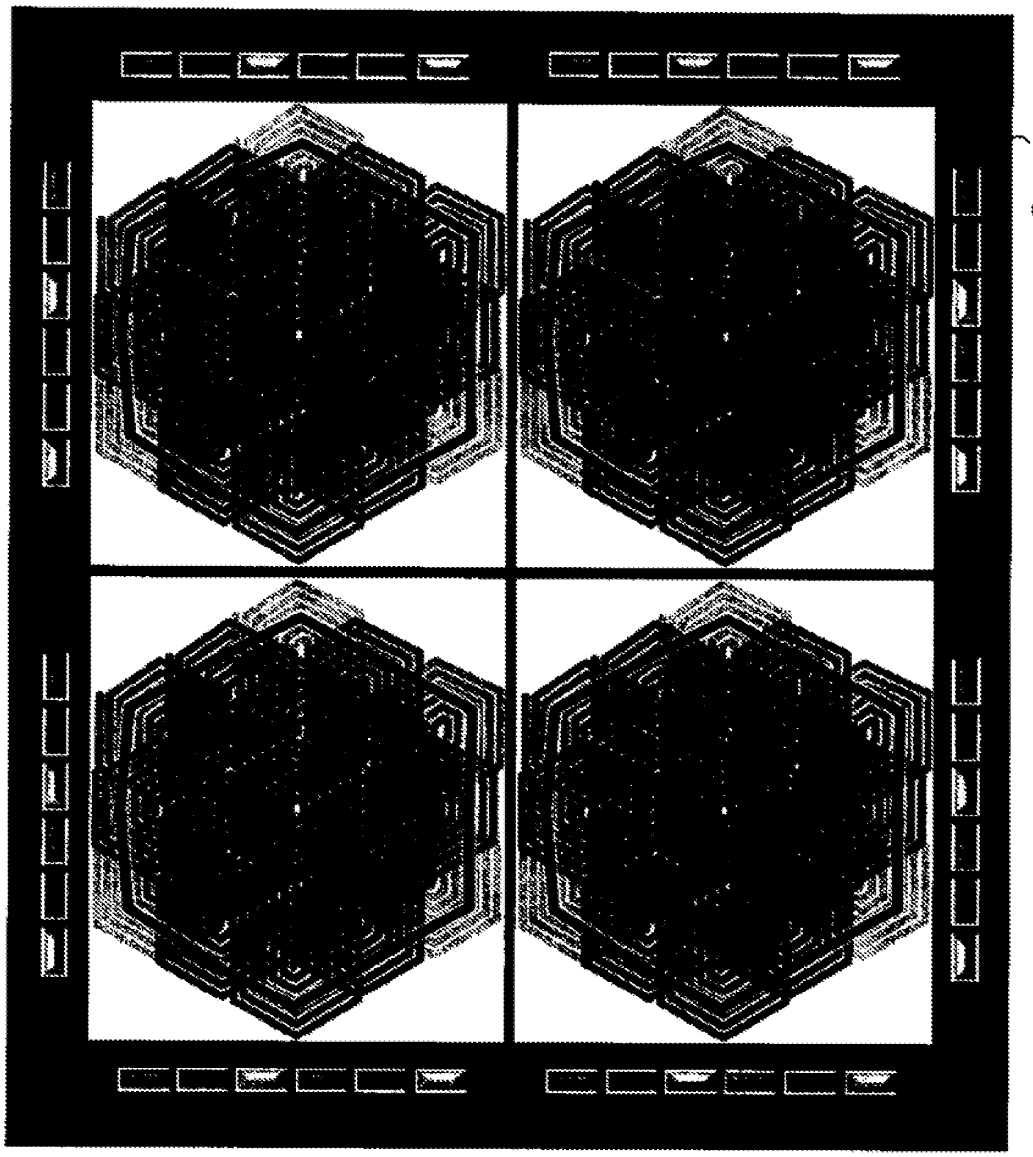


Figure 41

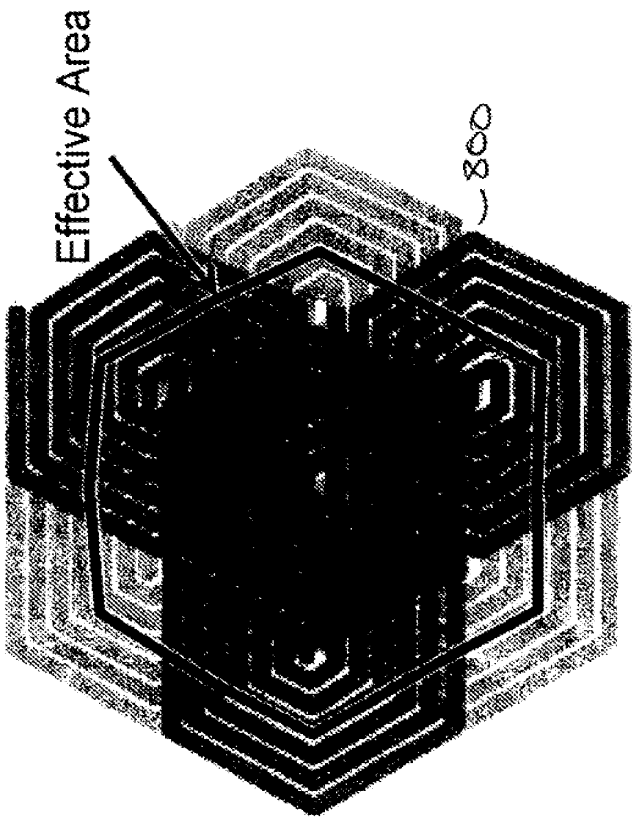


Figure 42

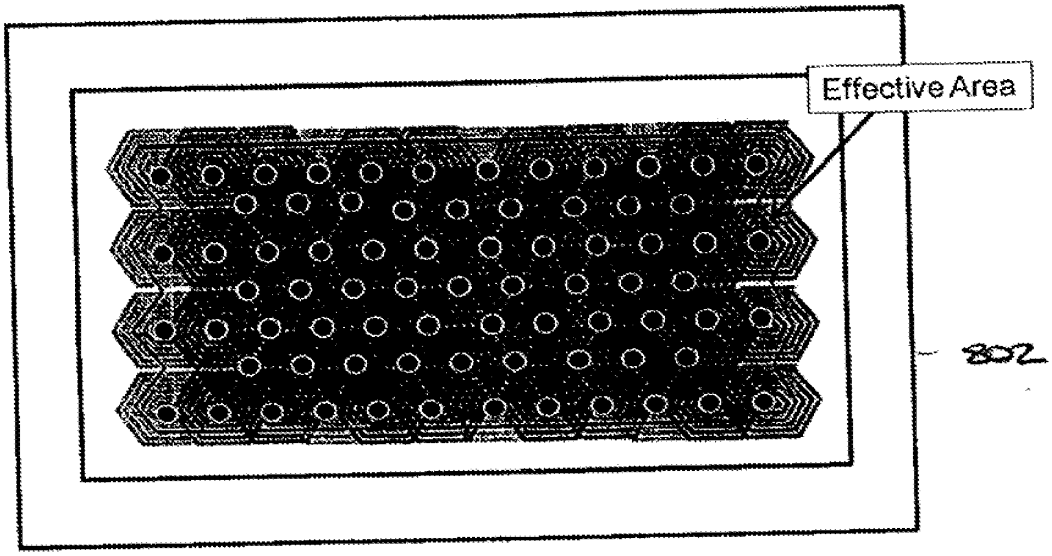

Effective Area
802

FIG. 43

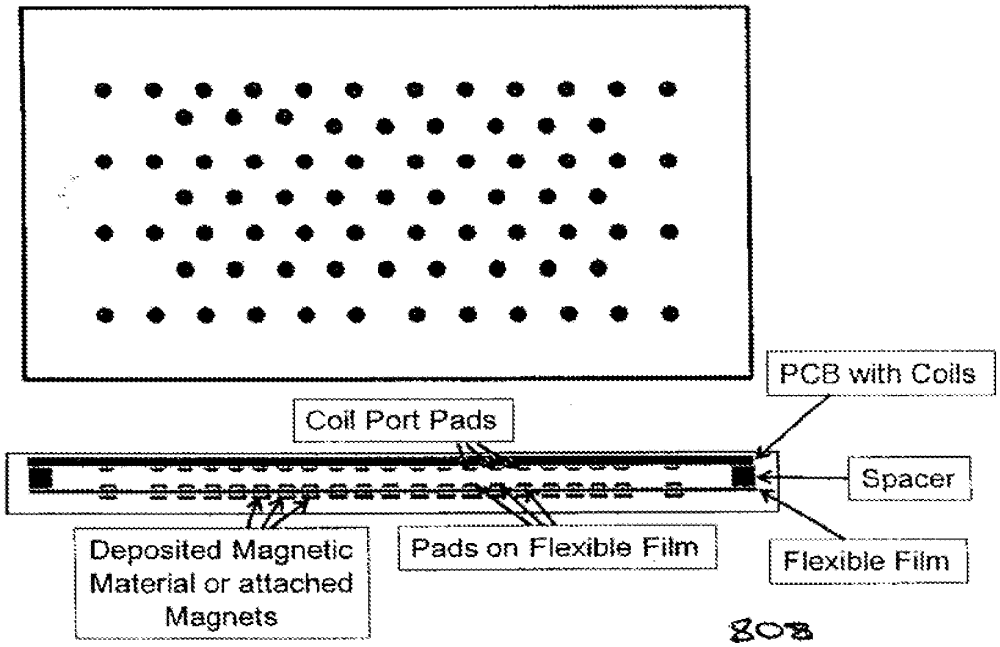

PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film
808

FIG. 44

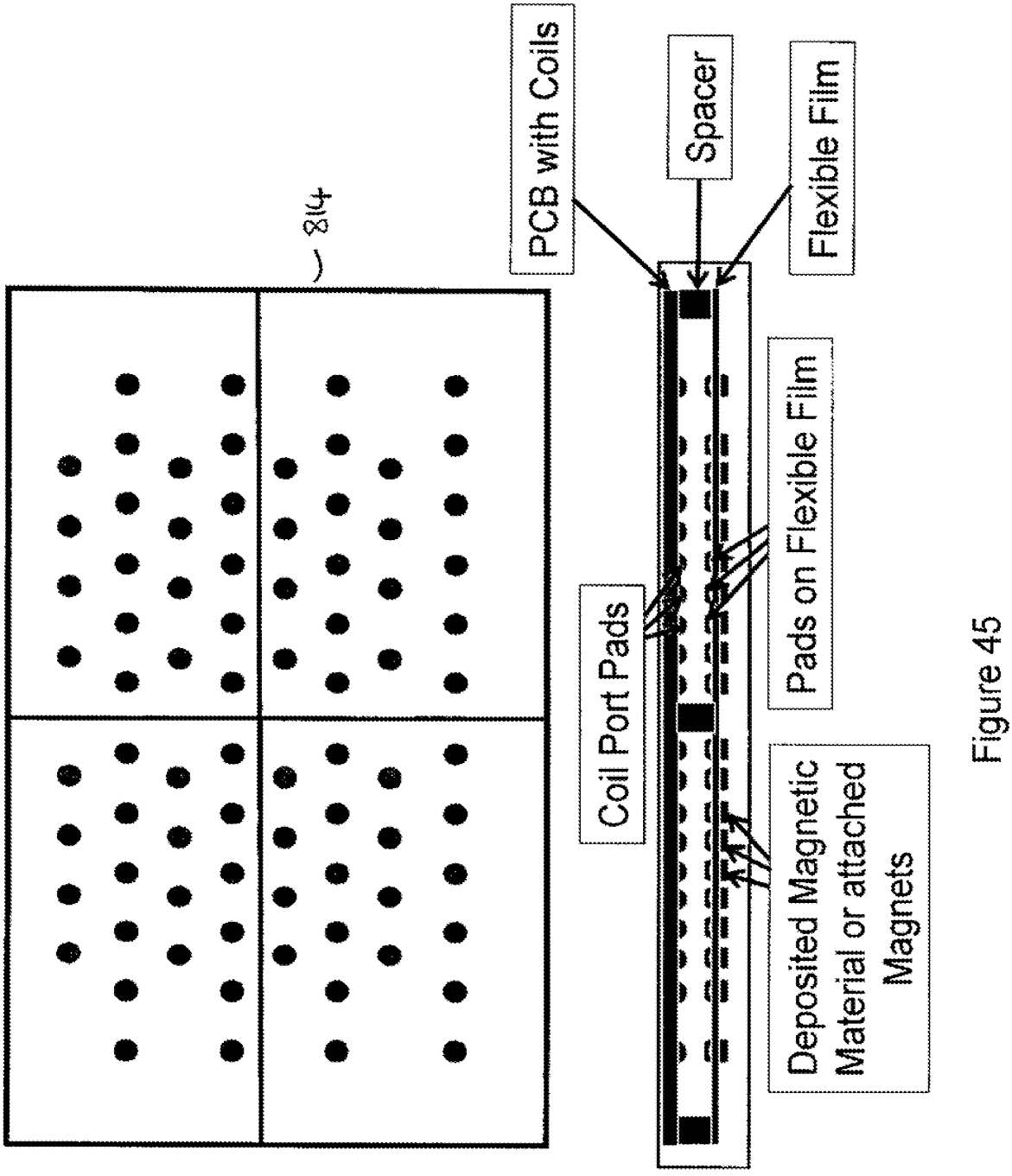
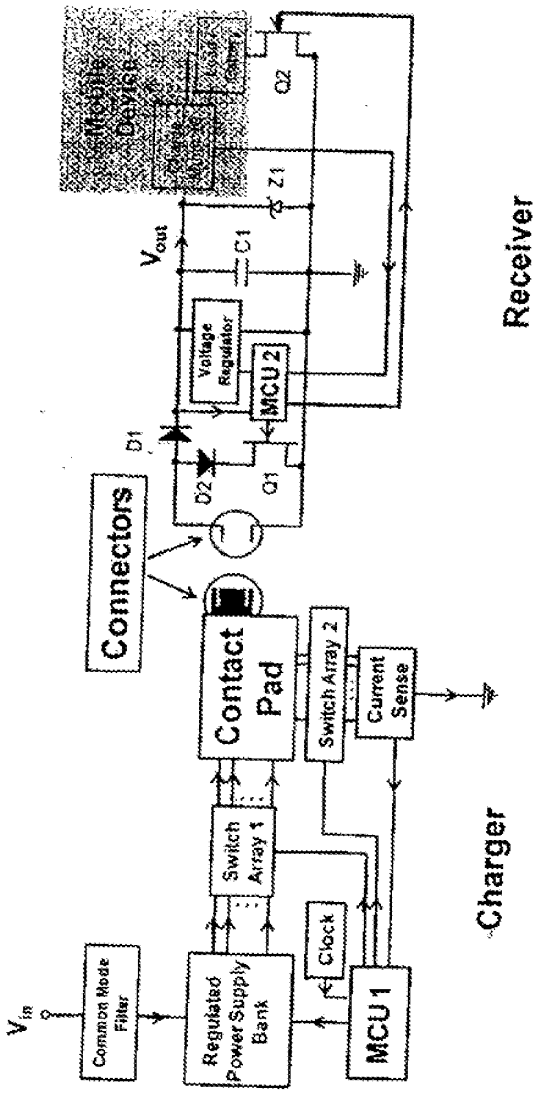

814
PCB with Coils
Spacer
Flexible Film
Coil Port Pads
Pads on Flexible Film
Deposited Magnetic Material or attached Magnets

Figure 45


Mobile Device
Q2
Z1
V_{out}
C1
Voltage Regulator
MCU 2
D1
D2
Q1
Connectors
Contact Pad
Switch Array 2
Current Sense
Switch Array 1
Clock
V_{in}
Common Mode Filter
Regulated Power Supply Bank
MCU 1
Receiver
Charger

820

FIG. 46

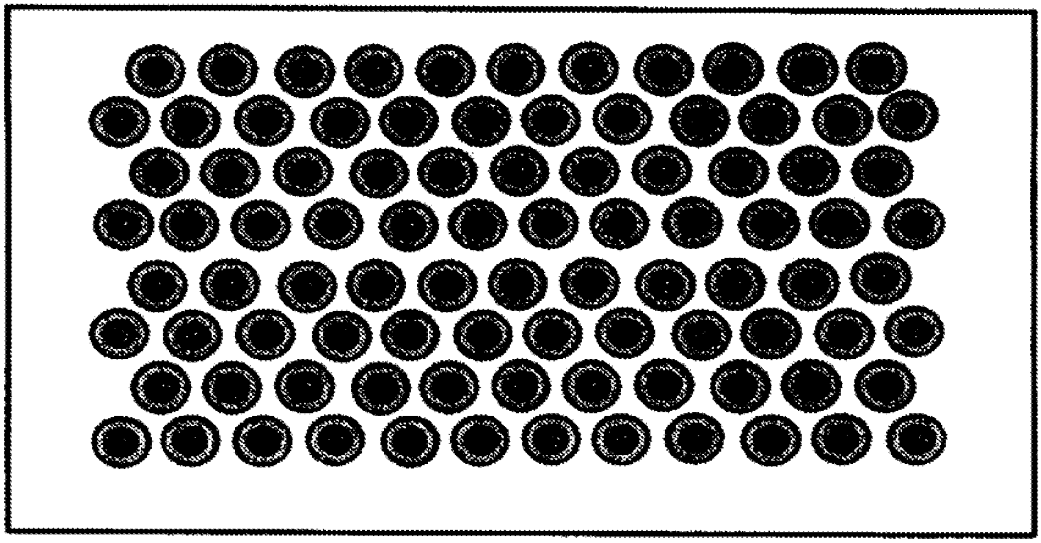


FIG. 47

824

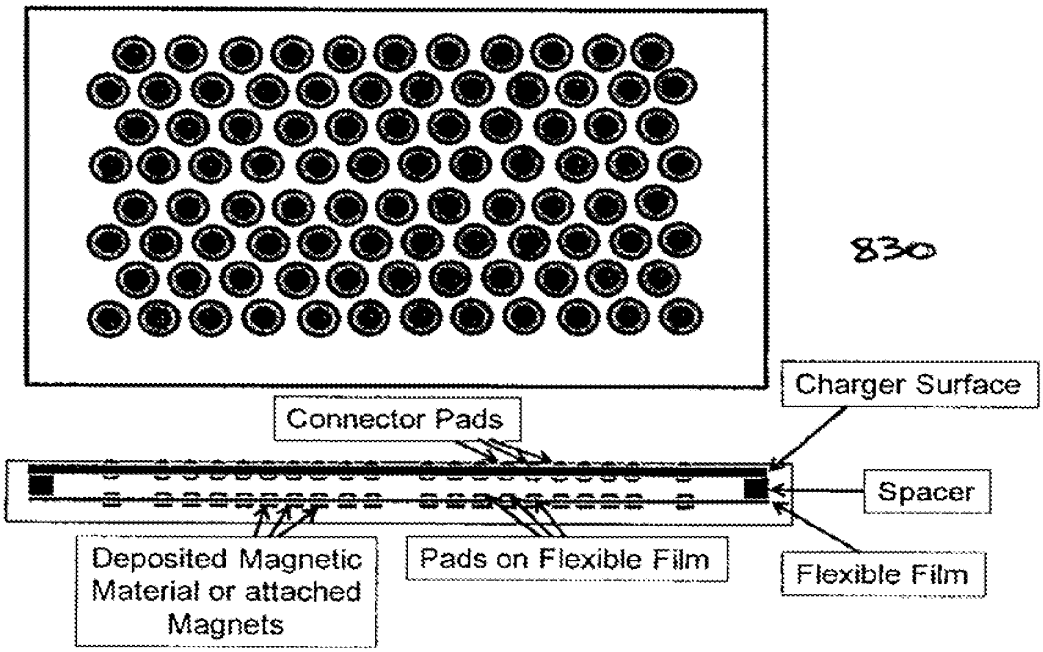


FIG. 48

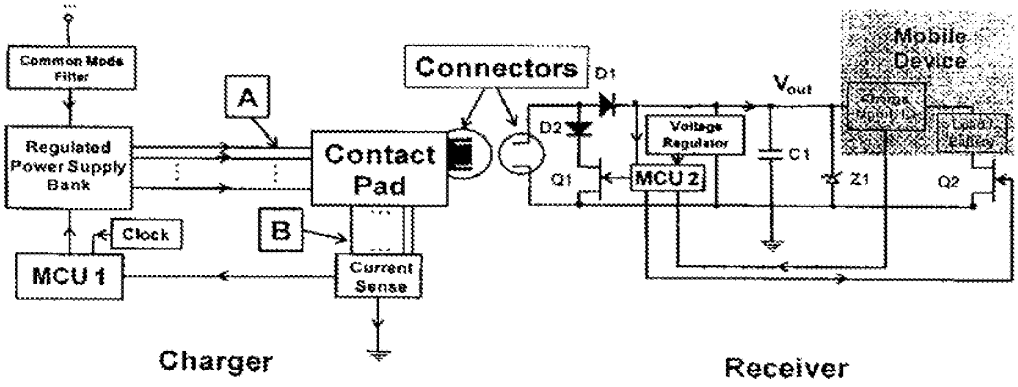


FIG. 49

836

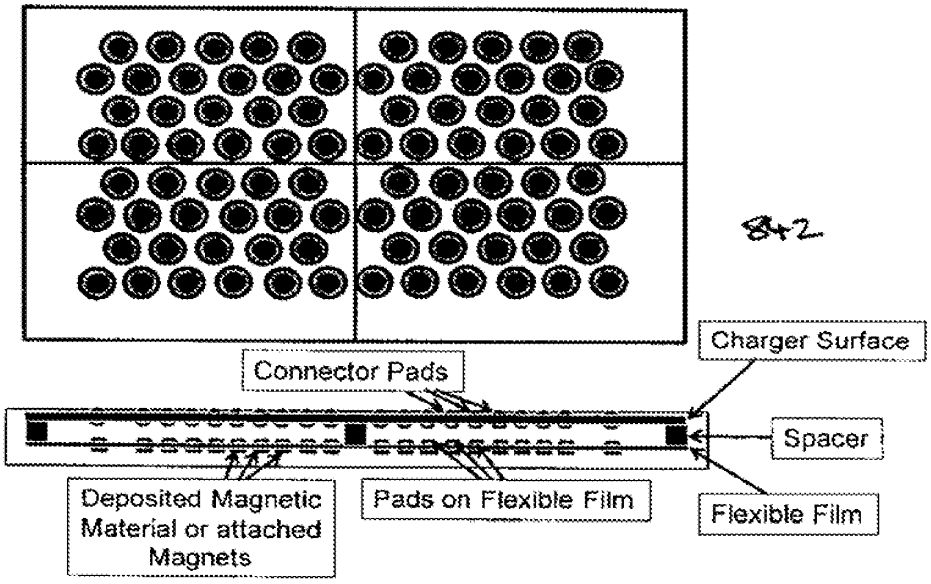
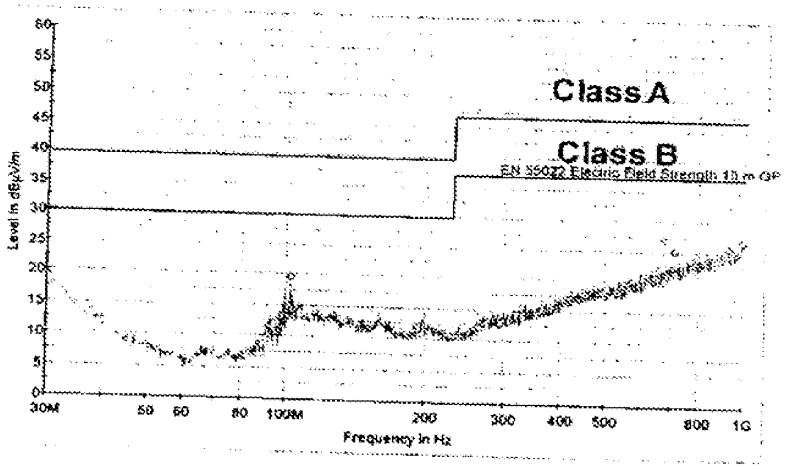
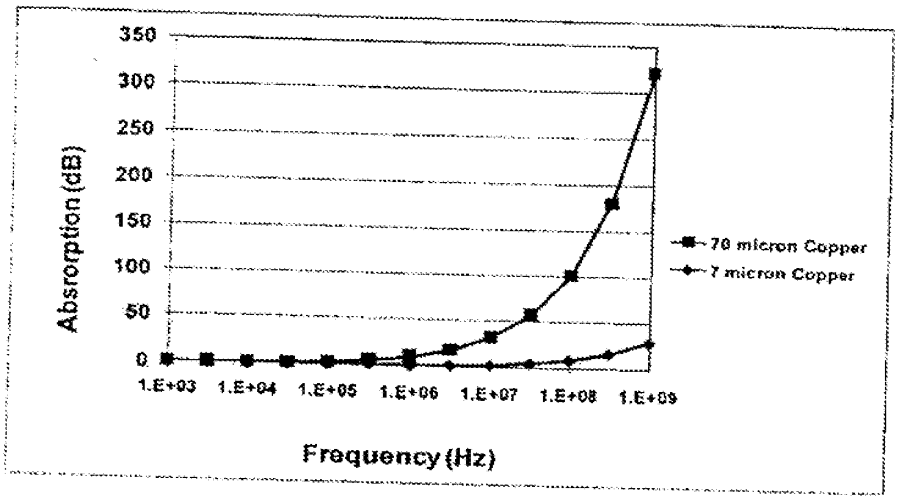


FIG. 50



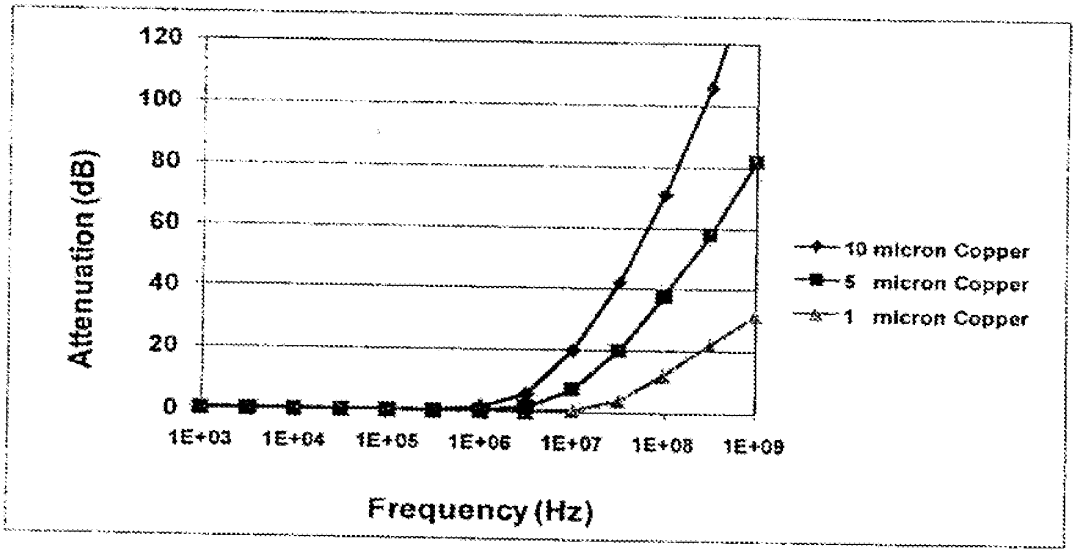
846

FIG. 51

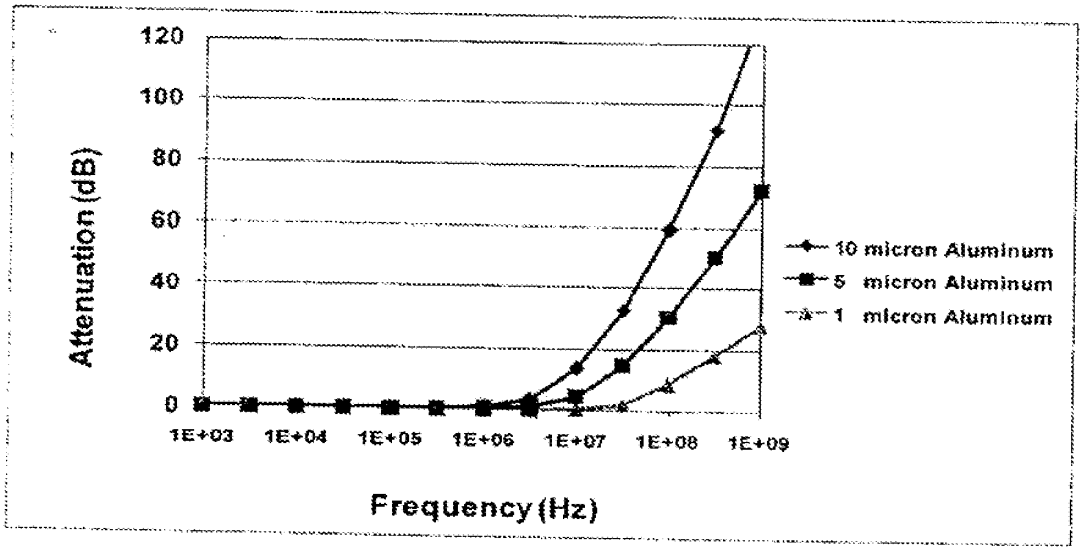


850

FIG. 52



854



856

FIG. 53

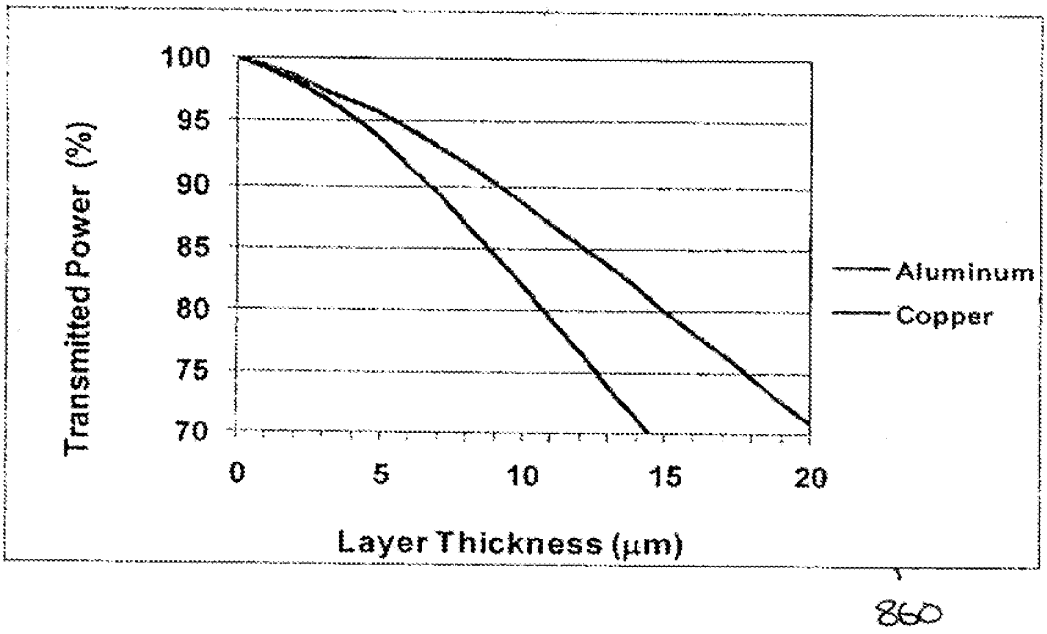

100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper
860

FIG. 54

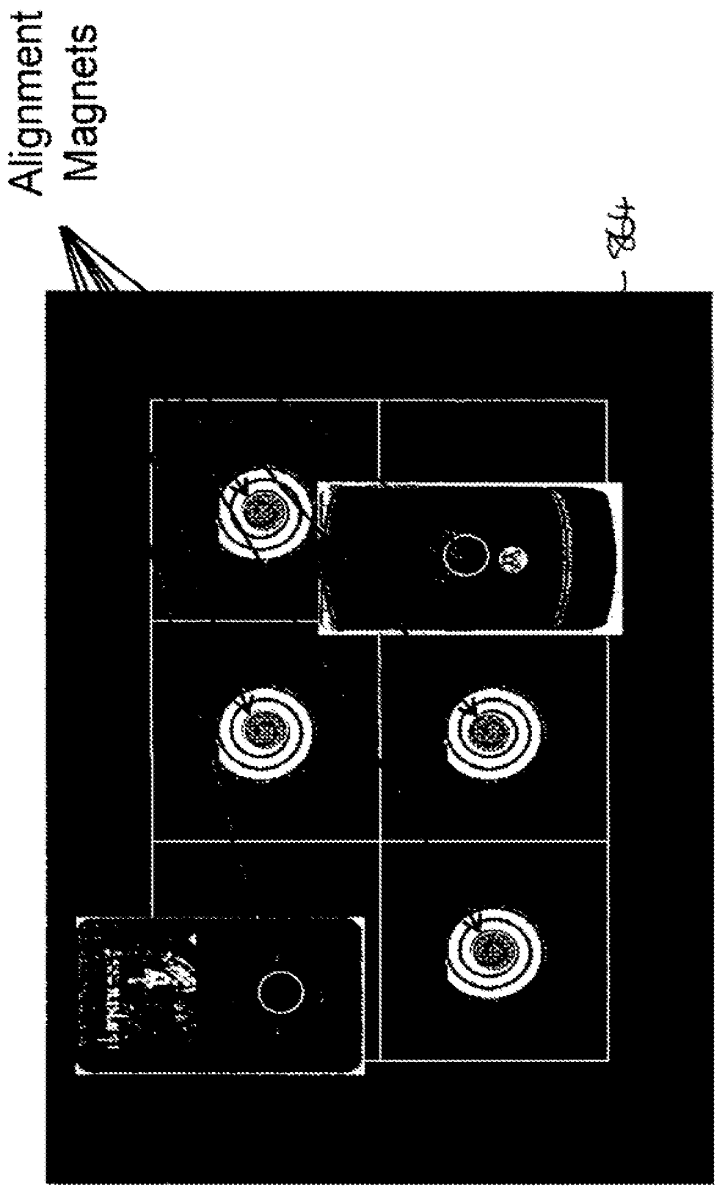


Figure 55

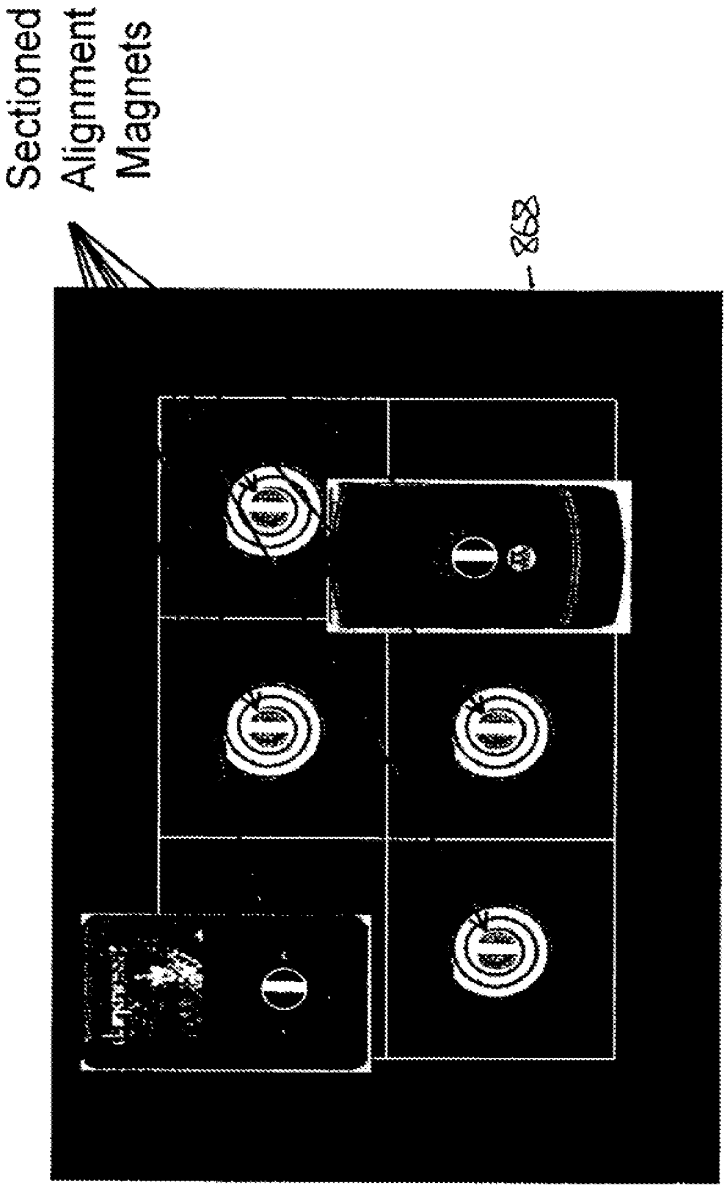


Figure 56

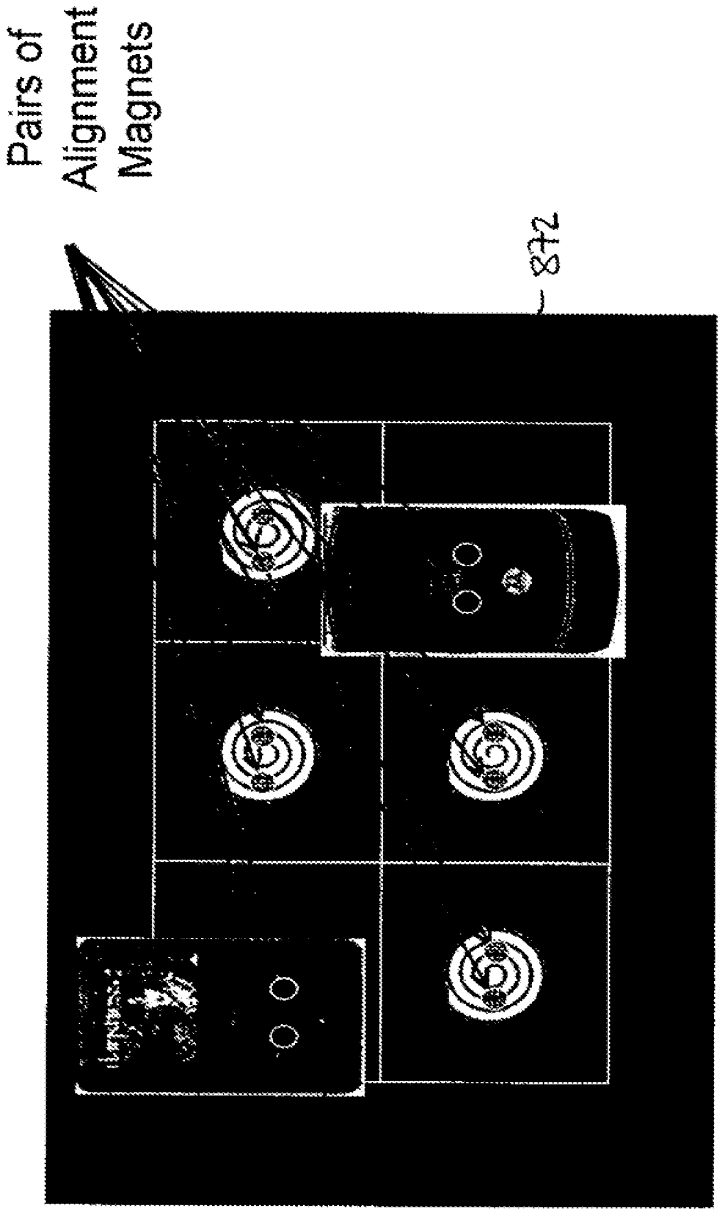


Figure 57

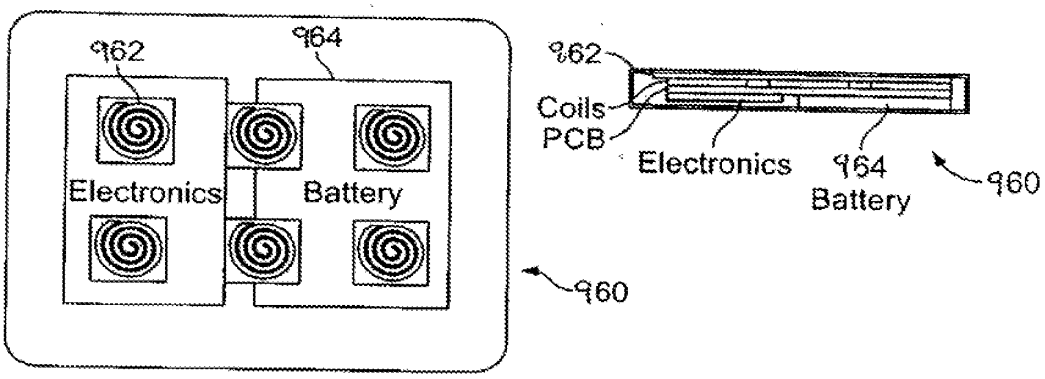

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

FIG. 58

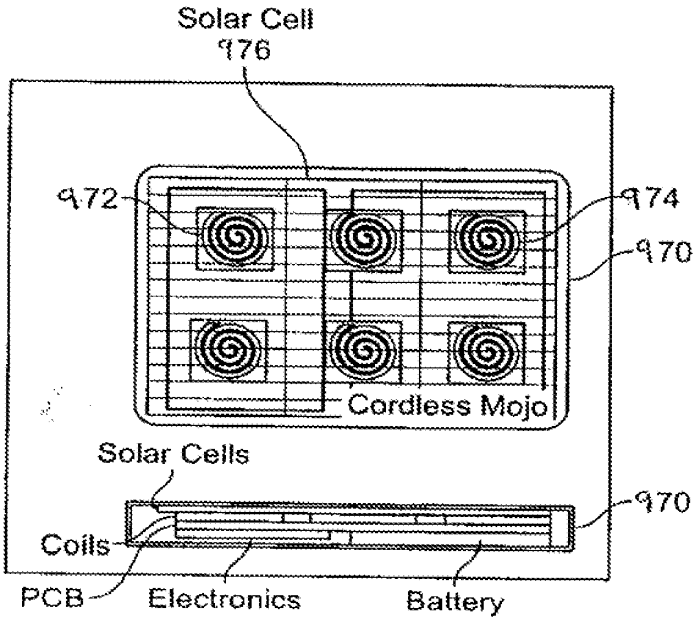

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

FIG. 59

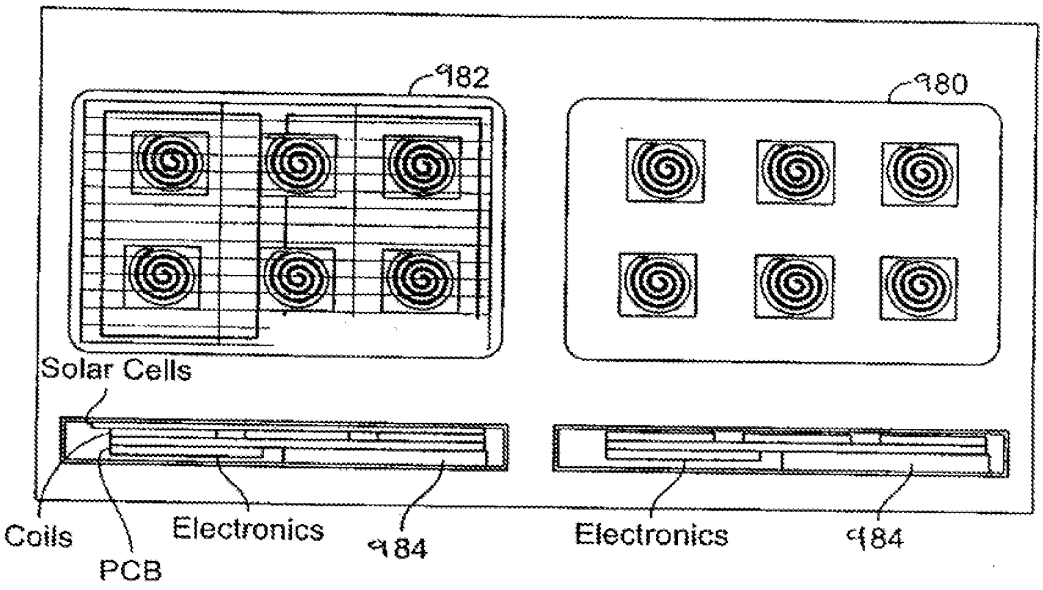

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

FIG. 60

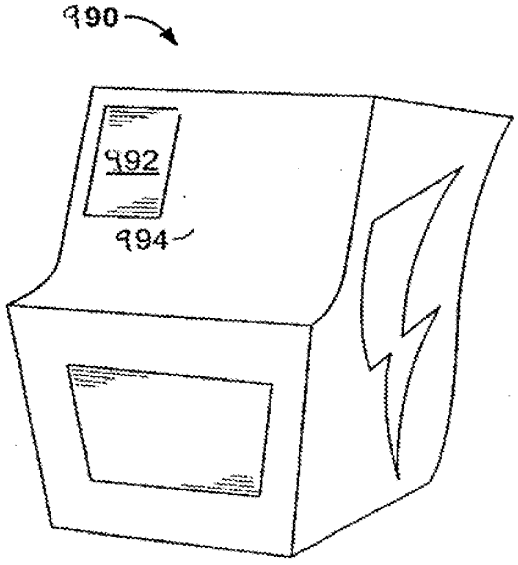

990
992
994

FIG. 61



FIG. 62

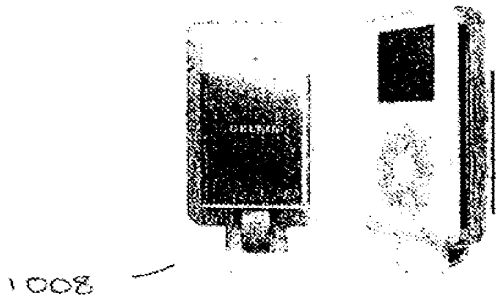


FIG. 63

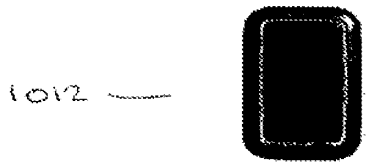


FIG. 64

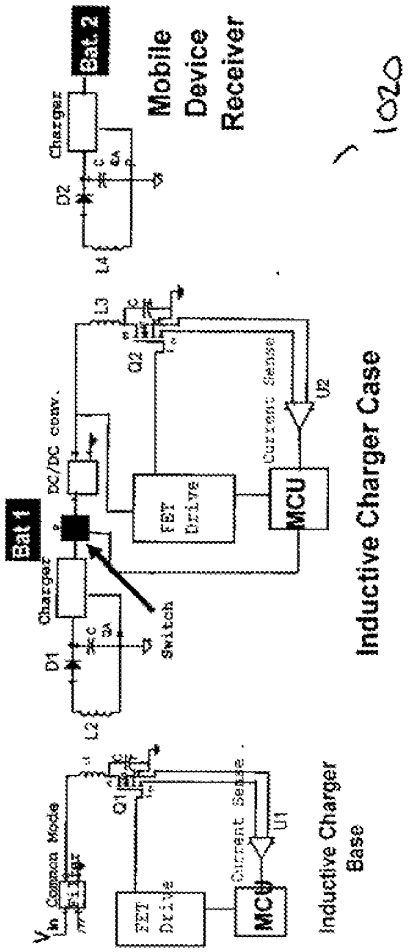

Mobile Device Receiver
1020
Bat. 2
Charger
D2
L4
L3
Q2
DC/DC conv.
Current Sense
U2
FET Drive
MCU
Bat 1
Charger
Switch
D1
L2
Inductive Charger Case
Q1
Current Sense
U1
Common Mode Filter
FET Drive
MCU
Inductive Charger Base

Figure 65

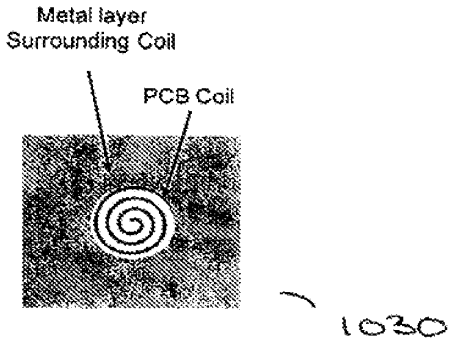


Figure 66

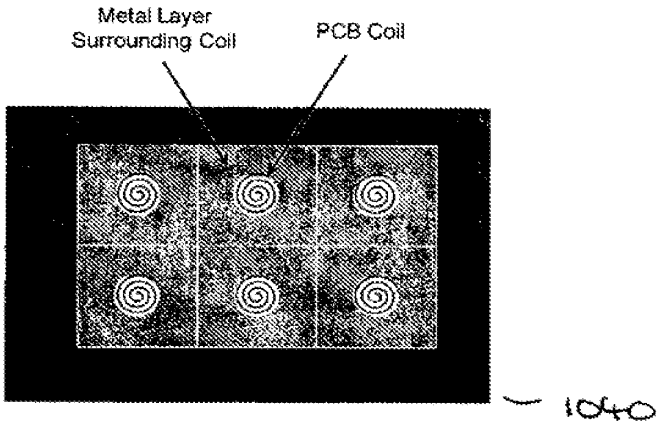


Figure 67

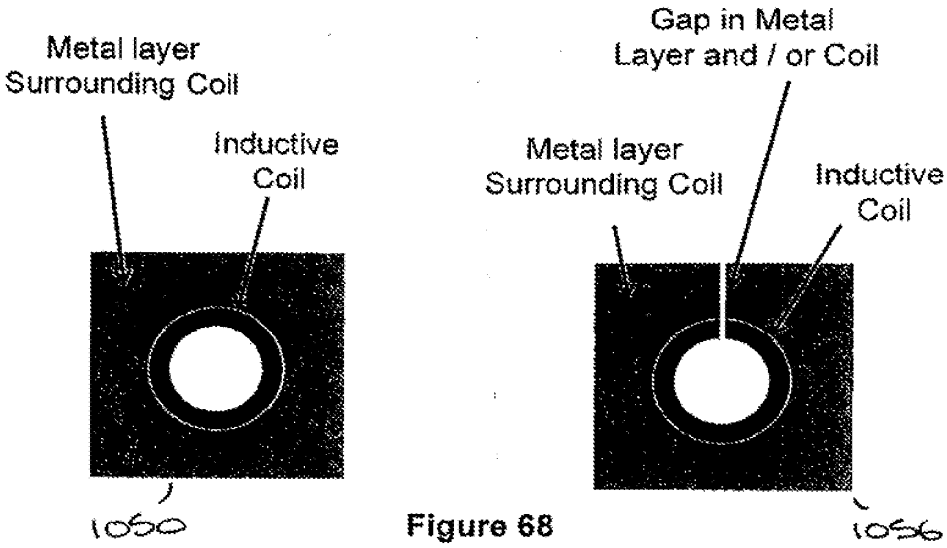


Figure 68

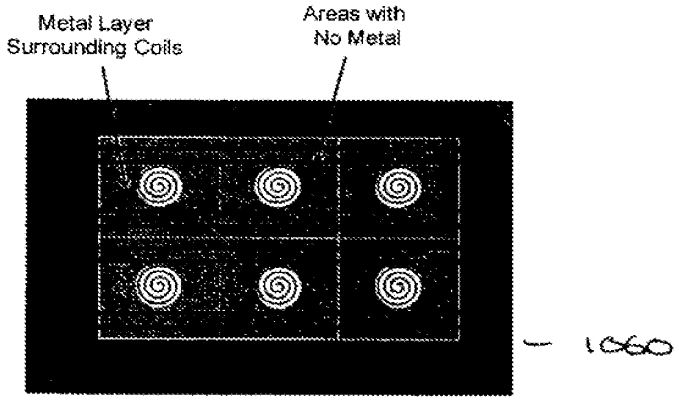
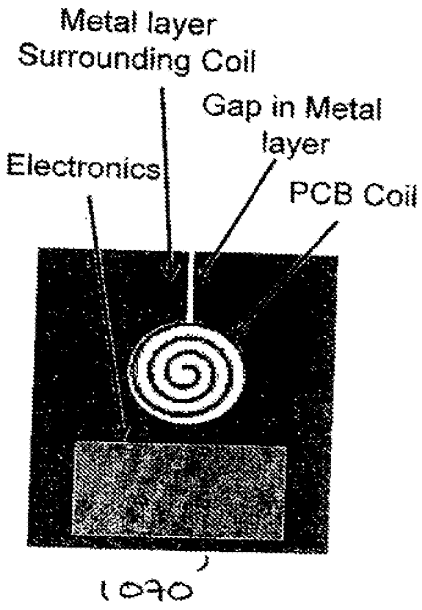


Figure 69



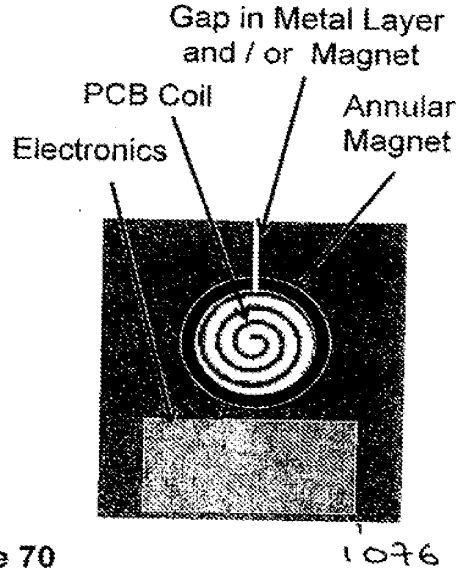


Figure 70

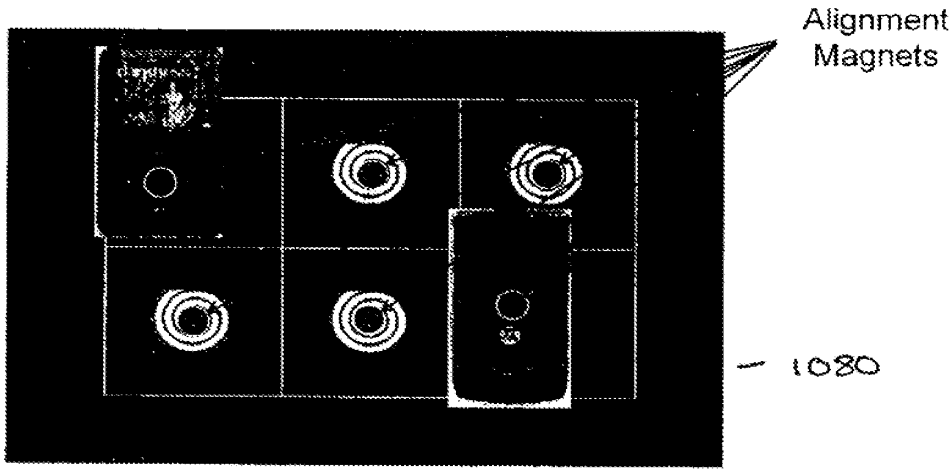


Figure 71

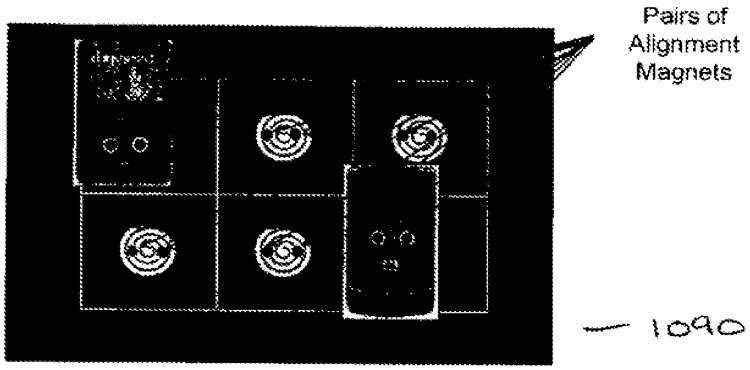


Figure 72

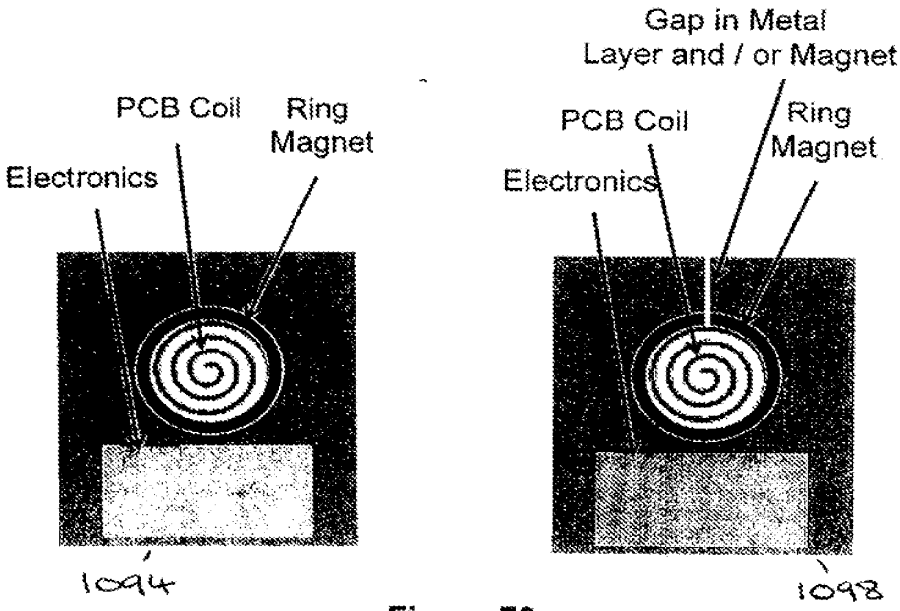


Figure 73

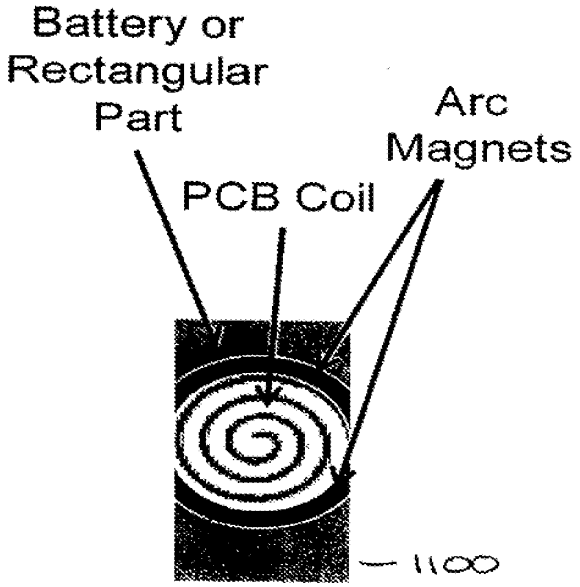


Figure 74

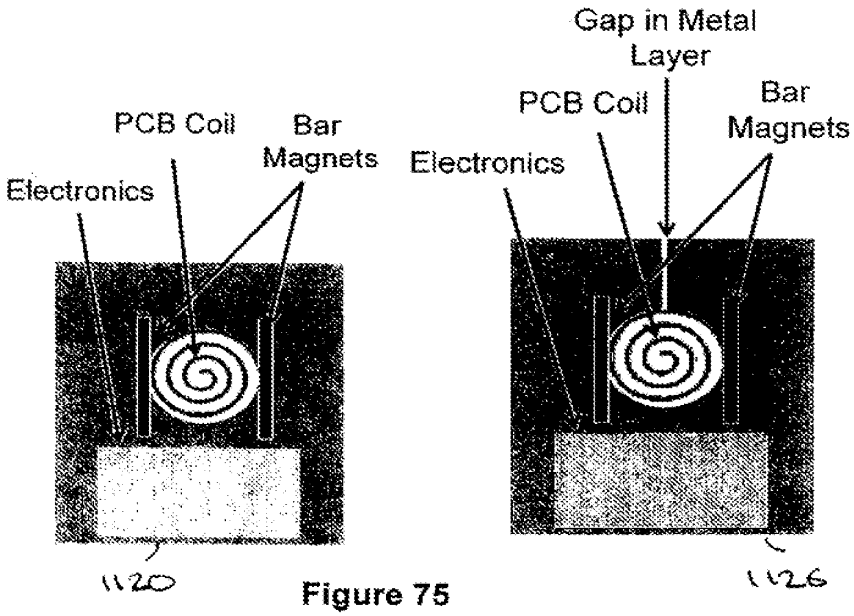


Figure 75

INTERNATIONAL SEARCH REPORT

International application No
PCT/US 08/63084

A CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/00 (2008.04)
USPC - 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC 320/108

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC 320/108 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PUbWEST(USPT PGPB.EPAB.JPAB), Google
Search Terms Inductive, base, receiver coll zener, mosfet, single unit, spiral, non-fernte, charge, primary coil

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X -- Y	US 7,21 1,986 B1 (FLOWERDEW et al) 01 May 2007 (01 05 2007), entire document especially the Abstract, Fig 2, col 4, lns 44-60, col 7, lns 52-61, col 6, lns 14-27	9-14 ---------- 1-8 and 15-20
Y	US 2004/0113589 A1 (CRISP et al) 17 June 2004 (17 06 2004), entire document especially paras [0088], [0136], [0154]	15-16 and 18
Y	US 2003/0094921 A1 (LAU et al) 22 May 2003 (22 05 2003), entire document especially the Abstract	17
Y	US 2003/0103039 A1 (BURR et al) 05 June 2003 (05 06 2003), entire document especially paras [0019], [0023), and [0029]	1-8 and 19-20
Y	US 2005/0127867 A1 (CALHOON et al) 16 June 2005 (16 06 2005), entire document especially para [0050]	2 and 7
Y	US 2005/0189910 A1 (HUI) 01 September 2005 (01 09 2005), entire document especially paras [0014], [0085]	6 and 8

☐ Further documents are listed in the continuation of Box C ☐

* **Special categories of cited documents**
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on pπoπfy claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published pnor to the international filing date but later than the priority dale claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 August 2008 (06 08 2008)	**08 AUG 2008**
Name and mailing address of the ISA/US Mail Stop PCT, Attn ISA/US, Commissioner for Patents P O Box 1450, Alexandna, Virginia 22313-1450 Facsimile No 571-273-3201	Authorized officer Lee W Young PCT Helpd βsk 571-272-4300 PCTOSP 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

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(74) 대리인
김성규

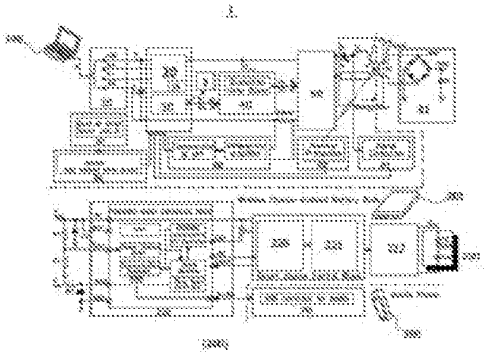
심사관 : 박대식

(54) 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치,충전용 배터리팩 및 무접점 충전장치를 이용한 휴대용단말기

(57) 요 약

본 발명은 무접점 충전장치에 관한 것으로, 보다 상세하게는 컴퓨터 USB 통신 가능하게 구성된 무접점 충전장치(1)와 휴대용 단말기의 충전용 배터리팩 사이에 유도기전력을 이용하여 무선 데이터 통신 및 전력공급이 가능하도록 구성한 것으로써, 데이터 통신 및 전력 공급을 함께 전송하도록 하며, 접촉전송에 다른 접촉불량이 없어 신호 전송이 양호하도록 하는 무접점 충전장치를 제공한다.

대 표 도



특허청구의 범위

청구항 1

합체형상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(10);

상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(20);

상기 USB커넥터(10)와 연결되고, 상기 컴퓨터 또는 노트북으로부터 공급되는 전원을 휴대용 단말기에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(50), 전류센싱블록(60) 및 전원공급용 부재를 제어하는 MPU 블록(30); 및

상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70)이 포함되어 구성되고,

상기 직렬공진 컨버터(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기로 공급되는 전원 신호를 변환하도록 구성되며,

상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기측의 2차코일(80)에 의한 부하변조 신호를 감지하여 상기 MPU블록(30)으로 감지된 신호를 전송하도록 구성되어, 상기 MPU 블록(30)에서 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지된 신호를 분석하여 상기 휴대용 단말기를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 2

제 1항에 있어서,

상기 1차코일(70)은,

분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되며,

상기 직렬공진 컨버터(50)는 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터인 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 3

제 1항에 있어서,

상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버를 구비한 게이트 드라이브 블록(40)과,

상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성된 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 4

제 1항에 있어서,

상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와,

상기 1차코일(70)과 직렬로 연결되어, 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도가 과열되면 전류

를 차단하는 바이메탈(71)과,

상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와,

음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)를 더 구비하는 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 5

삭제

청구항 6

제 1항에 있어서,

상기 USB드라이버블록(20)은,

USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고,

상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기와 서로 송수신하는 IrDA 포트(22)를 더 구비하고,

상기 휴대용 단말기의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부를 더 구성하는 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 7

제 1항 내지 제 4항 및 제 6항 중 어느 한 항의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고 전력 신호를 전송받기 위한 상기 2차코일(80)이 일측에 구성된 충전체몸체(201),

상기 충전체몸체(201) 내부 일측의 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하고, 상기 1차코일(70)과 송수신되는 데이터 신호를 처리하는 충전체제어부(210),

상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)가 포함되어 구성되며,

상기 충전회로(220)는 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급되도록 구성된 것을 특징으로 하는 충전용 배터리팩.

청구항 8

제 7항에 있어서,

상기 충전체제어부(210)는,

상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부,

상기 충전용 밧데리(230)의 충전정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하는 것을 특징으로 하는 충전용 배터리팩.

청구항 9

제 7항에 있어서,

상기 충전체몸체(201)는,

상기 휴대용 단말기와 분리 및 체결이 가능하도록 별체로 형성되는 분리형팩으로 구성되거나, 또는

상기 휴대용 단말기의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형팩으로 구성되며,

상기 2차코일(80)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되는 것을 특징으로 하는 충전용 배터리팩.

청구항 10

제 9항에 있어서,

상기 분리형팩의 충전체몸체(201)는,

상기 충전제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급하는 터미널 블록(240)을 더 구성한 것을 특징으로 하는 충전용 배터리팩.

청구항 11

제 8항에 있어서,

상기 충전체몸체(201)는,

충전리시버모듈(517)에 권선된 2차코일(516)로부터 유도된 전력이 무선 전력 수신 회로(513)를 통하여 충전하는 배터리셀(512),

상기 배터리셀(512) 저면, 전후좌우 사면을 감싸며, Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 자기장으로부터 상기 배터리셀(512)을 보호하는 차폐판(515)(515-1)(515-2)(515-3)(515-4),

상기 차폐판(515)과 상기 충전리시버모듈(517) 사이에 구비되어 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), Ni - Fe (80 중량부 : 20 중량부), 또는 파인메탈(Finemetal, Fe-Si-Cu-Nb)을 포함하여 구성되어 2차코일(516)에 유도자기장이 잘 유도되도록 하는 자성판(503),

상기 차폐판(515)과 상기 배터리셀(512) 사이에 Ni-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 빨어프릴 수 있는 절연체로 구비되어 상기 차폐판(515)의 열이 배터리셀(512)에 전도되지 않도록 하는 절연판(502),

상기 무선 전력 수신 회로(513)를 감싸며 Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 상기 무선 전력 수신 회로(513)에 자기장을 차폐하는 차폐부재(501)를 포함하여 구성된 것을 특징으로 하는 충전용 배터리팩.

청구항 12

제 7항의 무접점 충전장치(1)로부터 전원을 공급받고 데이터를 송수신하는 것을 특징으로 하는 무접점 충전장치를 이용한 휴대용 단말기.

청구항 13

제 9항의 일체형팩의 충전체몸체(201)를 구비하는 충전용 배터리팩(200)을 내재하여,

IrDA 컨트롤러(302) 및 무접점 충전장치(1)의 IrDA 포트(22)와 데이터 통신을 하는 IrDA 포트를 포함하여 구성된 것을 특징으로 하는 휴대용 단말기.

청구항 14

제 8항의 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접촉되어 전원을 공급받는 전력수신터미널블록(310)과,

상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및

상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)를 구성한 것을 특징으로 하는 무접점 충전장치를 이용한 휴대용 단말기.

발 명 의

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

[0019] 본 발명은 무접점 충전장치에 관한 것으로, 보다 상세하게는 컴퓨터 USB 통신 가능하게 구성된 무접점 충전장치와 휴대용 단말기의 충전용 배터리팩 사이에 유도기전력을 이용하여 무선 데이터 통신 및 전력공급이 가능하도록 구성하여, 데이터 통신 및 전력 공급을 함께 전송하도록 하며, 접촉전송에 따른 접촉불량이 없어 신호 전송이 양호하도록 하는 무접점 충전장치를 제공한다.

[0020] 일반적으로 휴대용 단말기는 사용자가 휴대하고 이동하면서 사용하기 편리한 장치로, 핸드폰, PDA, MP3 플레이어 등이 있다.

[0021] 이러한 휴대용 단말기는 충전된 밧데리를 장착하거나 내부에 내재된 밧데리에 충전하면서 일정시간 동안 사용하도록 구성된다. 따라서 필요한 때에 충전을 하고 필요한 데이터를 데스크탑 컴퓨터 또는 노트북으로부터 데이터를 전송받아서 원하는 기능을 작동하여 편리함을 제공하도록 구성된 것이다.

[0022] 이러한 휴대용 단말기용 핸드폰용 충전기는 도 11에 도시된 대한민국 특허 공개번호 제10-2001-0026976호(핸드폰 충전장치)에 의하면, 외부로부터 공급되는 전원선이 본체(600) 일측에 구비되고, 본체(600)의 상부 장착공간(601)에 핸드폰(610)의 저부가 삽입되면서, 핸드폰(610)의 후면 저부의 전원 단자와 본체(600) 장착공간(601)의 내부 단자(602)가 접촉되면서 핸드폰(610)에 전원을 공급하도록 구성된다.

[0023] 이와 같은 종래의 전원공급장치는 전원만 공급할 뿐 데이터를 전송하거나 처리할 수 없어, 별도의 데이터 케이블을 이용하여 컴퓨터와 연결해야만 하는 불편함이 있다. 또한 핸드폰의 단자와 본체의 단자는 접촉방식에 의하기 때문에 다수 회 반복하게 되면, 양측 단자 사이에 순간 전압변화가 발생하여 단자의 전기 접촉성이 불량하게 되고 기기의 안정성이 저하되는 문제점이 있다. 특히 습기가 있거나 먼지가 많이 있는 곳에서는 전기접촉성이 더욱 불량하여 핸드폰 및 전원공급장치가 고장날 우려가 있는 등의 문제점이 있다.

발명이 이루고자 하는 기술적 과제

[0024] 본 발명은 종래 기술의 문제점을 해결하기 위해 제안된 것으로, 본 발명의 목적은 TC, TA, 또는 PC의 USB Port의 출력을 전원 입력으로 하는 유도기전력을 이용한 무접점 전력 전송에 의해 휴대용 단말기(휴대폰, PDA, MP3 player, DAB 또는 DMB 단말기, PMP, 또는 Handheld 단말기 등)와 PC간 무선 데이터 통신과 무선 충전을 동시에 가능하게 하는, 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치 및 이를 이용한 휴대용 단말기를 제공하는 것이다.

[0025] 또한 본 발명의 다른 목적은, 충전하고자 하는 휴대용 단말기의 배터리 팩(2차측 무선충전 모듈이 내장된 팩) 이외의 다른 금속 이물질이 올려졌을 때 이를 감지하여 차단시킬 수 있는 이물질 감지 기능과, 휴대용 단말기의 배터리 팩을 인식하여 충전상태를 인식할 수 있는 식별기능을 가지며, 과부하와 온도 프로텍션 기능을 가지는, 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치 및 이를 이용한 휴대용 단말기를 제공하는 것이다.

발명의 구성 및 작용

[0026] 상기와 같은 목적을 달성하기 위한 본 발명 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치는, 합체형 상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(10); 상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(20); 상기 USB커넥터(10)와 연결되고, 상기 컴퓨터 또는 노트북으로부터 공급되는 전원을 휴대용 단말기에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(50), 전류센싱블록(60) 및 전원공급용 부재를 제어하는 MPU 블록(30); 및 상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70)이 포함되어 구성된다. 그리고 상기 직렬공진 컨버터(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기로 공급되는 전원 신호를 변환하도록 구성되며, 상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기측의 2차코일(80)에 의한 부하 변조 신호를 감지하여 상기 MPU블록(30)으로 감지된 신호를 전송하도록 구성되어, 상기 MPU 블록(30)에서 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지신호를 분석하여 상기 휴대용 단말기를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것을 특징으로 한다.

[0027] 이에 상기 1차코일(70)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되며, 상기 직렬공진 컨버터(50)는 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터로 구비되고, 상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버를 구비한 게이트 드라이브 블록(40)과, 상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성될 수 있다.

[0028] 그리고 상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여, 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와; 상기 1차코일(70)과 직렬로 연결되어, 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도가 과열되면 전류를 차단하는 바이메탈(71)과; 상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와; 음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)가 더 구비된다.

그리고 상기 1차코일(70)에서는 일정한 인터벌의 PWM펄스가 발생되고, 이에 응답하는 상기 2차코일(80)로부터의 신호를 상기 전류센싱블록(60)에서 감지하여 상기 MPU 블록(60)으로 전송하되, 상기 MPU 블록(30)에서는 감지된 신호가 규정된 신호이면 ID를 부여하여 데이터 신호 및 전력신호를 전송하도록 하며, 응답이 없거나 응답신호가 규정된 신호가 아닌 것으로 검출되면 이물질로 판별하여 데이터 신호 및 전력 신호의 전송을 중지하도록 하는 이물질 감지기능을 구비한 것이다.

또한 상기 USB드라이버블록(20)은 USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고, 상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기와 서로 송수신하기 위한 IrDA 포트(22)를 더 구비하고, 상기 휴대용 단말기의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부를 더 구성할 수 있다.

[0029] 본 발명의 다른 실시로, 충전용 배터리팩는 상기의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고 전력 신호를 전송받기 위한 상기 2차코일(80)이 일측에 구성된 충전체몸체(201); 상기 충전체몸체(201) 내부 일측의 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하고, 상기 1차코일(70)과 송수신되는 데이터 신호를 처리하는 충전체제어부(210); 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)가 포함되어 구성되며, 상기 충전회로(220)는 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급되도록 구성된다.

[0030] 이에 상기 충전체제어부(210)는 상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부, 상기 충전용 밧데리(230)의 충전정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하여 구비되고, 상기 충전체몸체(201)는 상기 휴대용 단말기와 분리 및 체결이 가능하도록 별체로 형성되는 분리형팩으로 구성되거나, 또는 상기 휴대용 단말기의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형팩으로 구성되며, 상기 2차코일(80)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되어 구성할 수 있다.

[0031] 그리고 상기 충전체몸체(201)는 충전리시버모듈(517)에 권선된 2차코일(516)로부터 유도된 전력이 무선 전력 수

신 회로(513)를 통하여 충전하는 배터리셀(512), 상기 배터리셀(512) 저면, 전후좌우 사면을 감싸며, Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 자기장으로부터 상기 배터리셀(512)을 보호하는 차폐판(515)(515-1)(515-2)(515-3)(515-4), 상기 차폐판(515)과 상기 충전리시버모듈(517) 사이에 구비되어 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), Ni - Fe (80 중량부 : 20 중량부), 또는 파인메탈(Finemetal, Fe-Si-Cu-Nb)을 포함하여 구성되어 2차코일(516)에 유도자기장이 잘 유도되도록 하는 자성판(503), 상기 차폐판(515)과 상기 배터리셀(512) 사이에 NI-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 떨어뜨릴 수 있는 절연체로 구비되어 상기 차폐판(515)의 열이 배터리셀(512)에 전도되지 않도록 하는 절연판(502), 그리고 상기 무선 전력 수신 회로(513)를 감싸며 Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 상기 무선 전력 수신 회로(513)에 자기장을 차폐하는 차폐부재(501)를 포함하여 구성될 수 있다.

[0032] 그리고 본 발명의 또 다른 실시인 무접점 충전장치를 이용한 휴대용 단말기는 상기의 무접점 충전장치(1)로부터 전원을 공급받고 데이터를 송수신하도록 구성된다.

[0033] 또한 휴대용 단말기는 상기의 일체형팩의 충전제품체(201)를 구비하는 충전용 배터리팩(200)을 내재하여, IrDA 컨트롤러(302) 및 무접점 충전장치(1)의 IrDA 포트(22)와 데이터 통신을 하는 IrDA 포트를 포함하여 구성될 수 있다.

[0034] 나아가 휴대용 단말기는 상기의 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접속되어 전원을 공급받는 전력수신터미널블록(310)과, 상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및 상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)를 구성할 수 있다.

[0035] 이하 첨부되는 도면을 참조하여 상세히 설명한다.

[0036] 즉 본 발명 무접점 충전장치(1)는 도 1 내지 도 10에서와 같이, 함체형상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북(100)의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(USB Connector)(10); 상기 USB커넥터(10)와 연결되어 상기 컴퓨터 또는 노트북(100)과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(USB Emulation Control Block)(20)이 구비된다. 또한 상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북(100)으로부터 전원을 공급받아 휴대용 단말기(300)에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(LLC Full-bridge Serial Resonator Converter)(50), 전류센싱블록(Current sensing Block)(60) 및 전원공급용 부재 등을 제어하는 MPU 블록(Micro Processor Unit Block, MPU Block)(30)이 구비된다. 그리고 상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기(300)에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70) 등으로 구성된다.

[0037] 이에 상기 직렬공진 컨버터(Resonator Convertoer)(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기(300) 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기(300)로 공급되는 전원 신호를 변환하도록 구성된 것이다. 그리고 상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기(300) 측의 2차코일(80)에 의한 부하변조(Load regulation) 신호를 감지하여 상기 MPU 블록(30)으로 신호를 전송하도록 구성된 것으로, 상기 MPU 블록(30)에서는 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지신호를 분석하여 상기 휴대용 단말기(300)를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것이다.

[0038] 그리고 상기 1차코일(70)은 분리형 변압기의 FPCB, PCB, 코일(Coil) 및 페라이트 코어(Ferrite Core) 중 어느 하나로 구성되고, 이를 위한 상기 직렬공진 컨버터(50)는 일반적인 변압기용 공진형 컨버터로 구성될 수 있으며, 특히 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)로 구성하여 안정적인 전력 전송이 되도록 구성함이 바람직하다.

[0039] 또한 상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버(Bootstrap Gate Driver)를 구비한 게이트 드라이브 블록(FET Gate Drive Block)(40)과, 상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지하기 위한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성한 것이다.

[0040] 나아가 도 1 및 도 3과 같이 상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여 측정된 온도의 과열 여부, 고온 여부에 따라 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와, 상기 1차코일(70)과 직렬로 연결되어 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도

가 과열되면 전류를 차단하는 바이메탈(Bimetal)(71)과, 상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와, 음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)를 더 구비할 수 있다. 또한 이와 같은 과열 방지용 온도센서를 구비한 온도보호회로부(92), 바이메탈(71), 먼지냄새 센서(90) 및 이온 발생부(91) 등은 무접점 충전장치(1)와 결합 및 작동하는 충전용 배터리팩(200) 및 휴대용 단말기(300) 등에도 적절한 구성으로 구비함이 바람직하다.

[0041] 이와 같이 구비된 본 발명 무접점 충전장치(1)의 구성 및 작동을 살펴보면 다음과 같다. 즉 본 발명은 코어-투-코어(Core-to-Core) 통신 방식을 이용하여, 무접점 충전장치(1)와, 충전용 배터리팩(200) 또는 충전용 배터리팩(200)이 내장된 휴대용 단말기(300) 간에 데이타 통신뿐만 아니라 충전용 전력을 함께 전송하도록 하는 구성이다.

[0042] 이러한 무접점 충전장치(1)는 휴대용 단말기(300), 충전용 배터리팩(200) 및 무접점 충전장치(1) 내부 시스템의 상태를 감시하고 제어할 수 있는 컴퓨터 또는 노트북(100)과 통신하는 통신수단을 수반한다. 이에 본 발명에서는 컴퓨터 또는 노트북(100)과 무접점 충전장치(1) 간에 USB 통신에 의하여 통신함을 예로 하였으며, 이는 USB 통신은 데이터 통신과 함께 충전용 전력을 하나의 회선으로 동시에 공급할 수 있기 때문이다. 그러나 RS-232c, SISC 및 시리얼, 패럴렐 등과 같은 다수의 데이터 전용 통신 방식으로 무접점 충전장치(1)와 컴퓨터 또는 노트북(100) 사이에 데이터 통신 연결이 가능하며, 이러한 경우에는 무접점 충전장치(1)는 별도의 일반적인 방법으로 전원을 공급받을 수 있다. 즉 무접점 충전장치(1)는 컴퓨터 또는 노트북(100)으로부터 통신연결됨과 함께 주변기기인 휴대용 단말기(300)의 충전용 전력을 컴퓨터 또는 노트북(100)으로부터 공급받을 수 있을 뿐만 아니라, 이와 다르게 별도의 일반적인 방법으로 전원 공급을 받을 수 있어, 결국 무접점 충전장치(1)와 휴대용 단말기(300) 사이에 충전 및 데이터 통신이 모두 가능하도록 구비한 것이다.

[0043] 즉 본 발명에서 예시하는 바람직한 실시예는 컴퓨터 또는 노트북(100)과 무접점 충전장치(1) 간에는 USB 통신방식으로 하였으며, 이러한 USB 통신 회선은 네개의 단자 중, 두개의 단자는 전원을 공급하며, 나머지 두 단자는 데이터를 전송하도록 규약되어있다. 따라서 USB 통신방식으로 무접점 충전장치(1)와 전원공급 및 데이터 송수신이 가능한 것이다. 이러한 USB 통신방식에서는 컴퓨터 또는 노트북(100)에 호스트 컨트롤러(Host Controller)가 내재되어 있어, 회선으로 연결되는 기기들을 제어할 수 있는 것이다. 그리고 이에 대응되는 무접점 충전장치(1)의 USB 드라이버블록(20)은 무접점 충전장치(1)의 USB용 컨트롤러가 내재되는 것으로, 무접점 충전장치(1)의 상태 및 무접점 충전장치(1)와 연결되는 충전용 배터리팩(200) 또는 휴대용 단말기(300)와 결합된 경우에 이들의 정보를 컴퓨터 또는 노트북(100)에 USB 방식으로 변환하여 송수신하게 된다.

[0044] 또한 이러한 USB 통신방식으로 통신하는 것은 1차코일(70) 및 2차코일(80)에서 비록 변조된 상태로 송수신된다. 그리고 충전용 배터리팩(200)에도 USB 통신을 위한 컨트롤러가 충전제어부(210)에 내재될 수 있으며, 또한 휴대용 단말기(300)에도 USB 통신을 위한 컨트롤러가 내재될 수 있으며, 이들 통신 신호는 무접점 충전장치(1)의 USB드라이버블록(20)을 거쳐야 하는 것이므로 결국 무접점 충전장치(1)를 허브로 하여 컴퓨터 또는 노트북(100)과 USB 방식의 통신을 하게 된다.

[0045] 따라서 상기 코어-투-코어(Core - to - Core) 통신 방식을 이용한 무접점 충전장치(1)와 휴대용 단말기(300) 간의 데이타 통신 및 전력을 전달하는 무접점 충전장치(1)는, 컴퓨터, 노트북(100)의 USB 포트로 연결하기 위한 USB커넥터(USB Connector)(10); 상기 컴퓨터, 노트북(100)과 USB커넥터(10)와 연결되어, 음악, 동영상, 데이타를 수신받아 USB 프로토콜로 에뮬레이션하는 USB드라이버블록(USB Emulation Control Block)(20); 무접점 충전장치(Wireless Charger)(1)의 내부 소자를 제어하기 위한 MPU블록(30); 부스트랩 게이트 드라이버(Bootstrap Gate Driver)를 포함하는 게이트 드라이브 블록(Gate Drive Block)(40); LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)인 직렬공진 컨버터(50); FPCB, PCB, 코일, 페라이트 코어로 구성된 분리형 변압기로써, 상기 MPU 블록(30)의 제어에 따라 신호를 우선으로 전송하여 휴대용 단말기(300)에 내장된 배터리 팩의 2차코일(80)로 전송하기 위한 1차코일(70); C-L 공진부에 직렬로 연결되고, 모든 쉽의 기능이 마비되었을 때 또는 코어(1차코일(70))가 과열되었을 때 차단할 수 있도록 삽입하여 안전장치를 확보하기 위한 바이메탈(Bimetal)(71); 상기 무접점 충전장치(1)의 먼지 및 냄새를 감지하기 위한 먼지냄새 센서(Dust & Smell Sensor Circuit)(90); 부가적인 음이온 발생기능이나 세균 박멸을 위한 항균 스프레이 분사하기 위한 이온 발생부(Ionizer High voltage drive circuit Control Block)(91); 2차코일(80)과 연결되는 충전용 배터리팩(200) 측의 무선 충전 모듈이 내장된 휴대용 단말기를 부하 변조(Load regulation)를 통하여 1차코일(70)의 충전 모듈의 MPU 블록(30)에서 충전용 배터리팩(200)의 ID를 인식하고, 충전용 배터리팩(200)의 2차정류단의 전압을 항상 정전압으로 제어할 수 있도록 무접점 충전장치(1)의 1차측 주파수 자동 가변 알고리즘을 통하여 전류 피드백에 의한 안정적인 전력 제어하기 위하며, 2차측 신호를 감지하기 위한 전류센싱블록(Current sensing block)(60);

충전 칩의 온도를 감지하기 위한 온도보호회로부(Thermal Protection Safety Block)(82); 충전용 배터리팩(200)인 2차측 신호의 피드백 신호를 감지한 1차코일(70)과 연결되어 2차측 신호를 검출하는 신호검출블록(61) 등을 포함한다.

[0046] 그리하여 휴대용 단말기(300)는 상기 구성의 무접점 충전장치(1)를 USB 통신의 허브로 하여, 컴퓨터(PC) 또는 노트북(100)으로부터 음악, 동영상, 데이터 등을 전송받을 수 있으며, 나아가 컴퓨터 또는 노트북(100)에서 휴대용 단말기(300)를 제어할 수 있는 것이다. 이를 위해 USB커넥터(10)와 연결된 USB드라이버블록(20)은 송수신되는 데이터를 USB 프로토콜로 에뮬레이션하며, USB드라이버블록(20) 및 MPU블록(30)에 의해 1차코일(분리형 변압기: FPCB, PCB, Coil, Ferrite core로 구성된 변압기)(70)에서 신호를 무선으로 휴대용 단말기(300) 또는 충전용 배터리팩(200)에 전송한다. 이에 1차코일(70)과 마찬가지로 충전용 배터리팩(200)의 2차코일(분리형 변압기: FPCB, PCB, Coil, Ferrite core로 구성된 변압기)(80)에서 전송된 데이터 신호를 수신하여, FSK(Frequency Shift Keying, 주파수 편이 방식)를 통하여 신호를 분리하고, 이 데이타를 휴대용 단말기(300)의 저장매체(메모리)에 데이터를 저장하며, 이에 USB 컨트롤러(301)를 구비할 수 있어 이를 통하여 데이터를 저장할 수 있다.

[0047] 이에 더하여 무접점 충전장치(1)가 가동하는 중에, 충전용 배터리팩(200)의 2차측 무선 충전모듈이 내장된 충전용 배터리팩(200) 또는 휴대용 단말기(300)를 상기 무접점 충전장치(1)에 근접시키면, 자동으로 컴퓨터 또는 노트북(100)에서 동기화되어 USB 통신으로 자동 접속되고, 휴대용 단말기(300)의 경우 저장매체 폴더가 활성되어 음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등을 무선으로 컴퓨터 또는 노트북(100)에서 업로드 및 다운로드 할 수 있다.

[0048] 즉 컴퓨터 또는 노트북(100)과 연결된 무접점 충전장치(1)는 일정한 인터벌을 두고 1차코일(70)로 하여 펄스를 발신하여 충전용 배터리팩(200)의 접속 여부를 감지하게 된다. 그리하여 무접점 충전장치(1)의 1차코일(70)과 충전용 배터리팩(200)의 2차코일(80) 간에 무선 데이터 통신을 할 수 있으며, 이와 별도로 상기 컴퓨터 또는 노트북(100)의 USB 포트의 전원 또는 별도의 공급전원을 충전용 배터리팩(200)에 공급할 수 있다. 이러한 무접점 충전장치(1) 및 배터리팩(200) 그리고 휴대용 단말기 등의 구성은 본 발명의 출원인이 다수 출원한 기술에 의해 실시가 가능한 것이다. 이와 같은 무접점 충전장치(1) 및 배터리팩(200)에 의한 충전 및 데이터 통신 방식에 더하여, 본 발명에서는 무접점 충전장치(1) 및 배터리팩(200) 그리고 휴대용 단말기 등에 전력전송 뿐만 아니라 데이터 통신도 동시에 가능하도록 구비하여, 메인 컴퓨터 또는 노트북 등의 제어장치로부터 데이터 송 수신 및 기능의 제어 그리고 상태 감시 등이 용이하게 할 수 있도록 구비한 것이다.

[0049] 그리고 전류센싱블록(60)에 의하여 감지된 2차코일(80)로부터의 신호가 휴대용 단말기(300)가 구비되지 않는 것으로 판별되거나, 음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등을 수신할 수 있는 메모리가 함께 구비되지 않은 것으로도 판별되는 신호로 수신될 경우에는, MPU블록(30)의 제어에 의하여 1차코일(70)로 USB 데이터(음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등)의 전송을 하지 않도록 하기 위하여, USB 데이터전송제어모듈(25)을 USB드라이버블록(USB Emulation Control Block)(20)에 더 구비하며, 이에 의하여 휴대용 단말기가 접속된 것으로 판명되면 다시 데이터를 전송할 수 있다. 그리하여 1차코일(70) 및 2차코일(80)은 전력전송 및 전력전송에 필요한 데이터가 전송되도록 하며, 또한 컴퓨터 또는 노트북에 이에 알맞은 신호를 전송하도록 구비할 수 있다.

[0050] 이에 무접점 충전장치(1)의 MPU블록(30)의 제어에 의하여 직렬공진 컨버터(50) 및 1차코일(70)과 2차코일(80)을 통하여, 무접점 충전장치(1)의 펄스신호에 대한 응답으로 충전용 배터리팩(200) 또는 휴대용 단말기(300)에서는 고유의 ID를 발생하여 다시 무접점 충전장치(1)로 전송하게 된다. 즉 충전용 배터리팩(200) 충전제어부(210)의 2차측 무선 충전 모듈이 내장된 ID칩에서 고유 ID 신호를 2차코일(80)을 통하여 발신하게 되면, 무접점충전장치(1)에서는 1차코일(70), 신호검출블록(61), 전류센싱블록(60)을 통하여, 공급되는 전력신호의 부하변조(Load regulation) 신호를 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID를 인식하게 된다. 이와 같이 인식된 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID를 인식하게 되면, 이러한 충전용 배터리팩(200) 또는 휴대용 단말기(300)에 대한 정보는 컴퓨터 또는 노트북(100)에 전송하게 된다. 즉 상기 무접점 충전용 배터리팩(200)이 상기 무접점 충전장치(1)에 올려지면 충전용 배터리팩(200)에 내장된 ID칩이 동작하여 무부하 상태에서 로드 레귤레이션을 하여 충전 스타트 ID를 무접점 충전장치(1)에 전송하고, 상기 무접점 충전장치(1)는 그 신호를 피드백 받아서 ID가 일치하며 올바른 신호인지를 확인하고 일치하면 풀 파워모드로 전력을 충전용 배터리팩(200)에 공급한다.

[0051] 그리고 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID가 인식되면, 1차코일(70) 및 2차코일(80)을 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 2차측 정류단 전압을 항상 정전압 제어를 한다. 이는

무접점 충전장치(1)의 1차 측 주파수 자동 가변 알고리즘을 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 2차측 충전 전력을 제어한다. 이러한 충전 전력 제어를 보면, 무접점 충전장치(1)의 1차코일(70), 신호검출블록(61), 전류센싱블록(60)에서는 Vdrop(= Vrec - Vbat)에 의한 2차측 소비전력|Pdis=(Vrec-Vbat)*Ichg|을 최소화하도록 구비된다. 이에 Vrec은 2차측 입력전압이 되는 2차측 정류회로(81)의 출력 전압(도 1의 상부 우측에 도시됨)이고, Vbat는 2차측 최종 충전 소비 전압이 되는 2차측 충전용 배터리팩(220)의 배터리 전압(도 1의 하부 우측에 도시됨)이며, Vdrop는 2차측에 있어 입력 전압(즉 Vrec)에 대한 충전 소비 전압(즉 Vbat)의 차이의 전압이 되며, Ichg는 2차측에 인가되는 전류이고, Pdis는 2차측에서 충전에 소비되는 전력이다. 이와 같은 정보는 2차측 배터리팩에서 1차측 무접점충전장치(1)로 신호전송되어 전력제어하게 되는 것이다. 따라서 충전용 배터리팩(200) 또는 휴대용 단말기(300)에서 별도의 2차측 충전모듈의 부재를 줄일 수 있고, 기타 충전칩들의 온도 상승을 억제하며, 이로써 복잡하고 가격이 비싼 스위칭 충전용 IC를 사용하지 않고 리니어 충전용 IC를 사용할 수 있으며, 또한 배터리 팩의 내부 공간을 확보할 수 있다.

[0052] 다음으로 살펴볼 수 있는 것은 충전모듈을 구비하지 아니한 이종의 금속체가 무접점 충전장치(1) 위에 올려졌을 때, 유도기전력에 의하여 이러한 이종의 금속체가 와전류에 의한 손실이 열로 발생하여 과열이 되어, 무접점 충전장치(1)가 손상되는 현상이 발생될 우려가 있다. 이러한 현상은 유도기전력을 이용한 무접점 충전장치(1)의 안정성에 가장 큰 영향을 미치는 문제이다. 그러므로 동전, 금속펜, 가위, 등 생활 속의 금속체 등, 충전모듈이 구비되지 아니한 이종의 금속체를 인식하고 전력을 차단하여 과열의 위험으로부터 안전하도록 하는 안전장치를 반드시 구비하여야만 한다.

[0053] 이를 위한 구성을 살펴보면, 1차코일(70)에서 2차코일(80)에 전력을 전달시키는 수단은 반파 또는 전파형 직렬/병렬 공진형 컨버터를 사용하여 LC공진을 시켜 전류를 정현파로 만들어 유도결합에 의해 2차 측에 전력을 전달하는 것이다. 이때 스위칭 주파수는 공진주파수 보다 높게 설정하여 소프트 스위칭이 되도록 한다. 1차코일(70)에서 일정한 인터벌(interval)을 두고 아주 짧은 시간 동안 PWM펄스를 인가하여, 이종의 이물질이 올려져 있는지 여부를 감지하여 판별하는 메카니즘을 구성한 것이다. 무부하시 스위칭 주파수와 전류의 위상이 항상 90도를 이루는데, 이물질이 근접되면 자기 인덕턴스의 변화에 의해 전류의 위상이 변화되고, 이 위상차의 레벨에 따라 이물질의 정도를 인식하도록 하였다. 즉 물체 근접이 감지되면 전력을 인가하는 일정시간 동안 ID 체크 신호를 발신하며, 제한된 고유 ID 신호가 감지되지 않거나 또는 상이한 ID가 인식이 되면, 이물질로 인식하여 무접점 충전장치(1)의 충전 시스템을 shut-down 시켜 충전 전력을 1차코일(70)로 공급되지 않도록 하여, 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 충전회로의 안정성을 확보한 것이다.

[0054] 즉 무접점 충전장치(1)에서는 상기 1차코일(70)에서 일정한 인터벌의 PWM펄스를 발생하고, 이에 응답하는 상기 2차코일(80)로부터의 신호를 상기 전류센싱블록(60)에서 감지함에, 감지된 신호가 규정된 신호이면 ID를 부여하여 데이터 신호 및 전력신호를 전송하며, 응답이 없거나 응답신호가 규정된 신호가 아니면 이물질로 감지하여 데이터 신호 및 전력 신호의 전송을 중지하는 이물질 감지기능을 더 포함하여 구성한 것이다.

[0055] 또한 이러한 이물질 감지기능에 의한 충전 중 이물질 감지는 복잡한 기술이 요구되는데 충전이 되면서 전력은 점점 떨어지도록 구비할 수 있다. 이 전력 곡선에 히스테리시스를 두어 이물질이 올려졌을 때, 히스테리시스 구간을 넘어가면 이물질로 인식하여 shut-down시키는 알고리즘이 사용하여 구현할 수 있다.

[0056] 본 발명은 상기 무접점 충전장치(1)의 안전장치와 무선충전용 모듈이 내장된 충전용 배터리팩(200)의 안전성 및 배터리 상태 감시기능을 갖춘 무선 충전 솔루션을 제공할 수 있다.

[0057] 그리고 상기 무접점 충전장치(1)는 기본적으로 온도보호회로부(82)에 의하여 1차코일(70)과 구성된 여러 칩의 온도를 검출하거나 장치몸체(2) 내부의 온도를 감지하여, 상시 온도가 45℃ 이상일 경우, Shut-down시키는 기능과, 과전류, 과전압에 대한 보호 기능을 칩에 내장하고, 또한 퓨즈(Fuse)를 내장하여 과전류를 차단한다. 그리고 상기 무접점 충전장치(1)의 구성 칩의 기능이 마비되어 이상신호가 검출되면 회로를 차단하며, 1차코일(70)과 연결된 C-L 공진부에 직렬로 바이메탈(Bimetal)(71)을 구성하여 1차코일(70)이 과열되었을 때 회로를 차단할 수 있도록 하는 등, 안전장치를 구성하였다.

[0058] 그리고 부가적으로 움이온 발생기능이나 세균 박멸을 위한 항균 스프레이가 분사되고, LCD 디스플레이부(3) 또는 컴퓨터, 노트북(100) 등에 충전이 되는 상태를 표시한다. 이에 더하여 충전용 밧데리(230)가 만충전되면, 충전용 IC에서 출력된 만충전 신호를 IB칩에서 받아서 만충전 상태를 충전제어부(210)의 제어에 의해 상기 무접점 충전장치(1)에 로드 레귤레이션을 통하여 전송하고, 이 신호를 피드백 받아 충전용 배터리팩(200)이 충전 완료 상태인 것을 디스플레이부(3), 컴퓨터 또는 노트북(100) 등에 표시한다.

[0059] 이러한 본 발명 무접점 충전장치(1)는 또한 도 4와 같이, 상기에 기술된 바와 같이 컴퓨터 또는 노트북 등으로부터 USB 포트를 이용하여 전력을 충전할 수 있으며, 또한 컴퓨터 또는 노트북과 근접되지 않는 상황, 즉 여행을 하는 등과 같은 상황에서 다양한 방법으로 충전할 수 있도록 부가된 구성을 할 수 있다. 즉 충전기, 어댑터, USB 포트 등을 입력으로 하는 24핀 커넥터를 사용할 수 있으며, 그 일 실시예로 24핀 표준 커넥터를 사용하여 여행용 충전기가 꽂일 경우, 1번 핀에 할당된 특정 ID저항을 통해 항상 4.2V를 21, 22번 핀을 통해 입력받고, 어댑터가 꽂일 경우 4, 5번 핀을 통해 전원을 입력받고, USB 포트에 꽂일 경우 16번 핀을 통해 전원을 입력 받을 수 있으며, 상기 무접점 충전장치(1)는 입력전원이 4V에서 5.5V에서 동작 가능하도록 구비할 수 있다.

[0060] 그리고 상기 24핀 표준 커넥터를 사용하는 어댑터를 사용하여 2개의 휴대용 단말기를 동시에 충전시킬 수 있는 도킹 스테이션을 구성하여 상기 무접점 충전기를 2개 연결하여 각각 휴대용 단말기 2대를 동시에 충전시킬 수도 있다.

[0061] 상기와 같이 구성된 본 발명의 다른 실시를 살펴보면 다음과 같다.

[0062] 즉 컴퓨터 또는 노트북(100)과 USB 통신하는 상기 USB드라이버블록(20)을 USB에 대한 컨트롤러 기능뿐만 아니라, IrDA 신호로 변환하는 기능을 부가한 것이다.

[0063] 따라서 이러한 USB드라이버블록(20)은 USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고, 상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기(300)과 서로 송수신하는 IrDA 포트(22)를 더 구비하고, 휴대용 단말기(300)의 IrDA 컨트롤블록(302)으로부터 발신되어 IrDA 포트(22)에서 수신된 상기 휴대용 단말기(300)의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부(미도시됨)를 더 구성하였다.

[0064] 이에 도 2 및 도 3은 본 발명에 따른 IrDA 송수신 모듈이 내장된 무접점 충전장치(1)를 나타낸 도면이다.

[0065] 이를 참조하면, 상기 무접점 충전장치(1)는 전원입력으로 컴퓨터나 노트북(100)의 USB포트에 연결하면, 상기 무접점 충전장치(1)에 내장된 IrDA 신호변환부(21)에 의해 USB 통신프로토콜 및 IrDA 등의 데이터를 상호 변환하고, IrDA 트랜시버를 통하여 PC 또는 노트북으로부터 저장된 음악, 동영상, 데이터 등을 연동하여 휴대용 단말기(300)(휴대폰, PDA, PMP, DMB단말기, MP3 등)와 데이터를 무선으로 상호 교환할 수 있다. 또한 전원 공급용 전력의 전송을 1차코일(70) 및 2차코일(80)에 의한 비접촉 분리형 변압기를 이용하여 상기 휴대용 단말기(300)로 에너지를 전달하여 배터리를 충전한다.

[0066] 상기 무접점 충전장치(1)에 내장된 IrDA 포트(22)와 상기 휴대용 단말기(300)의 IrDA포트를 일치시켜 2차측 무선 충전모듈이 내장된 휴대용 단말기(300)를 상기 무접점 충전장치(1)에 근접시키면, 상기 무접점 충전장치(1)는 상기에 언급된 바와 같은 기술의 1차코일(70) 및 2차코일(80)에 의해 자동으로 컴퓨터 본체와 동기화되며, 이에 무접점 충전장치(1)와 휴대용 단말기(300) 간에 상방이 적외선 통신이 가능하도록 컴퓨터 또는 노트북(100)에 USB가 자동으로 접속되며, 따라서 휴대용 단말기(300)의 저장매체 폴더가 팝업되고 음악(MP3 format), 동영상(avi, asf, dat format) 등 데이터를 무선 다운로드할 수 있으며, 기타 데이터 처리를 함께 할 수 있는 것이다.

[0067] 이에 도 3은 이러한 무접점 충전장치(1) 및 휴대용 단말기(300) 간에 각각 내장된 IrDA 포트에 의한 적외선 통신 방식과 전력을 전달하는 무접점 충전장치(1)에 대한 구성도를 도시한 것이다.

[0068] 즉 도 3의 상기 무접점 충전장치(1)는 USB 커넥터(USB Connector)(10), USB-to-IrDA로 신호변환하는 IrDA 신호변환부(21)가 내재된 USB드라이버블록(20), MPU 블록(30), 부츠트랩 게이트 드라이버(Bootstrap Gate Driver)를 포함하는 게이트 드라이브 블록(Gate Drive Block)(40), LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)의 직렬공진 컨버터(50), 1차코일(70), 2차코일(80), 바이메탈(Bimetal)(71), 먼지냄새 센서(Dust & Smell Sensor Circuit)(90), 이온 발생부(Ionizer High voltage drive circuit Control Block)(91), 전류센싱블록(Current sensing block)(60), 온도보호회로부(Thermal Protection Safety Block)(92), 및 2차측 신호를 검출하는 신호검출블록(61) 등을 포함한다.

[0069] 그리고 휴대용 단말기(300)에는 IrDA 컨트롤러(302) 및 IrDA 포트 등이 구비된다. 그리하여 휴대용 단말기(300)와 무접점 충전장치(1) 사이에 각각의 IrDA 포트를 이용하여 데이터 통신을 하도록 구비할 수 있다.

[0070] 상기와 같이 구성된 본 발명의 무접점 충전장치(1)와 결합되어 무접점 충전장치(1)와 서로 데이터를 무선으로 송수신하며, 전원용 전력을 무선으로 공급받는 충전용 배터리팩(200)을 구성한 것이다.

[0071] 즉 상기의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고, 전력 신호를 전송받는 상기 2차코일(80)이 일측에 구성된 충전체몸체(201), 상기 충전체몸체(201) 내부 일측에 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하며, 상기 1차코일(70)과 송수신하는 데이터 신호를 처리하는 충전체제어부(210), 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)를 포함하며, 상기 충전회로(220)은 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기(300)로 공급되도록 구성한 것이다.

[0072] 이에 상기 충전체제어부(210)는 상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부(고유 ID 칩), 상기 충전용 밧데리(230)의 충전 정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하여 구성한 것이다.

[0073] 그리고 상기 충전체몸체(201)는 상기 휴대용 단말기(300)와 분리 및 체결이 가능하도록 별체로 형성되는 분리형 팩으로 구성될 수 있다. 또한 상기 휴대용 단말기(300)의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형 팩으로도 구성될 수 있다.

[0074] 이에 분리형팩으로 구비된 충전체몸체(201)는 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기(300)로 공급하는 터미널 블록(240)을 더 구성하였다.

[0075] 이를 도 1 및 도 3으로 하여 설명하면, 상기 충전용 배터리팩(200)의 2차코일(80)은 휴대용 단말기의 풀브릿지 정류회로(Rectification Block)(81)와 연결된다. 그리고 정류회로(81)와 연결된 충전체제어부(210)는 상기 휴대용 단말기(300) 또는 충전용 배터리팩(Wireless charge-enabled Battery Pack)(200)의 고유 ID를 송출하여 무접점 충전장치(1)에서 이물질 감지가능이 수행되도록 하고, 충전 상태 피드백 충전 회로를 on-off하고 이를 무접점 충전장치(1)로 송출하며, 신호-to-USB 변환 기능이 가능하도록 구비될 수 있다. 그리고 충전을 위한 충전회로(Charse Manasement Block)(220), 배터리 용량 체크 회로(Fuel Gause Control Block)(221), 배터리 보호회로(Prototection Control Block)(222), PTC와 충전용 밧데리(230), 및 휴대용 단말기(300)에 내장된 USB 컨트롤러(301) 또는 IrDA 컨트롤블록(302) 등을 함께 구비할 수 있다.

[0076] 그리고 상기에 기술된 무접점 충전회로(1)의 안전장치와 같이, 충전용 배터리팩(200)에도 다수의 안전장치를 구비한다.

[0077] 즉 충전용 배터리팩(200)의 안전장치는 충전회로에 내장된 온도센서가 있어서 외부에 연결된 NTC가 온도변화에 따라 저항값이 변동되어 분배된 전압을 피드백 받아, 기 설정된 온도 이상이 되면 충전을 차단하는 기능을 내장할 수 있다. 또한 PCM이라는 보호회로에 의해 과전류, 과전압, 과방전, 단락 등으로부터 배터리를 보호하고 PTC 또는 바이메탈(Bimetal)을 사용하여 과전류와 온도에 의해 차단되어 충전용 배터리팩(200) 및 충전용 밧데리(230) 및 이들의 회로를 보호한다. 그리고 충전용 배터리팩(200)에 내장된 ID 칩 및 다수의 칩 등에 대해, 충전 중 내부의 오동작이 발생했을 경우, 상기 무접점 충전장치(1)에 로드 레귤레이션을 통해 이러한 오작동 신호를 전송하고, 상기 무접점 충전장치(1)에서 ESR를 통해 신호를 받아서 스위칭을 차단하여 전력공급을 중단하는 메커니즘을 구비할 수 있다.

[0078] 그리고 이러한 충전용 배터리팩(200)은 도 5 내지 도 9도와 같이, 휴대용 단말기(300) 내부에 함께 내재하여 일체로 구비할 수 있으며 또한 별체로 분리 및 결합이 용이하게 구비할 수 있다. 따라서 이러한 휴대용 단말기(300)는 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접촉되어 전원을 공급받는 전력수신터미널블록(310)과, 상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및 상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)을 구성할 수 있다.

[0079] 이와 같은 본 발명은 일반적으로 비접촉 변압기의 경우 접촉형인 일반 변압기와 달리 큰 공극을 갖기 때문에 자화인덕턴스는 일반 변압기에 비해 상대적으로 작고, 누설인덕턴스는 상대적으로 크기 때문에 기존 직렬 공진형 컨버터를 그대로 사용하면 부하 변화에 대한 많은 순환전류가 흐르는 단점을 가지게 된다. 뿐만 아니라 2차측 정류다이오드의 연속적인 전류에 의해 다이오드의 역 회복 특성에 따른 스위칭 손실이 발생할 우려가 있다. 그

러나 본 발명에서는 이러한 문제점을 개선하기 위해 비접촉 변압기용 풀브릿지 LLC 직렬 공진형 컨버터(50)를 적용하여 스위칭 주파수는 공진주파수보다 낮은 주파수에서 동작하여 기존 직렬 공진형 컨버터를 사용한 경우보다 순환전류를 많이 줄일 수 있고, 2차측 정류다이오드에 불연속 전류가 흐르기 때문에 다이오드의 스위칭 손실을 줄일 수 있는 장점을 가진다.

[0080] 또한 1차코일(70) 및 2차코일(80)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형의 평판 또는 통형상의 코일형태로 형성되도록 하여 서로 신호 전송이 원활하도록 구비한 것이다.

[0081] 이러한 본 발명에 따른 무접점 충전용 배터리팩(200)의 제조 구성의 예를 도 5 내지 도 9를 참조하여 기술하면 다음과 같다. 즉 도 5는 출인원 하드팩으로 된 충전용 배터리팩(200)에 대한 것이고, 도 6은 휴대용 단말기(300)에 내장되는 실시예에 대한 회로도이다.

[0082] 즉 출인원 하드팩의 충전용 배터리팩(200)은 2차코일과 자기장 차폐 쉴드, 정류회로, 충전회로(스위칭 또는 리니어 충전 회로), 무선 통신 ID 인식 회로, 보호회로, 배터리로 구성된다. 즉 2차코일(코일 또는 코어방식 포함)(80), 정류회로(Rectification Block)(81), LDO+IIC(TX, RX통신)+FET 드라이브+배터리 충전 상태 입력(Empty, Full 신호) 기능+오실레이터+충전회로 enable 또는 disable할 수 있는 포트를 내장한 어댑터 제어 블록(Adaptor Control Block)인 충전제어부(210), 배터리 보호회로(PCM)(222), PTC와 충전용 밧데리(230), 충전회로(220), 휴대폰과 연결되는 단자인 터미널 블록(240) 등으로 구성된다.

[0083] 그리고 내장형 충전용 배터리팩(200)의 경우에는 상기 휴대용 단말기(300)의 케이스 커버에 2차코일과 자기장 차폐 쉴드를 내장하고(코일을 커버에 사출 성형하거나 보호 케이스를 만들어서 초음파 융착하는 방법 사용), 휴대용 단말기(300)와 연결될 수 있는 단자를 만들어 이 단자를 통하여 연결된 휴대용 단말기(300)의 내장 회로에 정류회로, 무선 ID 인식회로를 부가하고, 상기 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320)와 충전블록(330)을 그대로 사용하여 내장된 배터리팩과 연결된 단자를 통하여 충전한다.

[0084] 또한 상기 휴대용 단말기(300)에 내장된 충전용 배터리팩(200)의 또 다른 구성은, 2차코일과 자기장 차폐 쉴드, 정류회로, 무선 통신 ID인식회로, 보호회로, 배터리 등을 휴대용 단말기(300) 케이스 커버에 융착하지 않고 내부에 내장하며, 상기 휴대용 단말기(300)와 정류회로 출력, 접지, 배터리 양극, 충전상태 핀 등의 연결 단자를 만들고 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320)와 충전블록(330)를 그대로 사용하여 배터리와 연결된 단자를 통하여 충전하도록 구성할 수있다.

[0085] 이러한 내장형 충전용 배터리팩(200)에 대한 회로는 도 6에 도시된 바와 같이, 휴대용 단말기(300)에 적용 가능한 무접점 충전용 세미 이너팩으로, 2차코일(코일 또는 코어방식 포함)(80), 정류회로(Rectification Block)(81), LDO+IIC(TX, RX통신)+FET 드라이브+배터리 충전 상태 입력(Empty, Full 신호) 기능+오실레이터+충전회로 enable 또는 disable할 수 있는 포트를 내장한 어댑터 제어 블록(Adapter Control Block)인 충전제어부(210), 배터리 보호회로(PCM)(222), PTC와 충전용 밧데리(230), GSM 휴대폰인 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320), 및 GSM휴대폰인 휴대용 단말기(300)에 내장된 충전블록(330)을 포함하여 구성될 수 있다. 이때 GSM휴대폰인 휴대용 단말기(300)는 단말기에 DC/DC컨버터(320)와 충전블록(330)이 내장된 휴대용 단말기(예:GSM 휴대폰)를 말한다.

[0086] 이에 무접점 충전장치(1)에 무접점 충전용 세미 이너팩, 즉 충전용 배터리팩(200)을 내장한 GSM 휴대폰인 휴대용 단말기(300)를 올려놓으면 무접점 충전장치(1)에서 전력을 발생시켜서 2차코일(80)을 통해 충전용 배터리팩(200)으로 전력을 전송한다.

[0087] 그리하여 충전용 배터리팩(200)인 2차 측에서는 2차코일(80)에서 AC 전력을 받아서 정류회로(81)에서 정류를 하여 DC로 만들고, 충전제어부(210)에서 RX핀을 통해 전압이 안정전압 이상(예 : 5.5V 이상)이면 TX핀을 통해 상기 무접점 충전장치(1)에 전력을 줄이기 위한 Power save 코드를 발생시켜 전달하여, 2차 측 전력이 안정전압(예 :5V 정도)으로 파라미터(주파수)를 조절한다. 이 경우를 반복하여 충전용 배터리팩(200)인 2차 측이 최적의 전압 조건인 안정전압(예 : 5V)이 되면 이에 대한 ID를 발생시키고, 무접점 충전장치(1)의 ID와 일치하면 상기 무접점 충전장치(1)에서 전력을 발생시킨다. 그렇지 않으면 무접점 충전장치(1)에서는 전력 공급을 차단하고 절전 모드로 들어가거나 이물질이 올려졌을 경우 고유ID에 대한 수신정보가 없기 때문에 에러를 발생시켜 전력 공급을 차단한다.

[0088] 도 7 내지 도 9는 이러한 충전용 배터리팩(200)의 다수 실시예에 따른 분해 사시도를 도시한 것이다.

[0089] 우선 충전용 배터리팩(200)의 제1실시예를 도시한 도 7의 구성을 살펴보면, A/S 라벨(411), 상부 케이스(Top case)(412), 무접점 충전용 PCB 보드(413), (-)Ni-Plate(414), PTC 또는 바이메탈(415), 리드선(416), (+)Ni-Plate(417), 보조 케이스(418), Nomax 테이프(419), 정류부 보드(420), 배터리셀(421), 2차측 코일(422), 하부 케이스(Bottom case)(423), 및 라벨(424)을 구비한다. 즉 정류부 보드(420)를 탑면에 배치한 실시예인 것이다.

[0090] 다음으로 도 8은 제2 실시예에 따른 무접점 충전용 내장형 배터리 팩 조립도(회로기판 탑면 배치)로, A/S 라벨(431), 상부 케이스(Top case)(432), 무접점 충전용 PCB 보드(433), (-)Ni-Plate(434), PTC 또는 바이메탈(435), 리드선(436), (+)Ni-Plate(437), 보조 케이스(hot melt 방식으로 충진할 수 있음)(438), Nomax 테이프(439), 연결 보드(440), 배터리셀(441), 2차측 코일(442), 하부 케이스(Bottom case)(443), 및 라벨(444)을 구비한다.

[0091] 그리고 도 9는 제3 실시예에 따른 무접점 충전용 내장형 배터리 팩 조립도(회로기판 측면 배치)로, A/S 라벨(451), 상부 케이스(Top case)(452), 무접점 충전용 PCB 보드(453), (-)Ni-Plate(454), PTC 또는 바이메탈(455), 리드선(456), (+)Ni-Plate(457), 보조 케이스(hot melt 방식으로 충진할 수 있음)(458), Nomax 테이프(459), 연결 보드(460), 배터리셀(461), 2차측 코일(462), 하부 케이스(Bottom case)(463), 및 라벨(464)을 구비한다.

[0092] 상기와 같이 구비되는 배터리팩은 도 10과 같은 개략적인 구조의 자기장을 막는 차폐용 부재를 구비한다. 이와 같은 차폐용 부재에 의하여 배터리 셀 및 충전용 회로들의 오작동을 방지하고 과열되는 것을 방지한다. 즉 도 7 내지 도 9의 배터리셀(421)(441)(461)은 도 10에 개략적으로 도시된 차폐용 부재가 구비된 배터리셀(512)의 구성과 같이 구성할 수 있다.

[0093] 즉 도 10은 무선 전력 수신 모듈을 가진 충전용 배터리팩(200)의 구성도로, 코일, 파인메탈, 박막알루미늄(호일 등), 리튬이온 또는 리튬폴리머로 된 배터리팩은 자기장을 100% 차단하기 위해 박막알루미늄을 넣어서 셀에 영향이 없도록 하여 셀의 사이클이 500회까지 충방전 가능하도록 구비한 것이다. 여기서 코일의 형상은 모든 형태의 코일을 포함한다. 즉 사각형상, 원형상 또는 타원 형상 등으로 다양하게 구비할 수 있다. 그리하여 무선 전력 수신 모듈을 가진 충전용 배터리팩(200)은 배터리셀(512)의 일측에 수직 또는 수평 방향으로 무선 전력 수신 회로(Wireless Power Receiver Circuits)를 구비하고, 상기 무선 전력 수신 회로(513)는 감싸는 자기장을 막는 차폐부재(501)를 포함하여 구성할 수 있다.

[0094] 그리고 코일, 파일메탈, 박막알루미늄(호일 등), 리튬이온 또는 리튬폴리머로 된 충전용 배터리팩(200)은 자기장을 100% 차단하기 위해 차폐판(515)를 구비하였다. 상기 차폐부재(501) 및 차폐판(515)는 Al, Cu, Ni alloy metal 등을 포함하여 얇은 판으로 형성된다. 또한 상기 차폐판(515)과 동일한 구성으로 배터리셀(512)을 중심으로 하여, 전후좌우면에도 각각 차폐판(515-1)(515-2)(515-3)(515-4)를 구비하여, 자기장으로부터 배터리셀(512)을 보호하도록 구성한 것이다. 이러한 차폐판(515)과 2차코일(516)이 권선된 충전리시버모듈(517) 사이에는 자성판(503)을 구비하여, 코일에 1차코일로부터 유도된 자기장이 2차코일(516)에 잘 유도될 수 있도록 투자율이 높은 자성체로 구비한 것이다. 이러한 자성판(503)은 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), 또는 Ni - Fe (80 중량부 : 20 중량부)로 구비되거나, 파일메탈(Finemetal, Fe-Si-Cu-Nb)로 Fe를 주성분으로, 이에 Si과 B 및 미량의 Cu와 Nb를 고온 상태에서 첨가하여 100℃ 이하로 급냉하여 고체화하여 제조한 것이다.

[0095] 그리고 차폐판(515)과 배터리셀(512) 사이에는 절연체인 절연판(502)을 구비한 것으로, 특히 Ni-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 빨어드릴 수 있는 절연체로 구비하여, 배터리셀(512)의 온도 상승을 방지하여 과열되지 않도록 하였다. 따라서 온도와 자기장의 영향이 배터리셀(512)에 미치지 않도록 하여, 충전리시버모듈(517)과 연결되어 배터리셀의 사이클이 500회까지 충방전 가능하도록 구비하였고, 이때 코일의 형상은 모든 가능한 형태의 형상으로 하여 구성할 수 있다. 미도시된 기호 511은 (-)터미널이고, 514는 (+)터미널이며 516은 코일을 도시한 것이다.

[0096] 상기의 충전용 배터리팩(200)의 예에 따른 무접점 충전장치(1)는 또한 함체 형상으로 형성된 장치몸체(2)의 상부면에 1차코일(70)을 형성한 것으로, 소용돌이 형상의 원형, 사각형 또는 다각형 형상으로 코일 또는 코어의 형태로 1차코일(70)을 구성할 수 있다. 그리고 이와 같이 1차코일(70)이 구성된 무접점 충전장치(1)의 상부로 충전용 배터리팩(200) 또는 충전용 배터리팩(200)이 내재된 휴대용 단말기(300)를 올려 놓으면, 컴퓨터 또는 노트북과 연결된 상태에서 송수신용 데이터 및 전원용 전력을 공급되도록 구성한 것이다.

[0097] 상술한 바와 같이, 본 발명의 바람직한 실시예를 참조하여 설명하였지만, 해당 기술 분야의 숙련된 당업자는 하기의 특허청구범위에 기재된 본 발명의 사상 및 영역으로부터 벗어나지 않는 범위 내에서 본 발명을 다양하게 수정 또는 변형하여 실시할 수 있다.

발명의 효과

[0098] 상기와 같은 구성된 본 발명에 따른 무선 데이타 통신과 전력 전송이 가능한 무접점 충전기 및 이를 이용한 휴대용 단말기는 TC, TA, PC의 USB Port의 출력을 전원 입력으로 하는 유도기전력을 이용한 무접점 전력 전송에 의해 휴대용 단말기(휴대폰, PDA, MP3 player, DAB 또는 DMB 단말기, PMP(Portable Music Player), Handheld 단말기 등)와 컴퓨터(PC)간 무선 데이터 통신과 무선 충전을 동시에 가능하여 전송시 에러가 발생되지않고 안정적으로 데이터를 송수신하면서 전력을 함께 공급할 수 있는 효과가 있다.

[0099] 또한 본 발명에 따른 무접점 충전기는 충전하고자 하는 휴대용 단말기의 배터리 팩(2차측 무선충전 모듈이 내장된 팩) 이외의 다른 금속 이물질이 올려졌을 때, 이를 감지하여 차단시킬 수 있는 이물질 감지 기능과, 휴대용 단말기의 배터리 팩을 인식하여 충전상태를 인식할 수 있는 식별기능을 가지며, 과부하와 온도 프로텍션 기능을 제공하여, 기기의 손상을 방지하며 최적의 충전 효율 상태를 유지하도록 하는 효과가 있다.

도면의 간단한 설명

[0001] 도 1은 본 발명에 따른 무접점 충전장치의 회로도이다.

[0002] 도 2는 본 발명에 따른 무접점 충전장치의 IrDA 통신이 적용된 실시예의 사시도이다.

[0003] 도 3은 본 발명에 따른 무접점 충전장치에 IrDA 통신이 적용된 실시예의 회로도이다.

[0004] 도 4는 본 발명에 따른 무접점 충전기에서 24핀 커넥터를 사용하는 충전기, 어댑터, USB 포트를 입력으로 사용하는 실시예를 도시한 예시도이다.

[0005] 도 5는 본 발명에 따른 충전용 배터리팩의 회로도이다.

[0006] 도 6은 본 발명에 따른 충전용 배터리팩에 대한 다른 실시예의 회로도이다.

[0007] 도 7은 본 발명에 따른 충전용 배터리팩의 제1실시예에 따른 분해사시도이다.

[0008] 도 8은 본 발명에 따른 충전용 배터리팩의 제2실시예에 따른 분해사시도이다.

[0009] 도 9는 본 발명에 따른 충전용 배터리팩의 제3실시예에 따른 분해사시도이다.

[0010] 도 10은 본 발명에 따른 충전용 배터리팩의 무선 전력 수신 모듈을 가진 배터리 팩에 대한 분해사시도이다.

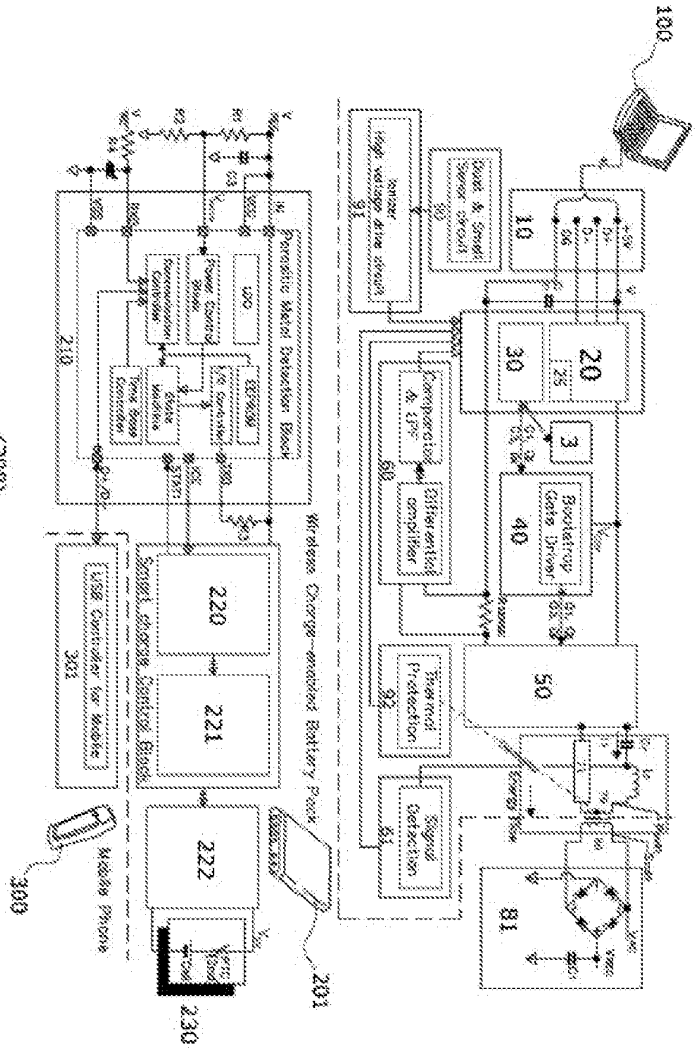
[0011] 도 11은 종래 기술에 따른 핸드폰용 충전장치에 대한 사용상태도이다.

[0012] <도면의 주요 부분에 대한 부호의 설명>

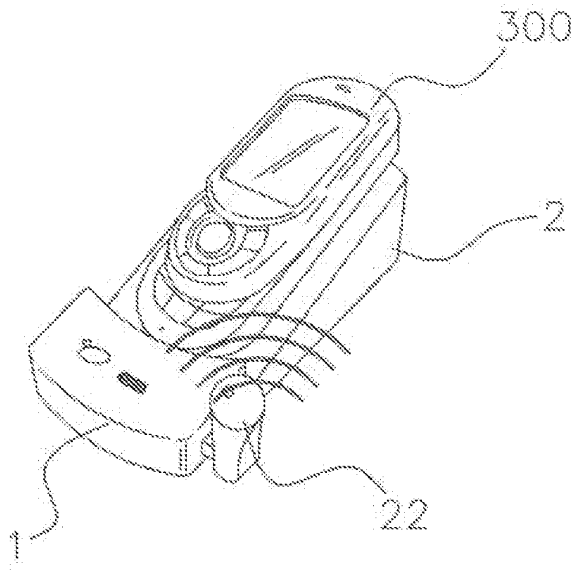
[0013]	1 : 무접점 충전장치	2 : 장치몸체
[0014]	10 : USB커넥터	10 : USB드라이버블록
[0015]	30 : MPU블록	50 : 직렬공진 컨버터
[0016]	60 : 전류센싱블록	
[0017]	70 : 1차코일	80 : 2차코일
[0018]	200 : 충전용 배터리팩	300 : 휴대용 단말기

도면

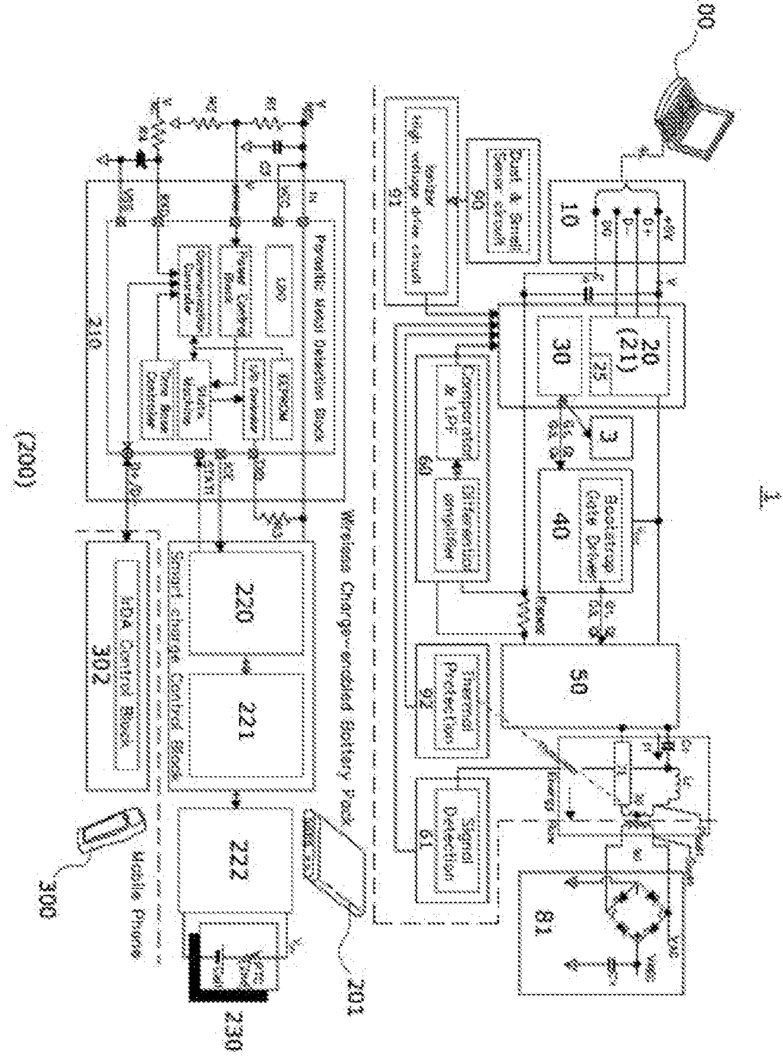
도면1


100
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10
20
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81
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92
3
Inverter high voltage drive circuit
Inverter Fault & Short Detect circuit
Temperature & Ipfc
Differential amplifier
Bootstrap Gate Driver
Thermal Protection
Signal Detection
Current Flow
Wireless Charge-enabled Battery Pack
Smart Charge Control Block
USB Controller for Mobile
Mobile Phone
300
201
230
220
221
222
302
(200)
Parasitic Metal Detection Block
210
LDO
EEPROM
Power Control
Temp Sense Controller
Gate Voltage Controller
Vout
Vrect
Vcc
Vpp
Vdd
Vss
Vpwm
Vpfc
Vsense
Vtemp
Vsig
Vbst
Vgate
Vsw
Vcom
Vfault
Vpulse
Vpfc_ref
Vpfc_fb
Vpfc_out
Vpfc_in
Vpfc_sw
Vpfc_gate
Vpfc_sense
Vpfc_temp
Vpfc_sig
Vpfc_bst
Vpfc_com
Vpfc_fault
Vpfc_pulse
Vpfc_ref
Vpfc_fb
Vpfc_out
Vpfc_in
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Vpfc_pulse

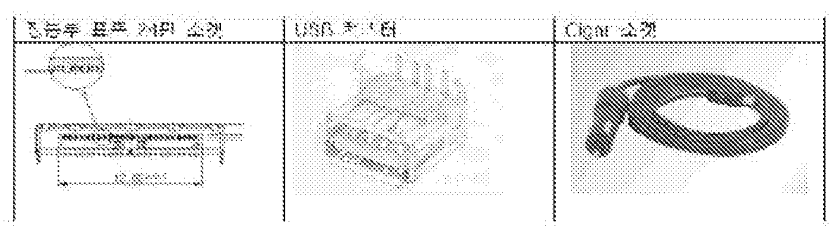
도면2



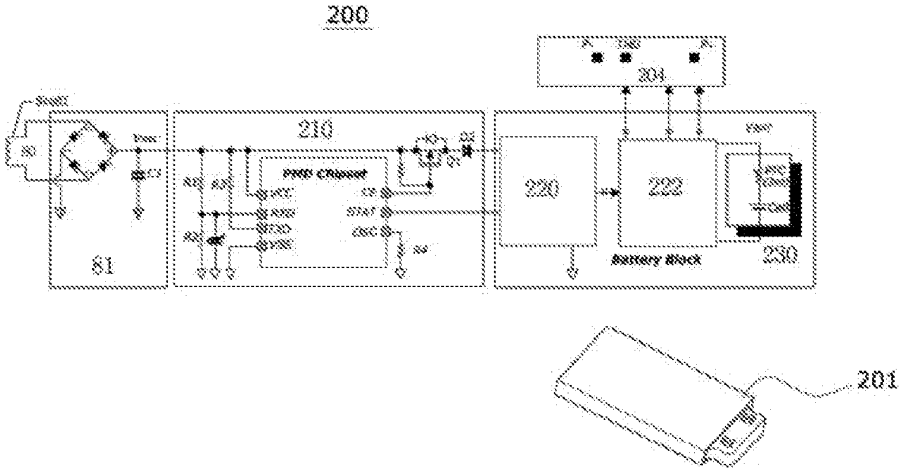
도면3


100
10
20
(21)
25
30
3
40
Bootstrap Gate Driver
50
60
Comparator & LPF
Differential amplifier
61
Signal Detection
81
90
91
92
Thermal Protection
1
Wireless Charge-enabled Battery Pack
Parasitic Metal Detection Block
210
(200)
220
221
222
201
230
Smart charge Control Block
IrDA Control Block
302
300
Mobile Phone

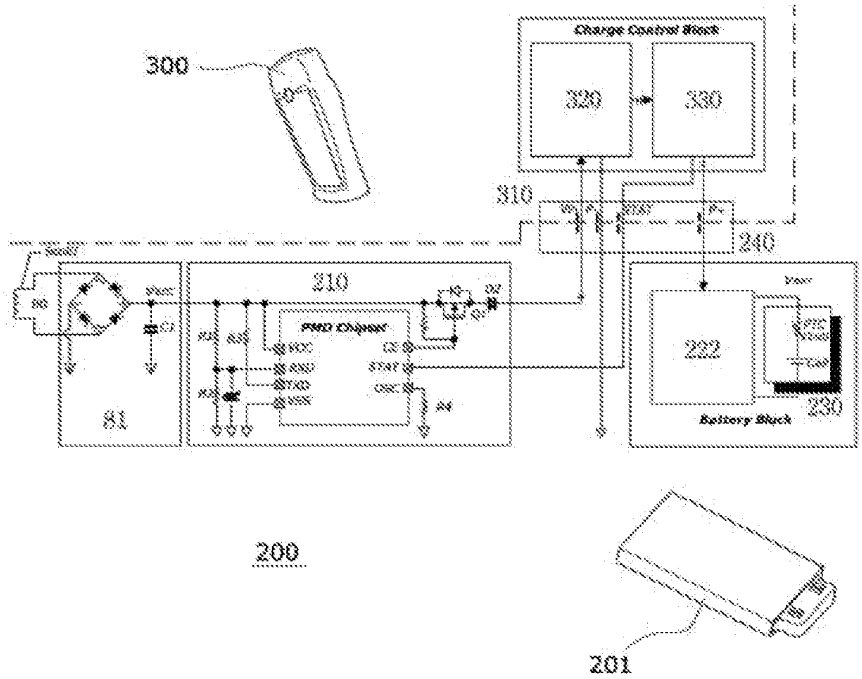
도면4


Cigar 소켓

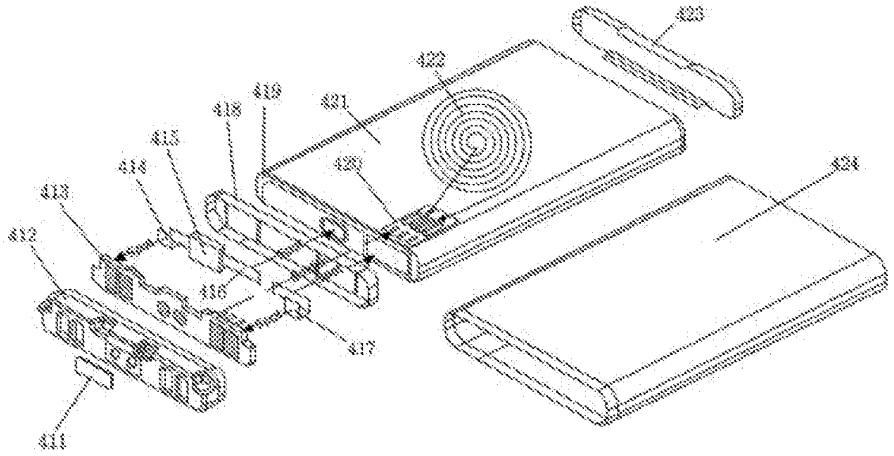
도면5


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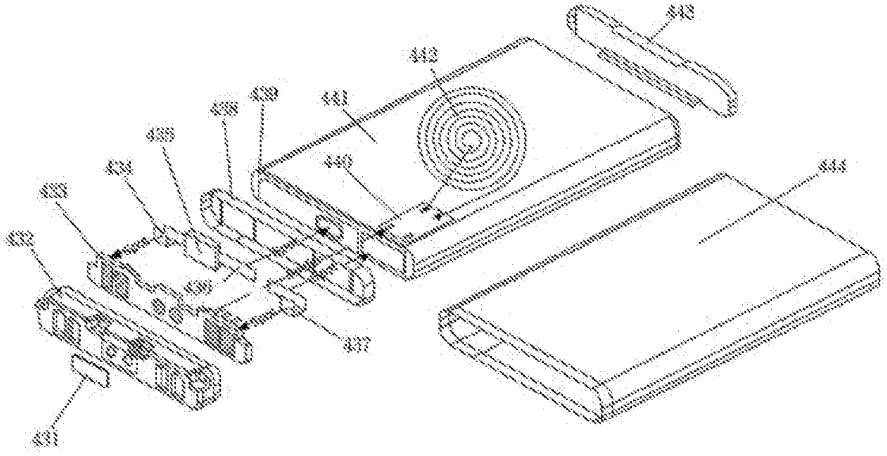
도면6


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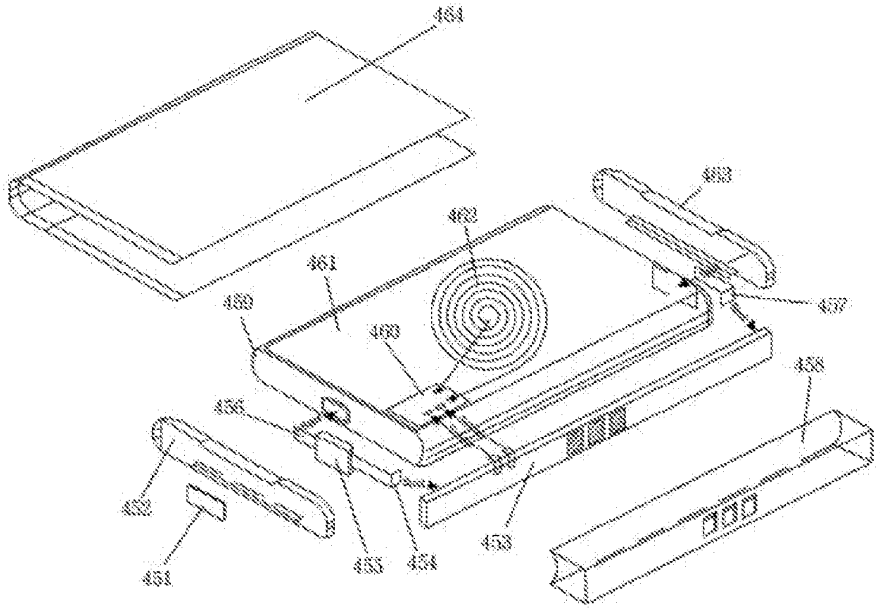
도면7


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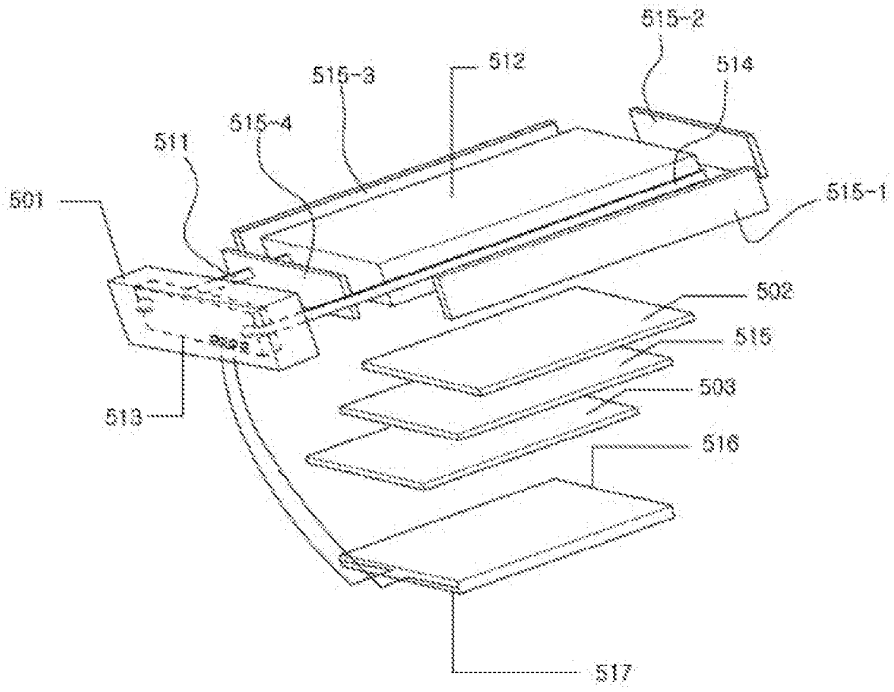
도면8


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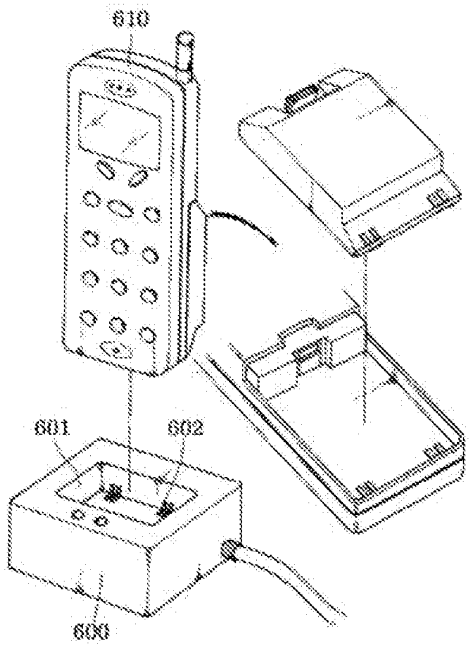
도면9


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도면10


515-2
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515-3
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515-4
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515-1
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513
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도면11



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特開2000－341885
（P2000－341885A）
(43)公開日　平成12年12月８日(2000.12.8)

(51)Int.Cl.[7]	識別記号	Ｆ Ｉ		ﾃｰﾏｺｰﾄﾞ(参考)
Ｈ０２Ｊ　17/00		Ｈ０２Ｊ　17/00	Ｂ	
Ｈ０１Ｆ　38/14		Ｈ０１Ｆ　23/00	Ｑ	

審査請求　未請求　請求項の数７　ＯＬ　（全　７　頁）

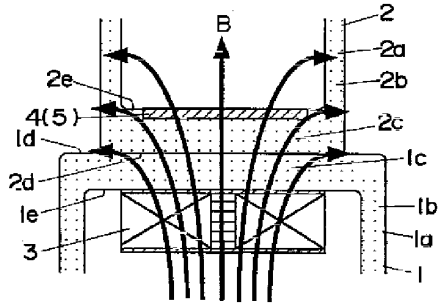
(21)出願番号　特願平11－146741

(22)出願日　平成11年５月26日(1999.5.26)

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(54)【発明の名称】　非接触電力伝達装置、及びその製造方法

(57)【要約】
【課題】　一次側コイルと二次側コイル間のギャップを極端に小さくすることができ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる非接触電力伝達装置を提供する。
【解決手段】　電力供給装置１側に一次側コイル３を、負荷機器２側に二次側コイル４を配設し、一次側コイル３から二次側コイル４への電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル３又は二次側コイル４を平面コイル５に形成し、該平面コイル５を電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設する。



１　電力供給装置
１ａ　相互接続部
１ｃ　接触壁
１ｄ　外面
１ｅ　内面
２　負荷機器
２ａ　相互接続部
２ｃ　接触壁
２ｄ　外面
２ｅ　内面
３　一次側コイル
４　二次側コイル
Ｂ　磁束

【特許請求の範囲】
【請求項１】　電力供給装置側に一次側コイルを、負荷機器側に二次側コイルを配設し、一次側コイルから二次側コイルへの電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル又は二次側コイルを平面コイルに形成し、該平面コイルを電力供給装置又は負荷機器の相互接続部の接触壁に配設することを特徴とする非接触電力伝達装置。
【請求項２】　平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面に配設することを特徴とする請求項１記載の非接触電力伝達装置。
【請求項３】　平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設し、且つ外面と内面の両面に配設した両コイルを電気的に接続することを特徴とする請求項１記載の非接触電力伝達装置。
【請求項４】　平面コイルを保護するための防護シールで平面コイルの露出部を覆うことを特徴とする請求項２又は３のいずれかに記載の非接触電力伝達装置。
【請求項５】　前記防護シールの中心部に磁気部を設けたことを特徴とする請求項４記載の非接触電力伝達装置。
【請求項６】　一次側コイルから発生する磁束と交差する場所に二次側コイルを複数配設したことを特徴とする請求項１乃至４のいずれかに記載の非接触電力伝達装置。
【請求項７】　上記平面コイルをホットスタンピングによって電力供給装置又は負荷機器の相互接続部の接触壁に配設することを特徴とする非接触電力伝達装置の製造方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、非接触電力伝達装置、及びその製造方法に関するものである。
【０００２】
【従来の技術】図９は従来の非接触電力伝達装置の電力伝達部を示すものである。この装置の電力伝達部の主要部は、電力供給装置１の相互接続部１ａ内に配設される一次側コイル３と、負荷機器２の相互接続部２ａ内に配設される二次側コイル４とで構成され、一次側コイル３から二次側コイル４への電磁誘導により非接触で電力伝達を行うものである（図中Ｂは磁束を表す）。尚、一次側コイル３は、電力供給装置１の相互接続部１ａのハウジング１ｂの接触壁１ｃの内面１ｅに、二次側コイル４は、負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの内面２ｅに、夫々密着して配設してある。
【０００３】ところで、一次側コイル３から二次側コイル４へ伝達される電力を増加させる方法としては、一次側コイル３又は二次側コイル４のインダクタを増やす、或いはコア挿入によって伝達効率を向上させる等が考えられる。まず一次側コイル３又は二次側コイル４のインダクタを増やす方法の場合、インダクタを増大させるために、コイルの巻数を増やすので、コイルが大きくなり、装置の小型化を妨げる。またコア挿入によって伝達効率を向上させる方法の場合も、先の方法と同じく、コア挿入によって装置の小型化を妨げることになる他、コストアップにもつながる。
【０００４】そこで、上記以外の方法として、一次側コイル３と二次側コイル４間のギャップをできるだけ小さくする方法が考えられる。即ち、これは、一次側コイル３が配設される電力供給装置１の相互接続部１ａのハウジング１ｂの接触壁１ｃの肉厚と、二次側コイル４が配設される負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの肉厚をできるだけ薄くして、一次側コイル３と二次側コイル４間の距離を可能な限り小さくする方法である。しかし、この方法では、ハウジング強度、ハウジング成型条件、及び絶縁距離等の制限により、ハウジング１ｂ、及びハウジング２ｂの接触壁１ｃ，２ｃの肉厚を薄くするにも限界がある。また、この方法の場合、図１０に示すように商品のデザインによっては、曲面部１４に一次側コイル３、及び二次側コイル４を配設しなければならないこともある。この場合、一次側コイル３と二次側コイル４間のギャップが大きくなってしまい、一次側コイル３から二次側コイル４へ伝達される電力を確保するのが困難になる。
【０００５】
【発明が解決しようとする課題】本発明は上記の点に鑑みて為されたものであり、一次側コイルと二次側コイル間のギャップを極端に小さくすることができ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる非接触電力伝達装置を提供することを目的としている。
【０００６】
【課題を解決するための手段】本発明の請求項１に係る非接触電力伝達装置は、電力供給装置１側に一次側コイル３を、負荷機器２側に二次側コイル４を配設し、一次側コイル３から二次側コイル４への電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル３又は二次側コイル４を平面コイル５に形成し、該平面コイル５を電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設することを特徴とするものである。
【０００７】また本発明の請求項２に係る非接触電力伝達装置は、請求項１の構成に加えて、平面コイル５に形成した一次側コイル３又は二次側コイル４のいずれかを電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）の外面１ｄ（２ｄ）に配設することを特徴とするものである。

【０００８】また本発明の請求項３に係る非接触電力伝達装置は、請求項１の構成に加えて、平面コイル５に形成した一次側コイル３又は二次側コイル４のいずれかを電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）の外面１ｄ（２ｄ）と内面１ｅ（２ｅ）の両面に配設し、且つ外面１ｄ（２ｄ）と内面１ｅ（２ｅ）の両面に配設した両コイル３，３（４，４）を電気的に接続することを特徴とするものである。

【０００９】また本発明の請求項４に係る非接触電力伝達装置は、請求項２又は３のいずれかの構成に加えて、平面コイル５を保護するための防護シール６で平面コイル５の露出部５ａを覆うことを特徴とするものである。

【００１０】また本発明の請求項５に係る非接触電力伝達装置は、請求項４の構成に加えて、前記防護シール６の中心部に磁気部７を設けたことを特徴とするものである。

【００１１】また本発明の請求項６に係る非接触電力伝達装置は、請求項１乃至４のいずれかの構成に加えて、一次側コイル３から発生する磁束Ｂと交差する場所に二次側コイル４を複数配設したことを特徴とするものである。

【００１２】また本発明の請求項７に係る非接触電力伝達装置の製造方法は、上記平面コイル５をホットスタンピングによって電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設することを特徴とするものである。

【００１３】

【発明の実施の形態】本発明の実施の形態を図１乃至図８に基づいて説明する。

【００１４】本発明の実施の形態の一例を図１乃至図３に示す。図１は本発明の非接触電力伝達装置の電力伝達部を示すものである。非接触電力伝達装置の電力伝達部は、電力供給装置１の相互接続部１ａと負荷機器２の相互接続部２ａから構成される。電力供給装置１の相互接続部１ａと、負荷機器２の相互接続部２ａは夫々、有底筒状のハウジング１ｂとハウジング２ｂで外殻が形成され、ハウジング１ｂの接触壁１ｃの内面１ｅには一次側コイル３が、ハウジング２ｂの接触壁２ｃの内面２ｅには二次側コイル４が、夫々ハウジング１ｂ、ハウジング２ｂの中心軸にコイルの巻き軸が一致するように配設される。尚、この例では、一次側コイル３には一般に使用される筒状コイルを用い、一方の二次側コイル４には図２に示すような銅箔を渦巻き状に形成した平面コイル５を用いる。またこの平面コイル５の形成、並びにハウジング２ｂの接触壁２ｃの内面２ｅへの配設はホットスタンピングによって行う。

【００１５】次に本発明の非接触電力伝達装置の動作説明をする。図３はこの非接触電力伝達装置の回路図を示すものであり、図３（ａ）が電力供給装置１の回路図、図３（ｂ）が負荷機器２の回路図である。まず電力供給装置１において、交流電源８から供給される交流電流を高周波発生回路９によって高周波電流に変換し、ハウジング１ｂの接触壁１ｃの内面１ｅに配設した一次側コイル３に高周波電流を流し、図１に示すような磁束Ｂを発生させる。次に負荷機器２において、ハウジング２ｂの接触壁２ｃの内面２ｅに配設した平面コイル５である二次側コイル４に前記磁束Ｂが交差することによって、電磁誘導により二次側コイル４に起電力が発生し、整流ダイオード１０により整流した後、電池１１に電流を供給し、充電を行う。こうして電力を供給された負荷機器２は負荷機器２に配設した電源スイッチ１３をオンにすることによって負荷１２を駆動させることができる。

【００１６】上記のように本発明の非接触電力伝達装置は、二次側コイル４を平面コイル５に形成し、平面コイル５を負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの内面２ｅに配設することで、平面コイル５である二次側コイル４の全部分と相手側コイルである一次側コイル３間の距離が短くなり、一次側コイル３から発生する磁束Ｂのうち二次側コイル４に交差する磁束Ｂの数を多くすることができるので、大きな起電力が得られ、一次側コイル３から二次側コイル４へ伝達される電力を増大させることができる。また逆に負荷機器２側に一定の電力を得ようとする場合、従来のものと比べて、一次側コイル３又は二次側コイル４のインダクタが小さくて済むため、部品の小型化、及びコストダウンを図ることができる。また平面コイル５であるため、縦方向のスペースを取らないので、装置を小型化、及び薄型化できる。また上記平面コイル５をホットスタンピングによって負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃに配設することで、非接触電力伝達装置の電力伝達部を低コストで製造することが可能となる。またホットスタンピングにより、ハウジングの曲面部にも平面コイル５を配設できるため、商品のハウジング形状の自由度が増す。

【００１７】次に本発明の実施の形態の他の例を図４に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は前記例と同じであり、この例では二次側コイル４をハウジング２ｂの接触壁２ｃに外面２ｄと面一となるように埋設する。このような構成とすることで、一次側コイル３と二次側コイル４間のギャップが、ハウジング１ｂの接触壁１ｃの厚みのみとなり、短くなるため、一次側コイル３から二次側コイル４へ伝達される電力をより増大させることができる。

【００１８】次に本発明の実施の形態の他の例を図５に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は第１の例と同じであり、この例では二次側コイル４として２つの平面コイル５，５をハウジング２ｂの接触壁２ｃの外面２ｄと内面２ｅの両面に配設し、且つ外面２ｄと内面２ｅの両

面に配設した両コイル５，５を電気的接続部材１５を介して接続する。尚、外面２ｄと内面２ｅの両面に配設した両コイル５，５は夫々、接触壁２ｃの外面２ｄ、及び内面２ｅと面一になるように埋設する。このような構成とすることで、一次側コイル３と二次側コイル４間のギャップが、ハウジング１ｂの接触壁１ｃの厚みのみとなり、短くなるため、一次側コイル３から二次側コイル４へ伝達される電力を増大させることができ、加えてハウジング２ｂの接触壁２ｃの外面２ｄと内面２ｅの両面に配設した両コイル５，５を接続することにより、コイルの巻数が増え、インダクタが増大するため、一次側コイル３から二次側コイル４へ伝達される電力をさらに増大させることができる。

【００１９】次に本発明の実施の形態の他の例を図６に示す。この非接触電力伝達装置は、第２の例の構成において、ハウジング２ｂの接触壁２ｃの外面２ｄに面一に埋設した平面コイル５を保護するために、防護シール６で平面コイル５の露出部５ａを覆ったものである。このような構成とすることで、負荷機器２の落下、転倒、及び電力供給装置１との着脱による二次側コイル４のコイルの断線又は劣化を防止することができる。

【００２０】次に本発明の実施の形態の他の例を図７に示す。この非接触電力伝達装置は、前記例の構成において、防護シール６の中心部に磁気部７を設けたものである。尚、磁気部７の中心は一次側コイル３と、二次側コイル４の巻き軸と同一直線上に位置する。このような構成とすることで、磁束Ｂが防護シール６の中心部の磁気部７に集束され、二次側コイル４を交差する磁束Ｂの数が増加するため、一次側コイル３から二次側コイル４へ伝達される電力の伝達効率を上げることができる。

【００２１】次に本発明の実施の形態の他の例を図８に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は第２の例と同じであり、この例では一次側コイル３から発生する磁束Ｂと交差する場所に二次側コイル４を複数配設する。このように１つの二次側コイル４の場合では交差しない磁束Ｂも二次側コイル４を前記磁束Ｂと交差するように複数設けることにより、二次側コイル４に交差する磁束Ｂの数を増やすことができるので、大きな起電力が得られ、一次側コイル３から二次側コイル４へ伝達される電力をより増大させることができる。

【００２２】

【発明の効果】本発明の請求項１記載の発明にあっては、電力供給装置側に一次側コイルを、負荷機器側に二次側コイルを配設し、一次側コイルから二次側コイルへの電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル又は二次側コイルを平面コイルに形成し、該平面コイルを電力供給装置又は負荷機器の相互接続部の接触壁に配設することで、一次側コイル又は二次側コイルが平面コイルとなっているため、該平面コイルの全部分と相手側コイル間の距離が短くなり、一次側コイルから発生する磁束のうち二次側コイルに交差する磁束の数を多くすることができるので、大きな起電力が得られ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる。また逆に負荷機器側に一定の電力を得ようとする場合、従来のものと比べて、一次側コイル又は二次側コイルのインダクタが小さくて済むため、部品の小型化、及びコストダウンを図ることができる。また平面コイルであるため、縦方向のスペースを取らないので、装置を小型化、及び薄型化できる。

【００２３】また本発明の請求項２記載の発明にあっては、請求項１記載の発明の効果に加えて、平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面に配設することで、一次側コイルと二次側コイル間のギャップが、電力供給装置又は負荷機器のいずれかの相互接続部の接触壁の厚みのみとなり、短くなるため、一次側コイルから二次側コイルへ伝達される電力をより増大させることができる。

【００２４】また本発明の請求項３記載の発明にあっては、請求項１記載の発明の効果に加えて、平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設し、且つ外面と内面の両面に配設した両コイルを電気的に接続することで、一次側コイルと二次側コイル間のギャップが、電力供給装置又は負荷機器のいずれかの相互接続部の接触壁の厚みのみとなり、短くなるため、一次側コイルから二次側コイルへ伝達される電力を増大させることができ、加えて電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設した両コイルを接続することにより、コイルの巻数が増え、インダクタが増大するため、一次側コイルから二次側コイルへ伝達される電力をさらに増大させることができる。

【００２５】また本発明の請求項４記載の発明にあっては、請求項２又は３のいずれかに記載の発明の効果に加えて、平面コイルを保護するための防護シールで平面コイルの露出部を覆うことで、負荷機器の落下、転倒、及び電力供給装置との着脱による一次側コイル又は二次側コイルのいずれかのコイルの断線又は劣化を防止することができる。

【００２６】また本発明の請求項５記載の発明にあっては、請求項４記載の発明の効果に加えて、前記防護シールの中心部に磁気部を設けたことで、磁束が防護シールの中心部の磁気部に集束され、二次側コイルを交差する磁束の数が増加するため、一次側コイルから二次側コイルへ伝達される電力の伝達効率を上げることができる。

【００２７】また本発明の請求項６記載の発明にあっては、請求項１乃至４のいずれかに記載の発明の効果に加えて、一次側コイルから発生する磁束と交差する場所に

二次側コイルを複数配設したことで、１つの二次側コイルの場合では交差しない磁束も二次側コイルを前記磁束と交差するように複数設けることにより、二次側コイルに交差する磁束の数を増やすことができるので、大きな起電力が得られ、一次側コイルから二次側コイルへ伝達される電力をより増大させることができる。

【００２８】また本発明の請求項７記載の発明にあっては、上記平面コイルをホットスタンピングによって電力供給装置又は負荷機器の相互接続部の接触壁に配設することで、非接触電力伝達装置の電力伝達部を低コストで製造することが可能となる。またホットスタンピングにより、ハウジングの曲面部にも平面コイルを配設できるため、商品のハウジング形状の自由度が増す。

【図面の簡単な説明】

【図１】本発明の実施の形態の一例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図２】同上の（ａ）は負荷機器の相互接続部の接触壁近傍の上面図、（ｂ）はＡ－Ａ線断面図である。

【図３】同上の（ａ）は電力供給装置の回路図、（ｂ）は負荷機器の回路図である。

【図４】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図５】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図６】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図７】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図８】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

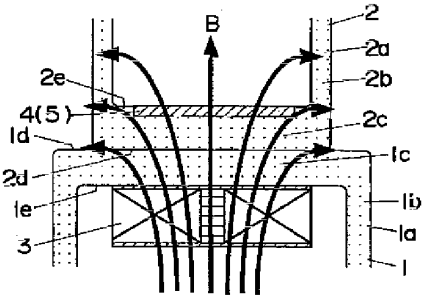
【図９】従来例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図１０】従来例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

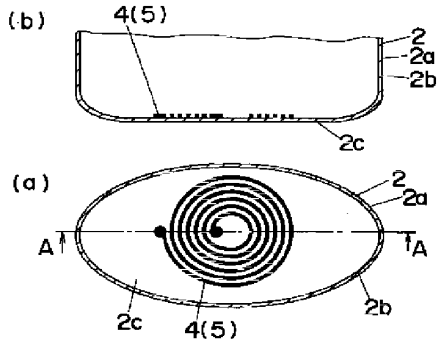
【符号の説明】

１　電力供給装置
１ａ　相互接続部
１ｃ　接触壁
１ｄ　外面
１ｅ　内面
２　負荷機器
２ａ　相互接続部
２ｃ　接触壁
２ｄ　外面
２ｅ　内面
３　一次側コイル
４　二次側コイル
５　平面コイル
５ａ　露出部
６　防護シール
７　磁気部
Ｂ　磁束

【図１】

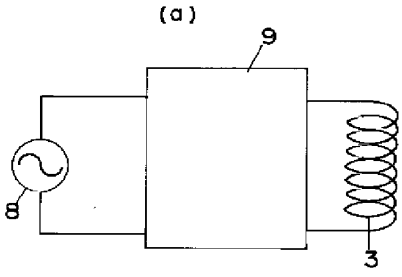


【図２】

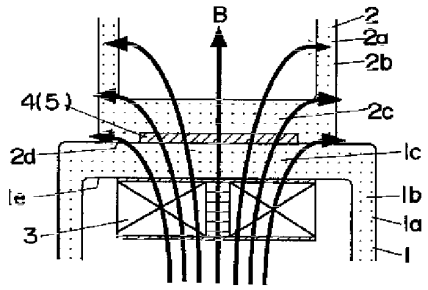


1　電力供給装置
1ａ　相互接続部
1ｃ　接触壁
1ｄ　外面
1ｅ　内面
2　負荷機器
2ａ　相互接続部
2ｃ　接触壁
2ｄ　外面
2ｅ　内面
3　一次側コイル
4　二次側コイル
Ｂ　磁束

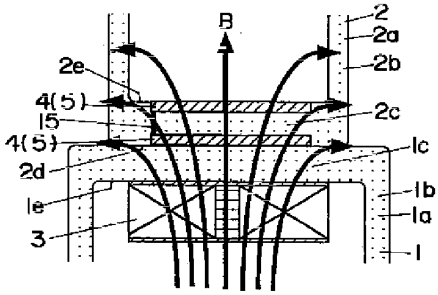
【図3】



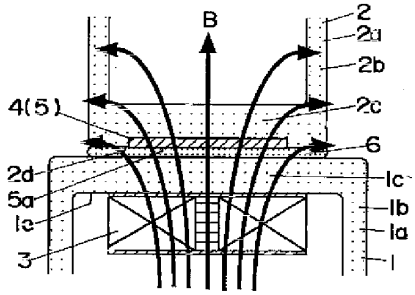
【図4】



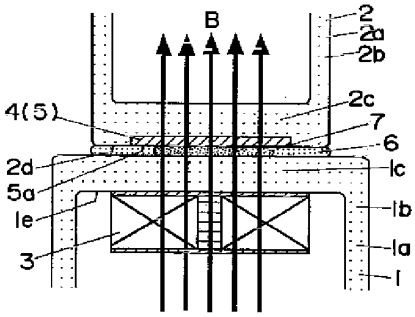
【図5】



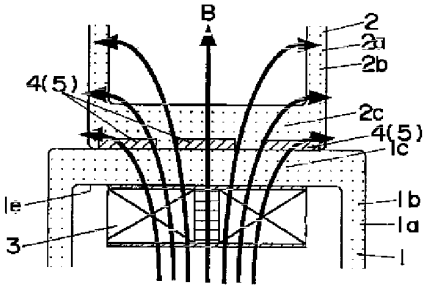
【図6】



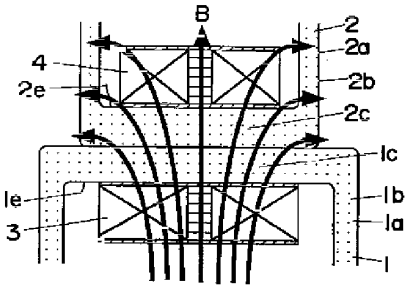
【図7】



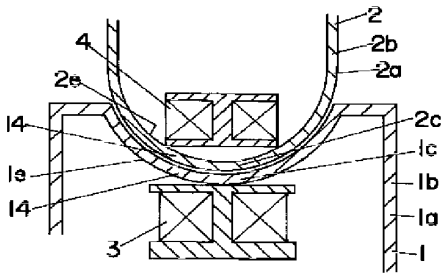
【図8】



【図9】



【図１０】



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Ｈ０１Ｆ　38/14		Ｈ０２Ｊ　17/00		Ｂ
Ｈ０２Ｊ　17/00		Ｈ０１Ｆ　23/00		Ｂ

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(21)出願番号　特願2001－230023(P2001－230023)

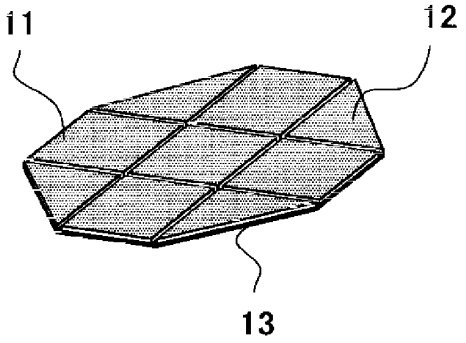
(22)出願日　平成13年７月30日(2001.7.30)

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(54)【発明の名称】　非接触電力伝送装置

(57)【要約】
【課題】　伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与した非接触電力伝送装置を提供すること。
【解決手段】　本発明の非接触電力伝送装置は、空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置であって、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着して構成される。



【特許請求の範囲】
【請求項１】　空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置において、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着したことを特徴とする非接触電力伝送装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、コイル間に生じる電磁誘導作用により、空間を介して電力を伝送する非接触電力伝送装置に関する。
【０００２】
【従来の技術】従来、空隙を介して対向させたコイル間に生じる電磁誘導作用を利用して非接触に電力を伝送する方式は、コードレス・パワー・ステーションと呼ばれ、１９９３年度刊行の日本応用磁気学会誌［１７，４８５－４８８］に開示されており、その利用例としては、非接触な電力伝送を行い得ることから、例えば、１９９１年度刊行の電気学会論文誌［Ａ，１１１－Ａ，８０７］に開示されているように、人工心臓の駆動装置への有効な電力供給手段として挙げられている。
【０００３】因みに、完全埋込型の人工心臓用トランスには、一対のコイルが使用され、そのトランスには、薄型化が要求されている。人工心臓の駆動装置のエネルギー伝送用の磁性材料としてアモルファス磁性材料を用いたトランスでは、その厚さが３ｍｍ程度になっているが、フェライトを用いたポットコアタイプのものでは、トランスの厚さが１５ｍｍ程度になっている。また、本発明者らはフェライト板を用いたトランスでトランスの薄型化を実現している。
【０００４】このようなコードレス・パワー・ステーションは、人工心臓の駆動装置への電力供給手段以外にも、携帯用家電製品等への電力供給やバッテリ充電にも応用可能である。
【０００５】
【発明が解決しようとする課題】しかしながら、上述したアモルファス磁性材料を用いて形成したトランスでは、薄型化を実現しているが、電力伝送時にはアモルファス磁性材では、高周波磁界による発熱が生じ、長時間使用の場合、人体での低温火傷を生ずるまでに昇温するという欠点を有している。
【０００６】また、人体等に使用する場合においては、コイル形状がある程度の曲率をもって形成される方が好都合となる場合も多い。従って、磁性体と配置したコイルがある程度の可撓性を有することは、実用上、有益となる。
【０００７】前述のアモルファス磁性材を装着したコイルにおいては、良好な可撓性が得られている。
【０００８】一方、フェライト板を装着したコイルにおいては、電力伝送時におけるフェライト部での発熱は殆ど生じず、生体への火傷などの問題は発生しない。一方、フェライト板は硬く、脆いので、フェライト板を装着したコイルの可撓性はない。
【０００９】本発明は、かかる問題点を解決すべくなされたもので、その技術的課題は、伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与することにある。
【００１０】
【課題を解決するための手段】本発明によれば、空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置において、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着した非接触電力伝送装置が得られる。
【００１１】
【作用】本発明においては、対向した平面渦巻型コイルの外側部に、軟磁性フェライトチップを敷くように設けたフェライトシートを配置することにより、非接触電力伝送が良好で、発熱が殆どなく、可撓性を有するトランス部が実現できる。
【００１２】非接触電力伝送が良好となるのは、フェライトシート部において、磁束の捕捉及び１次側と２次側の磁束結合が向上するからである。また、発熱が殆ど生じないのは、フェライトの電気抵抗が高いので、電磁誘導作用による渦電流発熱が極めて少ないためである。また、フェライト部の可撓性は、フェライトチップをプラスチックシート等に貼り付けて、フェライトシート状に形成することによって、ある程度の変形が可能となることで、付与している。
【００１３】
【実施例】以下、実施例について説明する。
【００１４】（実施例１）図１は、本発明の実施例１で用いるフェライトシートを示す斜視図である。
【００１５】まず、透磁率が約２５００で、飽和磁化が約0.５Ｔ（５０００Ｇ）のＭｎ-Ｚｎ系スピネルフェライト焼結体を使用して、厚さ１ｍｍからなる辺長１１ｍｍの正方形状角板１１と、これを対角方向に切断して、二等辺長各１０ｍｍとなる二等辺三角形板１２を作製した。
【００１６】平面渦巻コイルとして、直径１００μｍの銅線を１００本束ねたものを５ターン巻線し、外径３０ｍｍ、内径１５ｍｍ、厚さ1.５ｍｍに作製し、これらを対向させて、電源に接続される方を１次側（入力側）、電磁誘導で出力が発生する方を２次側（出力側）とした。
【００１７】次に、これら平面渦巻コイルを１ｍｍの空隙を持たせて対向させ、１対の平面渦巻コイルを構成し、周波数１００ｋＨｚ、１次側電圧、４Ｖの条件下で、２次側出力（最大伝送電力）P_2及び変換効率ηを求めた。但し、η＝（出力電力／入力電力）×１００

（％）である。

【００１８】測定における電磁誘導部の構成を、（１）対向するコイルのみの場合と、（２）上述したＭｎ－Ｚｎ系スピネルフェライト焼結体の正方形状角板１１を５枚とＭｎ－Ｚｎ系スピネルフェライト焼結体の二等辺三角形板１２の４枚を約０．５ｍｍの隙間を空けてポリエステルフィルム１３に貼り付け、正八角形状に作製したフェライトシートを対向するコイルの両外側部に装着した場合の２種類について測定している。その結果を表１に示す。

【００１９】

【表１】

構成 / 特性	フェライトシートの装着	
	なし	あり
2次側出力P_2 (W)	1.4	8.3
変換効率η (%)	8	82

【００２０】フェライトシートを装着することにより、２次側出力P_2及び変換効率ηが著しく向上することが判る。

【００２１】また、フェライトシートを装着したコイル部は可撓性を保有し、曲率半径５０ｍｍ程度までは容易に到達できた。

【００２２】（実施例２）図２は、本発明の実施例２で用いるフェライトシートを示す斜視図である。

【００２３】まず、透磁率が約８００で、飽和磁化が約０．３５Ｔ（３５００Ｇ）のＮｉ-Ｃｕ-Ｚｎ系スピネルフェライト焼結体を使用して、厚さ０．５ｍｍから成る辺長５ｍｍの正方形状角板２１と、これを対角方向に切断して二等辺長各４ｍｍとなる二等辺三角形板２２を作製した。

【００２４】これら四角形板２４枚と三角形板８枚を約０．５ｍｍの隙間を空けて、シリコンゴムシート２３に貼り付け、正八角形状にフェライトシートを作製した。

【００２５】これを使用した効果について、実施例１と同様にして測定した。その結果を表２に示す。

【００２６】

【表２】

構成 / 特性	フェライトシートの装着	
	なし	あり
2次側出力P_2 (W)	1.4	7.9
変換効率η (%)	8	80

【００２７】フェライトシートを装着することにより、２次側出力P_2及び変換効率ηが著しく向上することが判る。

【００２８】また、フェライトシートを装着したコイル部は可撓性を保有し、曲率半径３０ｍｍ程度までは容易に到達できた。

【００２９】

【発明の効果】本発明は、以上説明したように構成されているので、本発明によれば、伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与した非接触電力伝送装置を提供することができる。

【図面の簡単な説明】

【図１】本発明の実施例１で用いるフェライトシートを示す斜視図。

【図２】本発明の実施例２で用いるフェライトシートを示す斜視図。

【符号の説明】

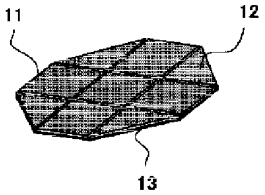
１１，２１　軟磁性フェライト焼結体の正方形状角板

１２，２２　軟磁性フェライト焼結体の二等辺三角形板

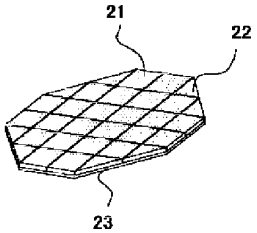
１３　ポリエステルフィルム

２３　シリコンゴムシート

【図１】



【図２】



Electronic Patent Application Fee Transmittal	
Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna/Nancy McElrath
Attorney Docket Number:	AFPA-01032US0
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	17265975
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Nancy McElrath
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	30-OCT-2013
Filing Date:	17-JAN-2012
Time Stamp:	17:27:16
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	5346
Deposit Account	061325
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Transmittal Letter	afpa_1032us0_IDS_Trans_1013.pdf	260154 f898a5523b9a39c613c2e7435ea732dbbb7c6678	no	3
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National Stage of an International Application under 35 U.S.C. 371
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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		PATENT APPLICATION
Inventor(s):	Partovi, Afshin et al.	
Appl. No.:	13/352,096	Art Unit: 2859
Confirm. No.:	4453	Examiner: Fantu, Yalkew
Filed:	01-17-2012	
Title:	Systems and Methods for Providing Positioning Freedom, and Support of Different Voltages, Protocols, and Power Levels in a Wireless Power System	**Customer No. 23910**

CERTIFICATE OF TRANSMISSION / MAILING UNDER 37 C.F.R. §1.8
I hereby certify that this correspondence is being electronically transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: **Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**, on the date shown below.

/Karl Kenna/ (Attorney Signature)
Karl Kenna, Reg. No. 45,445
Signature Date: Oct. 30, 2013

TRANSMITTAL LETTER RE INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

It is requested that the information identified in this statement be considered by the Examiner and made of record in the above-identified application. This statement is not intended to represent that a search has been made or that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56. If this is a continuation, divisional or continuation-in-part application, it is understood that the Examiner will consider all information which was considered by the Office in a parent application. MPEP §609. Such information therefore is not listed herein unless it is desired that the information be printed on a patent issuing from the subject application.

Enclosed with this statement are the following:

✓ Form PTO-1449. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ As allowed under 37 C.F.R § 1.98(a)(2)(ii), no copies of the U.S. patents and U.S. patent application publications are enclosed, unless required by the office.

___ As allowed under 37 CFR §1.98(d), copies of cited documents noted with an asterisk are not enclosed because they were previously submitted in U.S. Patent Application No. , which is relied on for an earlier effective filing date under 35 USC §120, and which included an Information Disclosure Statement that complies with 37 CFR §1.98(a) through (c).

___ A copy of an International Search Report dated _____ for Application No. _____.

___ A copy of an International Search Report dated _____ for Application No. _____.

___ If any of the cited/submitted documents is in a foreign language, a concise explanation of relevance is provided pursuant to 37 C.F.R. §1.98(a)(3)(I). For foreign language documents cited in a search report by a foreign patent office, the requirement for a concise explanation of relevance is satisfied by the submission herewith of an English language version of the search report. MPEP §609A(3). If a written English-language translation of a non-English language document, or portion thereof, is within the possession, custody or control of, or is readily available to any individual designated in §1.56(c), a copy of the translation accompanies this statement, 37 C.F.R. §1.98(a)(3)(ii), and satisfies the requirement for a concise explanation of relevance, MPEP §609A(3).

This statement should be considered because:

___ **37 C.F.R. §1.97(b)**. This statement qualifies under 37 C.F.R. §1.97, subsection (b) because:

(1) It is being filed within three months of the filing date of an application other than a continued prosecution application under § 1.53(d);

-- OR --

(2) It is being filed within 3 months of entry of a national stage;

-- OR --

(3) It is being filed before the mailing date of the first Office Action on the merits,

-- OR --

(4) It is being filed before the mailing date of the first Office Action after the filing of a Request for Continued Examination under 37 C.F.R. §1.114.

✓ **37 C.F.R. §1.97(c)**. Although it may not qualify under subsection (b), this statement qualifies under 37 C.F.R. §1.97, subsection (c) because:

(1) It is being filed before the mailing date of a FINAL Office Action, a Notice of Allowance, or an action that otherwise closes prosecution in the subject application, whichever occurs first.

-- AND *(check at least one of the following)* --

___ (a) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e).

-- OR –

✓ (b) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

__ **37 C.F.R. §1.97(d)**. Although it may not qualify under subsection (b) or (c), this statement qualifies under 37 C.F.R. §1.97, subsection (d) because:

(1) It is being filed on or before payment of the Issue Fee;
-- AND --
(2) It is accompanied by a STATEMENT as set forth in 37 C.F.R. §1.97(e);
-- AND --
(3) It is accompanied by the $180 fee set forth in 37 C.F.R. §1.17(p).

__ ***PTA Statement under 37 C.F.R. §1.704(d).*** Each item of information contained in the *Information Disclosure Statement* was cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in §1.56(c) more than thirty days prior to the filing of the *Information Disclosure Statement*.

__ *37 C.F.R. §1.97(e)(1).* THE UNDERSIGNED ATTORNEY HEREBY STATES THAT each item of information contained in this *Information Disclosure Statement* was first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this *Information Disclosure Statement*; or

__ *37 C.F.R. §1.97(e)(2).* THE UNDERSIGNED ATTORNEY HEREBY STATES THAT no item of information contained in this *Information Disclosure Statement* was cited in a communication from a foreign patent office in a counterpart foreign application and, to the knowledge of the person signing this statement after making reasonable inquiry, no item of information contained in this *Information Disclosure Statement* was known to any individual designated in §1.56(c) more than three months prior to the filing of this statement.

_✓_ ***Fee Authorization.*** The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Account No. 06-1325.

Respectfully submitted,

FLIESLER MEYER LLP

Date: Oct. 30, 2013

By: /Karl Kenna/
Karl Kenna
Reg. No. 45,445

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San Francisco, California 94133
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PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13352096
	Filing Date	2012-01-17
	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

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	Examiner Name	Fantu, Yalkew
	Attorney Docket Number	AFPA-01032US0

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	Application Number	13352096
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	First Named Inventor	Partovi, Afshin
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	Examiner Name	Fantu, Yalkew
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	1	HUI, "A New Generation of Universal Contactless Battery Charging Platform for Portable Consumer Electronic Equipment", IEEE Transactions on Power Electronics, Vol. 20, No. 3, May 2005, pp. 620-627, 8 pages.	☐
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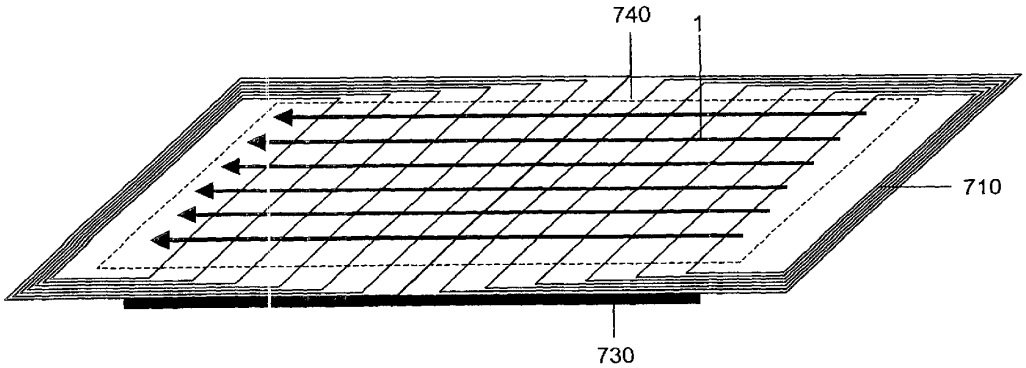
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(54) Title: IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER



(57) Abstract: There is disclosed a system and method for transferring power without requiring direct electrical conductive contacts. There is provided a primary unit having a power supply and a substantially laminar charging surface having at least one conductor that generates an electromagnetic field when a current flows therethrough and having an charging area defined within a perimeter of the surface, the at least one conductor being arranged such that electromagnetic field lines generated by the at least one conductor are substantially parallel to the plane of the surface or at least subtend an angle of 45° or less to the surface within the charging area; and at least one secondary device including at least one conductor that may be wound about a core. Because the electromagnetic field is spread over the charging area and is generally parallel or near-parallel thereto, coupling with flat secondary devices such as mobile telephones and the like is significantly improved in various orientations thereof.

WO 03/096512 A2

IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER

The present application claims priority from UK patent applications nos 0210886.8 of 13th May 2002, 0213024.3 of 7th June 2002, 0225006.6 of 28th October 2002 and 0228425.5 of 6th December 2002, as well as from US patent application no 10/326,571 of 20th December 2002. The full contents of all of these prior patent applications is hereby incorporated into the present application by reference.

This invention relates to a new apparatus and method for transferring power in a contact-less fashion.

Many of today's portable devices incorporate "secondary" power cells which can be recharged, saving the user the cost and inconvenience of regularly having to purchase new cells. Example devices include cellular telephones, laptop computers, the Palm 500 series of Personal Digital Assistants, electric shavers and electric toothbrushes. In some of these devices, the cells are recharged via inductive coupling rather than direct electrical connection. Examples include the Braun Oral B Plak Control power toothbrush, the Panasonic Digital Cordless Phone Solution KX-PH15AL and the Panasonic multi-head men's shavers ES70/40 series.

Each of these devices typically has an adaptor or charger which takes power from mains electricity, a car cigarette lighter or other sources of power and converts it into a form suitable for charging the secondary cells. There are a number of problems associated with conventional means of powering or charging these devices:

- Both the characteristics of the cells within each device and the means of connecting to them vary considerably from manufacturer to manufacturer, and from device to device. Therefore users who own several such devices must also own several different adaptors. If users are going away on travel, they will have to bring their collection of chargers if they expect to use their devices during this time.

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- These adaptors and chargers often require users to plug a small connector into the device or to place the device with accurate alignment into a stand causing inconvenience. If users fail to plug or place their device into a charger and it runs out of power, the device becomes useless and important data stored locally in the device might even be lost.

- In addition, most adaptors and chargers have to be plugged into mains sockets and hence if several are used together, they take up space in plug strips and create a messy and confusing tangle of wires.

- Besides the above problems with conventional methods of recharging devices, there are also practical problems associated with devices having an open electrical contact. For example, devices cannot be used in wet environments due to the possibility of corroding or shorting out the contacts and also they cannot be used in flammable gaseous environments due to the possibility of creating electrical sparks.

Chargers which use inductive charging remove the need to have open electrical contacts hence allowing the adaptor and device to be sealed and used in wet environments (for example the electric toothbrush as mentioned above is designed to be used in a bathroom). However such chargers still suffer from all other problems as described above. For example, the devices still need to be placed accurately into a charger such that the device and the charger are in a predefined relative position (See Figures 1a and 1b). The adaptors are still only designed specifically for a certain make and model of device and are still only capable of charging one device at a time. As a result, users still need to possess and manage a collection of different adaptors.

Universal chargers (such as the Maha MH-C777 Plus Universal charger) also exist such that battery packs of different shapes and characteristics can be removed from the device and charged using a single device. Whilst these universal chargers eliminate the need for having different chargers for different devices, they create even more inconvenience for the user in the sense that the battery packs first need to

be removed, then the charger needs to be adjusted and the battery pack needs to be accurately positioned in or relative to the charger. In addition, time must be spent to determine the correct pair of battery pack metal contacts which the charger must use.

It is known from US 3,938,018 "Induction charging system" to provide a means for non-contact battery charging whereby an inductive coil on the primary side aligns with a horizontal inductive coil on a secondary device when the device is placed into a cavity on the primary side. The cavity ensures the relatively precise alignment which is necessary with this design to ensure that good coupling is achieved between the primary and secondary coils.

It is also known from US 5,959,433 "Universal Inductive Battery Charger System" to provide a non-contact battery charging system. The battery charger described includes a single charging coil which creates magnetic flux lines which will induce an electrical current in a battery pack which may belong to cellular phones or laptop computers.

It is also known from US 4,873,677 "Charging Apparatus for an Electronic Device" to provide an apparatus for charging an electronic device which includes a pair of coils. This pair of coils is designed to operate in anti-phase such that magnetic flux lines are coupled from one coil to the other. An electronic device such as a watch can be placed on these two coils to receive power.

It is also known from US 5,952,814 "Induction charging apparatus and an electronic device" to provide an induction charger for charging a rechargeable battery. The shape of the external casing of the electronic device matches the internal shape of the charger thus allowing for accurate alignment of the primary and secondary coils.

It is also known from US 6,208,115 "Battery substitute pack" to provide a substitute battery pack which may be inductively recharged.

It is known from WO 00/61400 "Device for Inductively Transmitting Electrical Power" to provide a means of transferring power inductively to conveyors.

It is known from WO 95/11545 "Inductive power pick-up coils" to provide a system for inductive powering of electric vehicles from a series of in-road flat primaries.

To overcome the limitations of inductive power transfer systems which require that secondary devices be axially aligned with the primary unit, one might propose that an obvious solution is to use a simple inductive power transfer system whereby the primary unit is capable of emitting an electromagnetic field over a large area (See Figure 2a). Users can simply place one or more devices to be recharged within range of the primary unit, with no requirement to place them accurately. For example this primary unit may consist of a coil encircling a large area. When a current flows through the coil, an electromagnetic field extending over a large area is created and devices can be placed anywhere within this area. Although theoretically feasible, this method suffers from a number of drawbacks. Firstly, the intensity of electromagnetic emissions is governed by regulatory limits. This means that this method can only support power transfer at a limited rate. In addition, there are many objects that can be affected by the presence of an intense magnetic field. For example, data stored on credit cards maybe destroyed and objects made of metal will have induced therein eddy currents generating undesired heating effects. In addition, if a secondary device comprising a conventional coil (see Figure 2a) is placed against a metallic plate such as a copper plane in a printed circuit board or metallic can of a cell, coupling is likely to be significantly reduced.

To avoid the generation of large magnetic fields, one might suggest using an array of coils (See Figure 3) whereby only the coils needed are activated. This method is described in a paper published in the Journal of the Magnetics Society of Japan titled "Coil Shape in a Desk-type Contactless Power Station System" (29th Nov 2001). In an embodiment of the multiple-coil concept, a sensing mechanism senses the relative location of the secondary device relative to the primary unit. A control system then activates the appropriate coils to deliver power to the secondary device in a localised

fashion. Although this method provides a solution to the problems previously listed, it does so in a complicated and costly way. The degree to which the primary field can be localised is limited by the number of coils and hence the number of driving circuits used (i.e. the "resolution" of the primary unit). The cost associated with a multiple-coil system would severely limit the commercial applications of this concept. Non-uniform field distribution is also a drawback. When all the coils are activated in the primary unit, they sum to an equivalent of a large coil, the magnetic field distribution of which is seen to exhibit a minimum at the centre of the coil.

Another scheme is outlined in US 5,519,262 "Near Field Power Coupling System", whereby a primary unit has a number of narrow inductive coils (or alternatively capacitive plates) arranged from one end to the other of a flat plate, creating a number of vertical fields which are driven in a phase-shifted manner so that a sinusoidal wave of activity moves across the plate. A receiving device has two vertical field pickups arranged so that regardless of its position on the plate it can always collect power from at least one pickup. While this scheme also offers freedom of movement of the device, it has the disadvantages of needing a complex secondary device, having a fixed resolution, and having poor coupling because the return flux path is through air.

None of the prior art solutions can satisfactorily address all of the problems that have been described. It would be convenient to have a solution which is capable of transferring power to portable devices with all of the following features and is cost effective to implement:

- Universality: a single primary unit which can supply power to different secondary devices with different power requirements thereby eliminating the need for a collection of different adaptors and chargers;
- Convenience: a single primary unit which allows secondary devices to be placed anywhere within an active vicinity thereby eliminating the need for plugging-in or placing secondary devices accurately relative to an adaptor or charger;

- Multiple-load: a single primary unit that can supply power to a number of secondary different devices with different power requirements at the same time;
- Flexibility for use in different environments: a single primary unit that can supply power to secondary devices such that no direct electrical contact is required thereby allowing for secondary devices and the primary unit itself to be used in wet, gaseous, clean and other atypical environments;
- Low electromagnetic emissions: a primary unit that can deliver power in a manner that will minimize the intensity and size of the magnetic field generated.

It is further to be appreciated that portable appliances are proliferating and they all need batteries to power them. Primary cells, or batteries of them, must be disposed of once used, which is expensive and environmentally unfriendly. Secondary cells or batteries can be recharged and used again and again.

Many portable devices have receptacles for cells of an industry-standard size and voltage, such as AA, AAA, C, D and PP3. This leaves the user free to choose whether to use primary or secondary cells, and of various types. Once depleted, secondary cells must typically be removed from the device and placed into a separate recharging unit. Alternatively, some portable devices do have recharging circuitry built-in, allowing cells to be recharged in-situ once the device is plugged-in to an external source of power.

It is inconvenient for the user to have to either remove cells from the device for recharging, or to have to plug the device into an external power source for recharging in-situ. It would be far preferable to be able to recharge the cells without doing either, by some non-contact means.

Some portable devices are capable of receiving power coupled inductively from a recharger, for example the Braun Oral B Plak Control toothbrush. Such portable devices typically have a custom, dedicated power-receiving module built-in to the

device, which then interfaces with an internal standard cell or battery (which may or may not be removable).

However it would be convenient if the user could transform any portable device which accepts industry-standard cell sizes into an inductively-rechargeable device, simply by fitting inductively-rechargeable cells or batteries, which could then be recharged in-situ by placing the device onto an inductive recharger.

Examples of prior art include US 6,208,115, which discloses a substitute battery pack which may be inductively recharged.

According to a first aspect of the present invention, there is provided a system for transferring power without requiring direct electrical conductive contacts, the system comprising:

i) a primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area; and

ii) at least one secondary device including at least one electrical conductor;

wherein, when the at least one secondary device is placed on or in proximity to a charging area of the primary unit, the electromagnetic field lines couple with the at least one conductor of the at least one secondary device and induce a current to flow therein.

According to a second aspect of the present invention, there is provided a primary unit for transferring power without requiring direct electrical conductive contacts, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area.

According to a third aspect of the present invention, there is provided a method of transferring power in a non-conductive manner from a primary unit to a secondary device, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, the means having a height measured substantially perpendicular to the charging area that is less than either of the width or the length of

the charging area, and the secondary device having at least one electrical conductor; wherein:

i) an electromagnetic field, generated by the means when energised with a predetermined current and measured when the primary unit is effectively in electromagnetic isolation, has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions over the at least one charging area when averaged thereover; and

ii) the electromagnetic field links with the conductor of the secondary device when this is placed on or in proximity to the charging area.

According to a fourth aspect of the present invention, there is provided a secondary device for use with the system, unit or method of the first, second or third aspects, the secondary device including at least one electrical conductor and having a substantially laminar form factor.

In the context of the present application, the word "laminar" defines a geometry in the form of a thin sheet or lamina. The thin sheet or lamina may be substantially flat, or may be curved.

The primary unit may include an integral power supply for the at least one means for generating an electromagnetic field, or may be provided with connectors or the like enabling the at least one means to be connected to an external power supply.

In some embodiments, the means for generating the electromagnetic field have a height that is no more than half the width or half the length of the charging area; in some embodiments, the height may be no more than 1/5 of the width or 1/5 of the length of the charging area.

The at least one electrical conductor in the secondary device may be wound about a core that serves to concentrate flux therein. In particular, the core (where provided) may offer a path of least resistance to flux lines of the electromagnetic field generated by the primary unit. The core may be amorphous magnetically permeable material. In some embodiments, there is no need for an amorphous core.

Where an amorphous core is provided, it is preferred that the amorphous magnetic material is a non-annealed or substantially as-cast state. The material may be at least 70% non-annealed, or preferably at least 90% non-annealed. This is because annealing tends to make amorphous magnetic materials brittle, which is disadvantageous when contained in a device, such as a mobile phone, which may be subjected to rough treatment, for example by being accidentally dropped. In a particularly preferred embodiment, the amorphous magnetic material is provided in the form of a flexible ribbon, which may comprise one or more layers of one or more of the same or different amorphous magnetic materials. Suitable materials include alloys which may contain iron, boron and silicon or other suitable materials. The alloy is melted and then cooled so rapidly ("quenched") that there is no time for it to crystallise as it solidifies, thus leaving the alloy in a glass-like amorphous state. Suitable materials include Metglas® 2714A and like materials. Permalloy or mumetal or the like may also be used.

The core in the secondary device, where provided, is preferably a high magnetic permeability core. The relative permeability of this core is preferably at least 100, even more preferably at least 500, and most preferably at least 1000, with magnitudes of at least 10,000 or 100,000 being particularly advantageous.

The at least one means for generating an electromagnetic field may be a coil, for example in the form of a length of wire or a printed strip, or may be in the form of a conductive plate of appropriate configuration, or may comprise any appropriate arrangement of conductors. A preferred material is copper, although other conductive materials, generally metals, may be used as appropriate. It is to be understood that the term "coil" is here intended to encompass any appropriate

electrical conductor forming an electrical circuit through which current may flow and thus generate an electromagnetic field. In particular, the "coil" need not be wound about a core or former or the like, but may be a simple or complex loop or equivalent structure.

Preferably, the charging area of the primary unit is large enough to accommodate the conductor and/or core of the secondary device in a plurality of orientations thereof. In a particularly preferred embodiment, the charging area is large enough to accommodate the conductor and/or core of the secondary device in any orientation thereof. In this way, power transfer from the primary unit to the secondary device may be achieved without having to align the conductor and/or core of the secondary device in any particular direction when placing the secondary device on the charging surface of the primary unit.

The substantially laminar charging surface of the primary unit may be substantially planar, or may be curved or otherwise configured to fit into a predetermined space, such as a glove compartment of a car dashboard or the like. It is particularly preferred that the means for generating an electromagnetic field does not project or protrude above or beyond the charging surface.

A key feature of the means for generating an electromagnetic field in the primary unit is that electromagnetic field lines generated by the means, measured when the primary unit is effectively in magnetic isolation (i.e. when no secondary device is present on or in proximity to the charging surface), are distributed in two dimensions over the at least one charging area and subtend an angle of 45° or less to the charging area in proximity thereto (for example, less than the height or width of the charging area) and over any quarter length part of the charging area measured in a direction generally parallel to that of the field lines. The measurement of the field lines in this connection is to be understood as a measurement of the field lines when averaged over the quarter length of the charging area, rather than an instantaneous point measurement. In some embodiments, the field lines subtend an angle of 30° or less, and in some embodiments are substantially parallel to at least a central part of the

charging area in question. This is in stark contrast to prior art systems, where the field lines tend to be substantially perpendicular to a surface of a primary unit. By generating electromagnetic fields that are more or less parallel to or at least have a significant resolved component parallel to the charging area, it is possible to control the field so as to cause angular variations thereof, in or parallel to the plane of the charging area, that help to avoid any stationary nulls in the electromagnetic field that would otherwise reduce charging efficiency in particular orientations of the secondary device on the charging surface. The direction of the field lines may be rotated through a complete or partial circle, in one or both directions. Alternatively, the direction may be caused to "wobble" or fluctuate, or may be switched between two or more directions. In more complex configurations, the direction of the field lines may vary as a Lissajous pattern or the like.

In some embodiments, the field lines may be substantially parallel to each other over any given charging area, or at least have resolved components in or parallel to the plane of the charging area that are substantially parallel to each other at any given moment in time.

It is to be appreciated that one means for generating an electromagnetic field may serve to provide a field for more than one charging area; also that more than one means may serve to provide a field for just one charging area. In other words, there need not be a one-to-one correspondence of means for generating electromagnetic fields and charging areas.

The secondary device may adopt a substantially flat form factor with a core thickness of 2mm or less. Using a material such as one or more amorphous metal sheets, it is possible to have core thickness down to 1mm or less for applications where size and weight is important. See Figure 7a.

In a preferred embodiment, the primary unit may include a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending

generally parallel to or subtending an angle of 45° or less to the plane of the windings but substantially at right angles to the parallel sections.

The windings in this embodiment may be formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

Advantageously, the primary unit may include first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

According to a fifth aspect of the present invention, there is provided a system for transferring power in a contact-less manner consisting of:

- a primary unit consisting of at least one electrical coil whereby each coil features at least one active area whereby two or more conductors are substantially distributed over this area in such a fashion that it is possible for a secondary device to be placed in proximity to a part of this active area where the net instantaneous current flow in a particular direction is substantially non-zero;
- at least one secondary device consisting of conductors wound around a high permeability core in such a fashion that it is possible for it to be placed in proximity to an area of the surface of the primary unit where the net instantaneous current flow is substantially non-zero;

whereby the at least one secondary device is capable of receiving power by means of electromagnetic induction when the central axis of the winding is in proximity to the active area of the primary unit, is substantially not perpendicular to the plane of the active area of primary unit and is substantially not parallel to the conductors in the active area of at least one of the coils of the primary unit.

Where the secondary device comprises an inductively rechargeable battery or cell, the battery or cell may have a primary axis and be capable of being recharged by an alternating field flowing in the primary axis of the battery or cell, the battery or cell consisting of:

- an enclosure and external electrical connections similar in dimensions to industry-standard batteries or cells
- an energy-storage means
- an optional flux-concentrating means
- a power-receiving means
- a means of converting the received power to a form suitable for delivery to outside the cell through the external electrical connections, or to recharge the energy storage means, or both.

The proposed invention is a significant departure from the design of conventional inductive power transfer systems. The difference between conventional systems and the proposed system is best illustrated by looking at their respective magnetic flux line patterns. (See Figure 2a and 4)

- Conventional System: In a conventional system (See Figure 2a), there is typically a planar primary coil which generates a magnetic field with flux lines coming out of the plane in a perpendicular fashion. The secondary device has typically a round or square coil that encircles some or all of these flux lines.

- Proposed system: In the proposed system, the magnetic field travels substantially horizontally across the surface of the plane (see Figure 4) instead of directly out of the plane as illustrated in Figure 2a. The secondary device hence may have an elongated winding wound around a magnetic core. See Figure 7a and 7b. When the secondary device is placed on the primary unit, the flux lines would be attracted to travel through the magnetic core of the secondary device because it is the lowest reluctance path. This causes the secondary device and the primary unit to be coupled effectively. The

secondary core and winding may be substantially flattened to form a very thin component.

In describing the invention, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

It is to be understood that the term "charging area" used in this patent application may refer to the area of the at least one means for generating a field (e.g. one or more conductors in the form of a coil) or an area formed by a combination of primary conductors where the secondary device can couple flux effectively. Some embodiments of this are shown in Figures 6a to 6l and 9c as component **740**. A feature of a "charging area" is a distribution of conductors over a significant area of the primary unit configured such that it is possible for the at least one means for generating a field to be driven to achieve an instantaneous net flow of flux in one direction. A primary unit may have more than one charging area. One charging area is distinct from another charging area when flux cannot be effectively coupled by the secondary device (such as those shown in Figure 7a) in any rotation at the boundary.

It is to be understood that the term "coil" used in this patent refers to all conductor configurations which feature a charging area as described above. This includes windings of wire or printed tracks or a plane as shown in Figure 8e. The conductors may be made of copper, gold, alloys or any other appropriate material.

The present application refers to the rotation of a secondary device in several places. It is to be clarified here that if a secondary device is rotated, the axis of rotation being referred to is the one perpendicular to the plane of the charging area.

This radical change in design overcomes a number of drawbacks of conventional systems. The benefits of the proposed invention include:

- No need for accurate alignment: The secondary device can be placed anywhere on a charging area of the primary unit;

- Uniform coupling: In the proposed invention, the coupling between the primary unit and secondary device is much more uniform over the charging area compared to a conventional primary and secondary coil. In a conventional large coil system (see Figure 2a), the field strength dips to a minimum at the centre of the coil, in the plane of the coil (see Figure 2b). This implies that if sufficient power is to be effectively transferred at the centre, the field strength at the minimum has to be above a certain threshold. The field strength at the maximum will then be excessively higher than the required threshold and this may cause undesirable effects.

- Universality: a number of different secondary devices, even those having different power requirements, can be placed within charging areas on the charging surface of the primary unit to receive power simultaneously;

- Increased coupling coefficiency: Optional high permeability magnetic material present in the secondary device increases the induced flux significantly by offering a low reluctance path. This can significantly increase the power transfer.

- Desirable form factor for secondary device: The geometry of the system allows thin sheets of magnetic material (such as amorphous metal ribbons) to be used. This means that secondary devices can have the form factor of a thin sheet, making it suitable to be incorporated at the back of mobile phones and other electronic devices. If magnetic material was to be used in the centre of conventional coils, it is likely to increase the bulkiness of the secondary device.

- Minimised field leakage: When one or more secondary devices are present in the charging area of the primary unit, it is possible to use magnetic material in

such a way that more than half of the magnetic circuit is low reluctance magnetic material (see figure 4d). This means that more flux flows for a given magneto-motive force (mmf). As the induced voltage is proportional to the rate of change of flux linked, this will increase the power transfer to the secondary device. The fewer and shorter the air gaps are in the magnetic circuit, the less the field will fringe, the closer the flux is kept to the surface of the primary unit and hence leakage is minimized.

- Cost effectiveness: Unlike the multiple-coil design, this solution requires a much simpler control system and fewer components.

- Free axial rotation of secondary device: If the secondary device is thin or optionally even cylindrical (see Figure 10), it may be constructed such that it continues to couple well to the flux regardless of its rotation about its longest axis. This may in particular be an advantage if the secondary device is a battery cell fitted within another device, when its axial rotation may be difficult to control.

- The magnetic core in the secondary device may be located near other parallel planes of metal within or near the device, for example a copper printed circuit board or aluminium cover. In this case, the performance of embodiments of the present invention is significantly better than that of a conventional core-wound coil because the field lines through a conventional device coil will suffer flux-exclusion if the coil is placed up against the metal plane (because the lines of flux must travel perpendicular to the plane of the coil). Since in embodiments of the present invention the lines of flux travel along the plane of the core, and therefore also of the metal plane, performance is improved. An additional benefit is that the magnetic core in a secondary device of embodiments of the present invention can act as a shield between the electromagnetic field generated by the primary unit and any items (e.g. electrical circuits, battery cells) on the other side of the magnetic core.

- Because its permeability is higher than that of air, the magnetic core of the secondary device of embodiments of the present invention acts to concentrate magnetic flux, thus capturing more flux than would otherwise flow through an equivalent cross-section of air. The size of the core's "shape factor" (the equivalent flux-capturing sphere) is determined to a first-order approximation by the longest planar dimension of the core. Therefore if the core of the secondary device of embodiments of the present invention has planar dimensions with a significantly non-square aspect ratio, for example a 4:1 rectangle instead of a 1:1 square, it will capture proportionally more of any flux travelling parallel to the direction of its longest planar dimension. Therefore if used in devices which have a constrained aspect ratio (for example a long thin device such as a headset or pen), a significant increase in performance will be experienced compared with that of a conventional coil of the same area.

The primary unit typically consists of the following components. (See Figure 5)

- Power supply: This power supply converts mains voltage into a lower voltage dc supply. This is typically a conventional transformer or a switch-mode power supply;

- Control unit: The control unit serves the function of maintaining the resonance of the circuit given that the inductance of the means for generating a field changes with the presence of secondary devices. To enable this function, the control unit may be coupled to a sensing unit which feeds back the current status of the circuit. It may also be coupled to a library of capacitors which may be switched in and out as required. If the means for generating a field requires more than one driving circuit, the control unit may also coordinate the parameters such as the phase difference or on/off times of different driving circuits such that the desired effect is achieved. It is also possible for the Q (quality factor) of the system to be designed to function

over a range of inductances such that a need for the above control system is eliminated;

- Driving circuit: The driving unit is controlled by the control unit and drives a changing current through the means for generating a field or a component of the means. More than one driving circuit may be present depending on the number of independent components in the means;

- Means for generating an electromagnetic field: The means uses current supplied from the driving circuits to generate electromagnetic fields of pre-defined shapes and intensities. The exact configuration of the means defines the shape and intensity of the field generated. The means may include magnetic material to act as flux guides and also one or more independently driven components (windings), together forming the charging area. A number of embodiment designs are possible and examples are shown in Figures 6.

- Sensing unit: The sensing unit retrieves and sends relevant data to the control unit for interpretation.

The secondary device typically consists of the following components, as shown in Figure 5.

- Magnetic unit: the magnetic unit converts the energy stored in the magnetic field generated by the primary unit back into electrical energy. This is typically implemented by means of a winding wound around a highly permeable magnetic core. The largest dimension of the core typically coincides with the central axis of the winding.

- Conversion unit: the conversion unit converts the fluctuating current received from the magnetic unit into a form that is useful to the device that it is coupled to. For example, the conversion unit may convert the fluctuating

current into an unregulated dc supply by means of a full-wave bridge rectifier and smoothing capacitor. In other cases, the conversion unit may be coupled to a heating element or a battery charger. There is also typically a capacitor present either in parallel or in series with the magnetic unit to form a resonant circuit at the operating frequency of the primary unit.

In typical operation, one or more secondary devices are placed on top of the charging surface of the primary unit. The flux flows through the at least one conductor and/or core of the secondary devices present and current is induced. Depending on the configuration of the means for generating a field in the primary unit, the rotational orientation of the secondary device may affect the amount of flux coupled.

The primary unit

The primary unit may exist in many different forms, for example:

- As a flat platform or pad which can sit on top of tables and other flat surfaces;
- Built in to furniture such as desks, tables, counters, chairs, bookcases etc. such that the primary unit may not be visible;
- As part of an enclosure such as a drawer, a box, a glove compartment of a car, a container for power tools;
- As a flat platform or pad which can be attached to a wall and used vertically.

The primary unit may be powered from different sources, for example:

- A mains AC power outlet
- A vehicle lighter socket
- Batteries
- Fuel Cells
- Solar Panel
- Human power

The primary unit may be small enough such that only one secondary device may be accommodated on the charging surface in a single charging area, or may be large

enough to accommodate many secondary devices simultaneously, sometimes in different charging areas.

The means for generating a field in the primary unit may be driven at mains frequency (50Hz or 60Hz) or at some higher frequency.

The sensing unit of the primary unit may sense the presence of secondary devices, the number of secondary devices present and even the presence of other magnetic material which is not part of a secondary device. This information may be used to control the current being delivered to the field generating means of the primary unit.

The primary unit and/or the secondary device may be substantially waterproof or explosion proof.

The primary unit and/or the secondary device may be hermetically sealed to standards such as IP66.

The primary unit may incorporate visual indicators (for example, but not limited to, light emitting devices, such as light emitting diodes, electrophosphorescent displays, light emitting polymers, or light reflecting devices, such as liquid crystal displays or MITs electronic paper) to indicate the current state of the primary unit, the presence of secondary devices or the number of secondary devices present or any combination of the above.

The means for generating an electromagnetic field

The field generating means as referred to in this application includes all configurations of conductors where:

- The conductors are substantially distributed in the plane and;
- Substantial areas of the plane exist where there is a non-zero net instantaneous current flow. These are areas on which, given the correct orientation, the secondary devices will couple effectively and receive power. (See Figure 6)

- The conductors are capable of generating an electromagnetic field where the field lines subtend an angle of 45° or less or are substantially parallel to a substantial area of the plane.

Figures 6 illustrate some possibilities for such a primary conductor. Although most of the configurations are in fact coil windings, it is to be appreciated that the same effect can also be achieved with conductor planes which are not typically considered to be coils (See Figure 6e). These drawings are typical examples and are non-exhaustive. These conductors or coils may be used in combination such that the secondary device can couple effectively in all rotations whilst on the charging area(s) of the primary unit.

Magnetic Material

It is possible to use magnetic materials in the primary unit to enhance performance.

- Magnetic material may be placed below one or more charging areas or the entire charging surface such that there is also a low reluctance path on the underside of the conductors for the flux to complete its path. According to theory, an analogy can be drawn between magnetic circuits and electrical circuits. Voltage is analogous to magneto-motive force (mmf), resistance is analogous to reluctance and current is analogous to flux. From this, it can be seen that for a given mmf, flux flow will increase if the reluctance of the path is decreased. By providing magnetic material to the underside of the charging area, the reluctance of the magnetic circuit is essentially decreased. This substantially increases the flux linked by the secondary device and ultimately increases the power transferred. Figure 4d illustrates a sheet of magnetic material placed underneath the charging area and the resulting magnetic circuit.

- Magnetic material may also be placed above the charging surface and/or charging area(s) and below the secondary devices to act as a flux guide. This flux guide performs two functions: Firstly, the reluctance of the whole magnetic circuit is further decreased allowing more flux to flow. Secondly, it

provides a low reluctance path along the top surface of the charging area(s) so the flux lines will flow through these flux guides in favour of flowing through the air. Hence this has the effect of containing the field close to the charging surface of the primary unit instead of in the air. The magnetic material used for flux guides may be strategically or deliberately chosen to have different magnetic properties to the magnetic core (where provided) of the secondary device. For example, a material with lower permeability and higher saturation may be chosen. High saturation means that the material can carry more flux and the lower permeability means that when a secondary device is in proximity, a significant amount of flux would then choose to travel through the secondary device in favour of the flux guide. (See Figures 8)

- In some configurations of the primary unit field generating means, there may be conductors present that do not form part of the charging area, such as the component marked **745** in Figure 6a and 6b. In such cases, one may wish to use magnetic material to shield the effects of these conductors.

- Examples of some materials which may be used include but are not limited to: amorphous metal (metallic glass alloys such as MetGlas™), mesh of wires made of magnetic material, steel, ferrite cores, mumetal and permalloy.

The Secondary device

The secondary device may take a variety of shapes and forms. Generally, in order for good flux linkage, a central axis of the conductor (for example, a coil winding) should be substantially non-perpendicular to the charging area(s).

- The secondary device may be in the shape of a flattened winding. (See Figure 7a) The magnetic core inside can consist of sheets of magnetic material such as amorphous metals. This geometry allows the secondary device to be incorporated at the back of electronic devices such as mobile phones, personal digital assistants and laptops without adding bulk to the device.

- The secondary device may be in the shape of a long cylinder. A long cylindrical core could be wound with conductors (See Figure 7b).
- The secondary device may be an object with magnetic material wrapped around it. An example is a standard-sized (AA, AAA, C, D) or other sized/shaped (e.g. dedicated/customised for particular applications) rechargeable battery cell with for example magnetic material wrapped around the cylinder and windings around the cylindrical body.
- The secondary device may be a combination of two or more of the above. The above embodiments may even be combined with a conventional coil.

The following non-exhaustive list illustrates some examples of objects that can be coupled to a secondary device to receive power. Possibilities are not limited to those described below:

- A mobile communication device, for example a radio, mobile telephone or walkie-talkie;
- A portable computing device, for example a personal digital assistant or palmtop or laptop computer;
- Portable entertainment devices, for example a music player, games console or toy;
- Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
- A portable imaging device, for example a video camcorder or a camera;
- Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
- Consumer devices, for example torches, clocks and fans;
- Power tools, for example cordless drills and screwdrivers;
- Wireless peripheral devices, for example wireless computer mouse, keyboard and headset;
- Time keeping devices, for example clock, wrist watch, stop watch and alarm clock;
- A battery-pack for insertion into any of the above;
- A standard-sized battery cell.

In the case of unintelligent secondary devices such as a battery cell, some sophisticated charge-control means may also be necessary to meter inductive power to the cell and to deal with situations where multiple cells in a device have different charge states. Furthermore, it becomes more important for the primary unit to be able to indicate a "charged" condition, since the secondary cell or battery may not be easily visible when located inside another electrical device.

A possible system comprising an inductively rechargeable battery or cell and a primary unit is shown in Figure 10. In addition to the freedom to place the battery 920 freely in (X,Y) and optionally rotate it in rZ, relative to the primary unit 910, the battery can also be rotated along its axis rA while continuing to receive power.

When a user inserts a battery into a portable device, it is not easy to ensure that it has any given axial rotation. Therefore, embodiments of the present invention are highly advantageous because they can ensure that the battery can receive power while in any random orientation about rA.

The battery or cell may include a flux concentrating means that may be arranged in a variety of ways:

1. As shown in Figure 11a, a cell 930 may be wrapped in a cylinder of flux-concentrating material 931, around which is wrapped a coil of wire 932.
    a. The cylinder may be long or short relative to the length of the cell.
2. As shown in Figure 11b, a cell 930 may have a portion of flux-concentrating material 931 on its surface, around which is wrapped a coil of wire 932.
    a. The portion may be conformed to the surface of the cell, or embedded within it.
    b. Its area may be large or small relative to the circumference of the cell, and long or short relative to the length of the cell.
3. As shown in Figure 11c, a cell 930 may contain a portion of flux-concentrating material 931 within it, around which is wrapped a coil of wire 932.

a. The portion may be substantially flat, cylindrical, rod-like, or any other shape.
b. Its width may be large or small relative to the diameter of the cell
c. Its length may be large or small relative to the length of the cell

In any of these cases, the flux-concentrator may be a functional part of the battery enclosure (for example, an outer zinc electrode) or the battery itself (for example, an inner electrode).

Issues relating to charging of secondary cells (e.g. AA rechargeable cells in-situ within an appliance include:

- Terminal voltage could be higher than normal.
- Cells in series may behave strangely, particularly in situations where some cells are charged, others not.
- Having to provide enough power to run the device and charge the cell.
- If fast-charging is effected incorrectly, the cells may be damaged.

Accordingly, some sophisticated charge-control means to meter inductive power to the appliance and the cell is advantageously provided. Furthermore, it becomes more important for the primary unit to be able to indicate a "charged" condition, since the secondary cell or battery may not be easily visible when located inside an electrical device.

A cell or battery enabled in this fashion may be charged whilst fitted in another device, by placing the device onto the primary unit, or whilst outside the device by placing the cell or battery directly onto the primary unit.

Batteries enabled in this fashion may be arranged in packs of cells as in typical devices (e.g. end-to-end or side-by-side), allowing a single pack to replace a set of cells.

Alternatively, the secondary device may consist of a flat "adapter" which fits over the batteries in a device, with thin electrodes which force down between the battery electrodes and the device contacts.

Rotating electromagnetic field

In the coils such as those in Figure 6, 9a and 9b, the secondary devices will generally only couple effectively when the windings are placed substantially parallel to the direction of net current flow in the primary conductor as shown by the arrow **1**. In some applications, one might require a primary unit which will transfer power effectively to secondary devices regardless of their rotation as long as:

- the central axis of the secondary conductor is not perpendicular to the plane and;
- the secondary device is in close proximity to the primary unit

To enable this, it is possible to have two coils, for example one positioned on top of the other or one woven into or otherwise associated with the other, the second coil capable of generating a net current flow substantially perpendicular to the direction of the first coil at any point in the active area of the primary unit. These two coils may be driven alternately such that each is activated for a certain period of time. Another possibility is to drive the two coils in quadrature such that a rotating magnetic dipole is generated in the plane. This is illustrated in Figure 9. This is also possible with other combinations of coil configurations.

Resonant circuits

It is known in the art to drive coils using parallel or series resonant circuits. In series resonant circuits for example, the impedance of the coil and the capacitor are equal and opposite at resonance, hence the total impedance of the circuit is minimised and a maximum current flows through the primary coil. The secondary device is typically also tuned to the operating frequency to maximise the induced voltage or current.

In some systems like the electric toothbrush, it is common to have a circuit which is detuned when the secondary device is not present and tuned when the secondary device is in place. The magnetic material present in the secondary device shifts the self-inductance of the primary unit and brings the circuit into resonance. In other systems like passive radio tags, there is no magnetic material in the secondary device and hence does not affect the resonant frequency of the system. These tags are also typically small and used far from the primary unit such that even if magnetic material is present, the inductance of the primary is not significantly changed.

In the proposed system, this is not the case:

- High permeability magnetic material may be present in the secondary device and is used in close proximity to the primary unit;
- One or more secondary devices may be brought in close proximity to the primary unit simultaneously.

This has the effect of shifting the inductance of the primary significantly and also to different levels depending on the number of secondary devices present on the pad. When the inductance of the primary unit is shifted, the capacitance required for the circuit to resonant at a particular frequency also changes. There are three methods for keeping the circuit at resonance:

- By means of a control system to dynamically change the operating frequency;
- By means of a control system to dynamically change the capacitance such that resonance is achieved at the predefined frequency;
- By means of a low Q system where the system remains in resonance over a range of inductances.

The problem with changing the operating frequency is that the secondary devices are typically configured to resonate at a predefined frequency. If the operating frequency changes, the secondary device would be detuned. To overcome this problem, it is possible to change the capacitance instead of the operating frequency. The secondary devices can be designed such that each additional device placed in proximity to the primary unit will shift the inductance to a quantised level such that

an appropriate capacitor can be switched in to make the circuit resonate at a predetermined frequency. Because of this shift in resonant frequency, the number of devices on the charging surface can be detected and the primary unit can also sense when something is brought near or taken away from the charging surface. If a magnetically permeable object other than a valid secondary device is placed in the vicinity of the charging surface, it is unlikely to shift the system to the predefined quantised level. In such circumstances, the system could automatically detune and reduce the current flowing into the coil.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made, by way of example only, to the accompanying drawings, in which:

FIGURE 1 shows the magnetic design of typical prior art contact-less power transfer systems which require accurate alignment of the primary unit and secondary device;

FIGURE 2a shows the magnetic design of another typical prior art contact-less power transfer system which involves a large coil in the primary unit;

FIGURE 2b shows the non-uniform field distribution inside the large coil at 5mm distance from the plane of the coil, exhibiting a minimum in the centre;

FIGURE 3 shows a multiple-coil system where each coil is independently driven such that a localised field can be generated.

FIGURE 4a shows an embodiment of the proposed system which demonstrates a substantial departure from prior art with no secondary devices present;

FIGURE 4b shows an embodiment of the proposed system with two secondary devices present;

FIGURE 4c shows a cross section of the active area of the primary unit and the

contour lines of the magnetic flux density generated by the conductors.

FIGURE 4d shows the magnetic circuit for this particular embodiment of the proposed invention;

FIGURE 5 shows a schematic drawing of an embodiment of the primary unit and the secondary device;

FIGURE 6a to 6l show some alternative embodiment designs for the field generating means or a component of the field generating means of the primary unit;

FIGURES 7a and 7b show some possible designs for the magnetic unit of the secondary device;

FIGURES 8 shows the effect of flux guides (the thickness of the flux guide has been exaggerated for clarity);

FIGURE 8a shows that without flux guides, the field tends to fringe into the air directly above the active area;

FIGURE 8b shows the direction of current flow in the conductors in this particular embodiment;

FIGURE 8c shows that the flux is contained within the flux guides when magnetic material is placed on top of the charging area;

FIGURE 8d shows a secondary device on top of the primary unit;

FIGURE 8e shows a cross section of the primary unit without any secondary devices;

FIGURE 8f shows a cross section of the primary unit with a secondary device on top and demonstrates the effect of using a secondary core with higher permeability than

the flux guide.

FIGURE 9a shows a particular coil arrangement with a net instantaneous current flow shown by the direction of the arrow;

FIGURE 9b shows a similar coil arrangement to FIGURE 9a except rotated by 90 degrees;

FIGURE 9c shows the charging area of the primary unit if the coil of FIGURE 9a is placed on top of FIGURE 9b. If the coil in FIGURE 9a is driven in quadrature to FIGURE 9b, the effect is a rotating magnetic dipole shown here;

FIGURE 10 shows the case where the secondary device has an axial degree of rotation;

FIGURE 11 shows various arrangements of secondary devices with axial degrees of rotation;

FIGURE 12a and FIGURE 12b show another embodiment of the type of coil arrangement shown in FIGURE 9a and FIGURE 9b; and

FIGURE 13 shows a simple embodiment of driving unit electronics.

Referring firstly to Figure 1, there is shown two examples of prior art contact-less power transfer systems which both require accurate alignment of a primary unit and a secondary device. This embodiment is typically used in electric toothbrush or mobile phone chargers.

Figure 1a shows a primary magnetic unit **100** and a secondary magnetic unit **200**. On the primary side, a coil **110** is wound around a magnetic core **120** such as ferrite. Similarly, the secondary side consists of a coil **210** wound around another magnetic core **220.** In operation, an alternating current flows in to the primary coil **110** and

generates lines of flux **1**. When a secondary magnetic unit **200** is placed such that it is axially aligned with the primary magnetic unit **100**, the flux **1** will couple from the primary into the secondary, inducing a voltage across the secondary coil **210.**

Figure 1b shows a split transformer. The primary magnetic unit **300** consists of a U-shaped core **320** with a coil **310** wound around it. When alternating current flows into the primary coil **310**, changing lines of flux are generated **1**. The secondary magnetic unit **400** consists of a second U-shaped core **420** with another coil **410** wound around it. When the secondary magnetic unit **400** is placed on the primary magnetic unit **300** such that the arms of the two U-shaped cores are in alignment, the flux will couple effectively into the core of the secondary **420** and induce voltage across the secondary coil **410.**

Figure 2a is another embodiment of prior art inductive systems typically used in powering radio frequency passive tags. The primary typically consists of a coil **510** covering a large area. Multiple secondary devices **520** will have voltage induced therein when they are within the area encircled by the primary coil **510.** This system does not require the secondary coil **520** to be accurately aligned with the primary coil **510**. Figure 2b shows a graph of the magnitude of magnetic flux intensity across the area encircled by the primary coil **510** at 5mm above the plane of the primary coil. It shows a non-uniform field, which exhibits a minimum **530** at the centre of the primary coil **510**.

Figure 3 is another embodiment of a prior art inductive system wherein a multiple coil array is used. The primary magnetic unit **600** consists of an array of coils including coils **611, 612, 613.** The secondary magnetic unit **700** may consist of a coil **710.** When the secondary magnetic unit **700** is in proximity to some coils in the primary magnetic unit **600**, the coils **611, 612** are activated while other coils such as **613** remain inactive. The activated coils **611, 612** generate flux, some of which will couple into the secondary magnetic unit **700.**

Figure 4 shows an embodiment of the proposed invention. Figure 4a shows a

primary coil **710** wound or printed in such a fashion that there is a net instantaneous current flow within the active area **740.** For example, if a dc current flows through the primary coil **710,** the conductors in the active area **740** would all have current flowing in the same direction. Current flowing through the primary coil **710** generates flux **1**. A layer of magnetic material **730** is present beneath the charging area to provide a return path for the flux. Figure 4b shows the same primary magnetic unit as shown in Figure 4a with two secondary devices **800** present. When the secondary devices **800** are placed in the correct orientation on top of the charging area **740** of the primary magnetic unit, the flux **1** will flow through the magnetic core of the secondary devices **800** instead of flowing through the air. The flux **1** flowing through the secondary core would hence induce current in the secondary coil.

Figure 4c shows some contour lines for the flux density of the magnetic field generated by the conductors **711** in the charging area **740** of the primary magnetic unit. There is a layer of magnetic material **730** beneath the conductors to provide a low reluctance return path for the flux.

Figure 4d shows a cross-section of the charging area **740** of the primary magnetic unit. A possible path for the magnetic circuit is shown. The magnetic material **730** provides a low reluctance path for the circuit and also the magnetic core **820** of the secondary magnetic device **800** also provides a low reluctance path. This minimizes the distance the flux has to travel through the air and hence minimizes leakage.

Figure 5 shows a schematic drawing of an embodiment of the whole system of the proposed invention. In this embodiment, the primary unit consists of a power supply **760,** a control unit **770,** a sensing unit **780** and an electromagnetic unit **700.** The power supply **760** converts the mains (or other sources of power) into a dc supply at an appropriate voltage for the system. The control unit **770** controls the driving unit **790** which drives the magnetic unit **700.** In this embodiment, the magnetic unit consists of two independently driven components, coil 1 and coil 2, arranged such that the conductors in the charging area of coil 1 would be perpendicular to the conductors in the charging area of coil 2. When the primary unit is activated, the

control unit causes a 90-degree phase shift between the alternating current that flows through coil 1 and coil 2. This creates a rotating magnetic dipole on the surface of the primary magnetic unit **700** such that a secondary device is able to receive power regardless of its rotational orientation (See Figure 9). In standby mode where no secondary devices are present, the primary unit is detuned and current flow into the magnetic unit **700** is minimised. When a secondary device is placed on top of the charging area of the primary unit, the inductance of the primary magnetic unit **700** is changed. This brings the primary circuit into resonance and the current flow is maximised. When there are two secondary devices present on the primary unit, the inductance is changed to yet another level and the primary circuit is again detuned. At this point, the control unit **770** uses feedback from the sensing unit **780** to switch another capacitor into the circuit such that it is tuned again and current flow is maximised. In this embodiment, the secondary devices are of a standard size and a maximum of six standard-sized devices can receive power from the primary unit simultaneously. Due to the standard sizes of the secondary devices, the change in inductance due to the change in secondary devices in proximity is quantized to a number of predefined levels such that only a maximum of 6 capacitances is required to keep the system operating at resonance.

Figures 6a to 6l show a number of different embodiments for the coil component of the primary magnetic unit. These embodiments may be implemented as the only coil component of the primary magnetic unit, in which case the rotation of the secondary device is important to the power transfer. These embodiments may also be implemented in combination, not excluding embodiments which are not illustrated here. For example, two coils illustrated in Figure 6a may be placed at 90 degrees to each other to form a single magnetic unit. In Figures 6a to 6e, the charging area **740** consists of a series of conductors with net current generally flowing in the same direction. In certain configurations, such as Figure 6c, there is no substantial linkage when the secondary device is placed directly over the centre of the coil and hence power is not transferred. In Figure 6d, there is no substantial linkage when the secondary device is positioned in the gap between the two charging areas **740**.

Figure 6f shows a specific coil configuration for the primary unit adapted to generate electromagnetic field lines substantially parallel to a surface of the primary unit within the charging area **740**. Two primary windings **710**, one on either side of the charging area **740**, are formed about opposing arms of a generally rectangular flux guide **750** made out of a magnetic material, the primary windings **710** generating opposing electromagnetic fields. The flux guide **750** contains the electromagnetic fields and creates a magnetic dipole across the charging area **740** in the direction of the arrows indicated on the Figure. When a secondary device is placed in the charging area **740** in a predetermined orientation, a low reluctance path is created and flux flows through the secondary device, causing effective coupling and power transfer. It is to be appreciated that the flux guide **750** need not be continuous, and may in fact be formed as two opposed and non-linked horseshoe components.

Figure 6g shows another possible coil configuration for the primary unit, the coil configuration being adapted to generate electromagnetic field lines substantially parallel to the charging surface of the primary unit within the charging area **740**. A primary winding **710** is wound around a magnetic core **750** which may be ferrite or some other suitable material. The charging area **740** includes a series of conductors with instantaneous net current generally flowing in the same direction. The coil configuration of Figure 6g is in fact capable of supporting or defining a charging area **740** on both upper and lower faces as shown in the drawing, and depending on the design of the primary unit, one or both of the charging areas may be made available to secondary devices.

Figure 6h shows a variation of the configuration of Figure 6g. Instead of the primary windings **710** being evenly spaced as in Figure 6g, the windings **710** are not evenly spaced. The spacing and variations therein can be selected or designed so as to provide improved uniformity of performance or field strength levels over the charging area **740**.

Figure 6i shows an embodiment in which two primary windings **710** as shown in Figure 6g are located in a mutually orthogonal configuration so as to enable a

direction of the field lines to be dynamically switched or rotated to other orientations about the plane of the charging surface.

Figures 6j and 6k show additional two-coil configurations for the primary unit which are not simple geometric shapes with substantially parallel conductors.

In Figure 6j, line **710** indicates one of a set of current-carrying conductors lying in the plane of the charging surface **600**. The shape of the main conductor **710** is arbitrary and need not be a regular geometric figure – indeed, conductor **710** may have straight and curved sections and may intersect with itself. One or more subsidiary conductors **719** are arranged alongside and generally parallel (at any given local point) to the main conductor **710** (only two subsidiary conductors **719** are shown here for clarity). Current flow in subsidiary conductors **719** will be in the same direction as in the main conductor **710**. The subsidiary conductors **719** may be connected in series or parallel so as to form a single coil arrangement.

In Figure 6k, a set of current-carrying conductors **720** (only some of which are shown for clarity) is arranged in the plane of the charging surface **600**. A main conductor **710** is provided as in Figure 6j, and the conductors **720** are each arranged so as to be locally orthogonal to the main conductor **710**. The conductors **720** may be connected in series or parallel so as to form a single coil arrangement. If a first sinusoidal current is fed into the conductor **710**, and a second sinusoidal current having a 90° phase shift relative to the first current is fed into the coil **720**, then by varying the relative proportions and signs of the two currents a direction of a resultant electromagnetic field vector at most points on the charging area **740** will be seen to rotate through 360°.

Figure 6l shows yet another alternative arrangement in which the magnetic core **750** is in the shape of a round disc with a hole in the centre. The first set of current carrying conductors **710** is arranged in a spiral shape on the surface of the round disc. The second set of conductors **720** is wound in a toroidal format through the centre of the disc and out to the perimeter in a radial fashion. These conductors can be driven

in such a way, for example with sinusoidal currents at quadrature, that when a secondary device is placed at any point inside the charging area **740** and rotated about an axis perpendicular to the charging area, no nulls are observed by the secondary device.

Figure 7a and 7b are embodiments of the proposed secondary devices. A winding **810** is wound around a magnetic core **820**. Two of these may be combined in a single secondary device, at right angles for example, such that the secondary device is able to effectively couple with the primary unit at all rotations. These may also be combined with standard coils, as the ones shown in Figure 2a **520** to eliminate dead spots.

Figure 8 shows the effect of flux guides **750** positioned on top of the charging area. The thickness of the material has been exaggerated for the sake of clarity but in reality would be in the order of millimetres thick. The flux guides **750** will minimize leakage and contain the flux at the expense of reducing the amount of flux coupled to the secondary device. In Figure 8a, a primary magnetic unit is shown without flux guides **750**. The field will tend to fringe into the air directly above the charging area. With flux guides **750,** as shown in Figure 8b to 8f, the flux is contained within the plane of the material and leakage is minimised. In Figure 8e, when there is no secondary device **800** on top, the flux remains in the flux guide **750**. In Figure 8f, when a secondary device **800** is present with a relatively more permeable material as the core, part of the flux will flow via the secondary device. The permeability of the flux guide **750** can be chosen such that it is higher than that of typical metals such as steel. When other materials such as steel, which are not part of secondary devices **800,** are placed on top, most of the flux will remain in the flux guide **750** instead of travelling through the object. The flux guide **750** may not be a continuous layer of magnetic material but may have small air gaps in them to encourage more flux flow into the secondary device **800** when it is present.

Figure 9 shows an embodiment of a primary unit whereby more than one coil is used. Figure 9a shows a coil **710** with a charging area **740** with current flow parallel to the

direction of the arrow **2**. Figure 9b shows a similar coil arranged at 90 degrees to the one in Figure 9a. When these two coils are placed on top of each other such that the charging area **740** overlaps, the charging area will look like the illustration in Figure 9c. Such an embodiment would allow the secondary device to be at any rotation on top of the primary unit and couple effectively.

Figure 10 shows an embodiment where the secondary device has an axial degree of rotation, for example where it is, or is embedded within, a battery cell. In this embodiment the secondary device may be constructed such that it couples to the primary flux when in any axial rotation (rA) relative to the primary unit (**910**), as well as having the same degrees of freedom described above (i.e. translational (X,Y) and optionally rotational perpendicular to the plane of the primary (rZ)).

Figure 11a shows one arrangement where a rechargeable battery cell **930** is wrapped with an optional cylinder of flux-concentrating material **931** which is itself wound with copper wire **932**. The cylinder may be long or short relative to the length of the cell.

Figure 11b shows another arrangement where the flux-concentrating material **931** covers only part of the surface of the cell **930**, and has copper wire **932** wrapped around it (but not the cell). The material and wire may be conformed to the surface of the cell. Their area may be large or small relative to the circumference of the cell, and long or short relative to the length of the cell.

Figure 11c shows another arrangement where the flux-concentrating material **931** is embedded within the cell **930** and has copper wire **932** wrapped around it. The material may be substantially flat, cylindrical, rod-like, or any other shape, its width may be large or small relative to the diameter of the cell, and its length may be large or small relative to the length of the cell.

In any case shown in Figures 10 and 11, any flux-concentrating material may also be a functional part of the battery enclosure (for example, an outer zinc electrode) or the battery itself (for example, an inner electrode).

In any case shown in Figures 10 and 11, the power may be stored in a smaller standard cell (e.g. AAA size) fitted within the larger standard cell enclosure (e.g. AA).

Figure 12 shows an embodiment of a primary unit similar to that shown in Figure 9. Figure 12a shows a coil generating a field in a direction horizontal to the page, Figure 12b shows another coil generating a field vertical to the page, and the two coils would be mounted in a substantially coplanar fashion, possibly with one above the other, or even intertwined in some fashion. The wire connections to each coil are shown **940** and the charging area is represented by the arrows **941**.

Figure 13 shows a simple embodiment of the Driving Unit (790 of Figure 5). In this embodiment there is no Control Unit. The PIC processor **960** generates two 23.8kHz square waves 90 degrees out of phase with one another. These are amplified by components **961** and driven into two coil components **962**, which are the same magnetic units shown in Figure 12a and Figure 12b. Although the driving unit is providing square waves, the high resonant "Q" of the magnetic units shapes this into a sinusoidal waveform.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A system for transferring power without requiring direct electrical conductive contacts, the system comprising:

i) a primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area; and

ii) at least one secondary device including at least one electrical conductor;

wherein, when the at least one secondary device is placed on or in proximity to a charging area of the primary unit, the electromagnetic field lines couple with the at least one conductor of the at least one secondary device and induce a current to flow therein.

2. A system as claimed in claim 1, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

3. A system as claimed in claim 1, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

4. A system as claimed in any preceding claim, wherein the means includes a plurality of conductors configured so as to cause a directional component of the electromagnetic field lines, resolved onto the charging area, to be changed over time.

5. A system as claimed in claim 4, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be switched between at least two different directions.

6. A system as claimed in claim 4, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be moved through an angle.

7. A system as claimed in claim 6, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be rotated.

8. A system as claimed in any preceding claim, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

9. A system as claimed in any preceding claim, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

10. A system as claimed in any preceding claim, wherein the means does not project beyond the charging surface.

11. A system as claimed in any preceding claim, wherein the at least one charging area is provided with a substrate of a magnetic material.

12. A system as claimed in any preceding claim, wherein the primary unit includes at least one selectively operable capacitor configured such that a capacitance of a circuit including the at least one means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

13. A system as claimed in any preceding claim, wherein the at least one charging area is provided with a flux guide having a relative permeability less than that of the core of the at least one secondary device.

14. A system as claimed in any preceding claim, wherein the primary unit includes a power supply.

15. A system as claimed in any preceding claim, wherein the at least one conductor in the secondary device is wound about a core that serves to concentrate flux therein.

16. A system as claimed in claim 15, wherein the core is a magnetically permeable material.

17. A system as claimed in claim 16, wherein the core is an amorphous magnetic material.

18. A system as claimed in claim 17, wherein the core is a substantially non-annealed amorphous magnetic material.

19. A system as claimed in any one of claims 15 to 18, wherein the core is formed as a flexible ribbon.

20. A system as claimed in any preceding claim, wherein the secondary device comprises an inductively rechargeable battery or cell.

21. A system as claimed in claim 20, wherein the inductively rechargeable battery or cell includes at least one conductor wound about a flux concentrating means.

22. A system as claimed in any preceding claim, wherein at least one of the at least one means is configured to generate an electromagnetic field over more than one charging area.

23. A system as claimed in any one of claims 1 to 21, wherein a plurality of means is configured to generate an electromagnetic field over a single charging area.

24. A system as claimed in any preceding claim, wherein the means has a height that is no more than half of the length or half of the width of the charging area.

25. A system as claimed in any preceding claim, wherein the means has a height that is no more than 1/5 of the length or 1/5 of the width of the charging area.

26. A primary unit for transferring power without requiring direct electrical conductive contacts, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in

two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area.

27. A primary unit as claimed in claim 26, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

28. A primary unit as claimed in claim 26, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

29. A primary unit as claimed in any one of claims 26 to 28, wherein the means includes a plurality of conductors configured so as to cause a directional component of the electromagnetic field lines, resolved onto the charging area, to be changed over time.

30. A primary unit as claimed in claim 29, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be switched between at least two different directions.

31. A primary unit as claimed in claim 29, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be moved through an angle.

32. A primary unit as claimed in claim 31, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be rotated.

33. A primary unit as claimed in any one of claims 26 to 32, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

34. A primary unit as claimed in any one of claims 26 to 33, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

35. A primary unit as claimed in any one of claims 26 to 34, wherein the means does not project beyond the charging surface.

36. A primary unit as claimed in any one of claims 26 to 35, wherein the at least one area is provided with a substrate of a magnetic material.

37. A primary unit as claimed in any one of claims 26 to 36, including at least one selectively operable capacitor configured such that a capacitance of a circuit including the at least one means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

38. A primary unit as claimed in any one of claims 26 to 37, wherein the primary unit includes a power supply.

39. A primary unit as claimed in any one of claims 26 to 38, wherein the at least one area is provided with a flux guide having a relative permeability less than that of any core that may be provided in the at least one secondary device.

40. A primary unit as claimed in any one of claims 26 to 39, wherein at least one of the at least one means is configured to generate an electromagnetic field over more than one charging area.

41. A primary unit as claimed in any one of claims 26 to 39, wherein a plurality of means is configured to generate an electromagnetic field over a single charging area.

42. A primary unit as claimed in any one of claims 26 to 41, wherein the means has a height that is no more than half of the length or half of the width of the charging area.

43. A primary unit as claimed in any one of claims 26 to 42, wherein the means has a height that is no more than 1/5 of the length or 1/5 of the width of the charging area.

44. A method of transferring power in a non-conductive manner from a primary unit to a secondary device, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, the means having a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area, and the secondary device having at least one electrical conductor; wherein:

i) an electromagnetic field, generated by the means when energised with a predetermined current and measured when the primary unit is effectively in electromagnetic isolation, has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions over the at least one charging area when averaged thereover; and

ii) the electromagnetic field links with the conductor of the secondary device when this is placed on or in proximity to the charging area.

45. A method according to claim 44, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

46. A method according to claim 44, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

47. A method according to any one of claims 44 to 46, wherein a directional component of the electromagnetic field lines, resolved onto the charging area, is changed over time.

48. A method according to claim 47, wherein the resolved directional component of the field lines is switched between at least two different directions.

49. A method according to claim 47, wherein the resolved directional component of the field lines is moved through an angle.

50. A method according to claim 49, wherein the resolved directional component of the field lines is rotated.

51. A method according to any one of claims 44 to 50, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

52. A method according to any one of claims 44 to 51, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

53. A method according to any one of claims 44 to 52, wherein the at least one charging area is provided with a substrate of a magnetic material and wherein the magnetic material completes a magnetic circuit.

54. A method according to any one of claims 44 to 53, wherein the primary unit includes at least one selectively operable capacitor that is switched in or out such that a capacitance of a circuit including the at least one primary unit means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

55. A method according to any one of claims 44 to 54, wherein the charging surface, at least within the at least one charging area, is provided with a flux guide having a relative permeability less than that of any core that may be provided in the at least one secondary device.

56. A secondary device for use with the system, primary unit or method of any one of the preceding claims, the secondary device including at least one electrical conductor and having a substantially laminar form factor.

57. A secondary device as claimed in claim 56, wherein the at least one electrical conductor is wound about a core that serves to concentrate flux therein.

58. A secondary device as claimed in claim 57, wherein the core is a magnetically permeable material.

59. A secondary device as claimed in claim 58, wherein the core is an amorphous magnetic material.

60. A secondary device as claimed in claim 59, wherein the core is a substantially non-annealed amorphous magnetic material.

61. A secondary device as claimed in any one of claims 57 to 60, wherein the core is formed as a flexible ribbon.

62. A secondary device as claimed in any one of claims 56 to 61, wherein the secondary device comprises an inductively rechargeable battery or cell.

63. A secondary device as claimed in claim 57 or any claim depending therefrom, having a core thickness of 2mm or less.

64. A secondary device as claimed in claim 63, having a core thickness of 1mm or less.

65. A secondary device as claimed in any one of claims 56 to 64, wherein the secondary device has a primary axis and couples with the electromagnetic field when located on or in proximity to the charging area in any rotation about its axis.

66. A secondary device as claimed in claim 65 depending from claim 62, wherein the core is at least partially wrapped around a central part of the battery or cell.

67. A system as claimed in any one of claims 1 to 25, wherein the primary unit includes a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending generally parallel to the plane of the windings but substantially at right angles to the parallel sections.

68. A system as claimed in claim 67, wherein the windings are formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

69. A system as claimed in claim 67 or 68, wherein the primary unit includes first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged

generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

70. A primary unit as claimed in any one of claims 26 to 43, including a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending generally parallel to the plane of the windings but substantially at right angles to the parallel sections.

71. A primary unit as claimed in claim 70, wherein the windings are formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

72. A primary unit as claimed in claim 70 or 71, including first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

73. A system for transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

74. A primary unit for transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

75. A method of transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

76. A secondary device for receiving power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

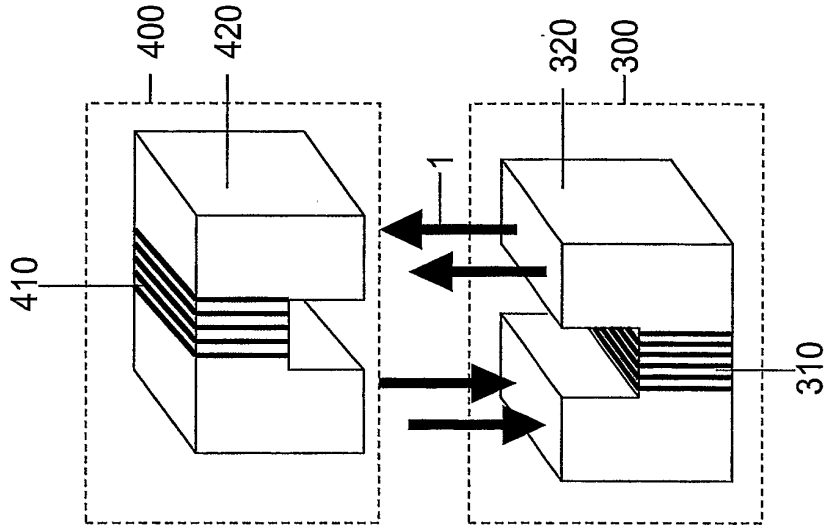


Figure 1b
(Prior Art)

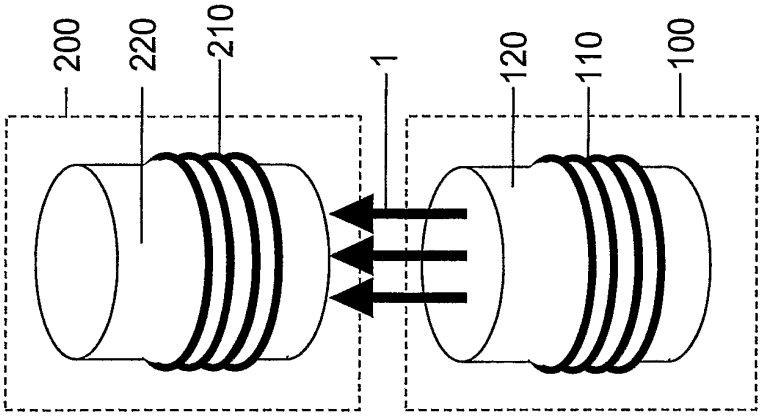


Figure 1a
(Prior Art)

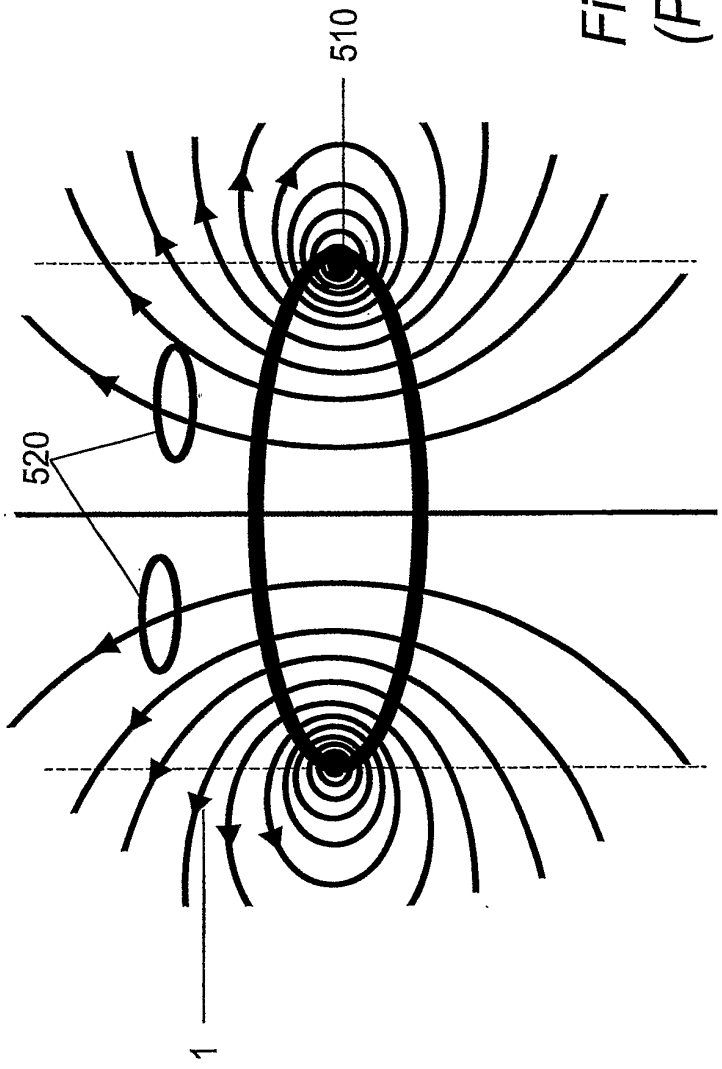


Figure 2a
(Prior Art)

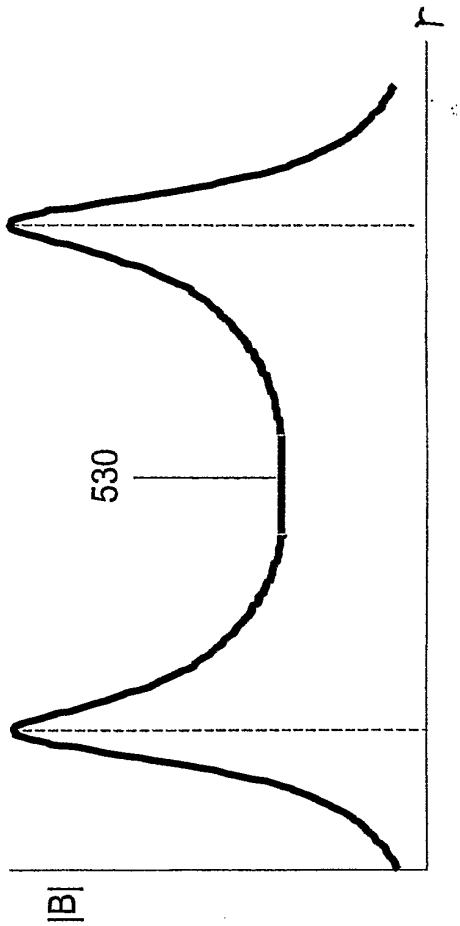


Figure 2b
X =5mm

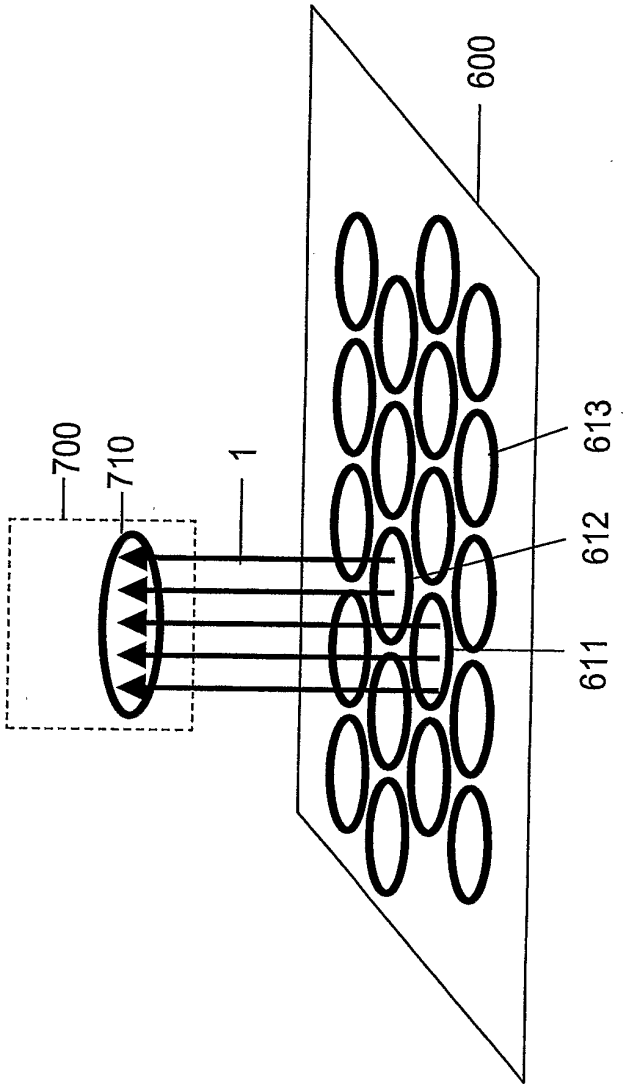


Figure 3

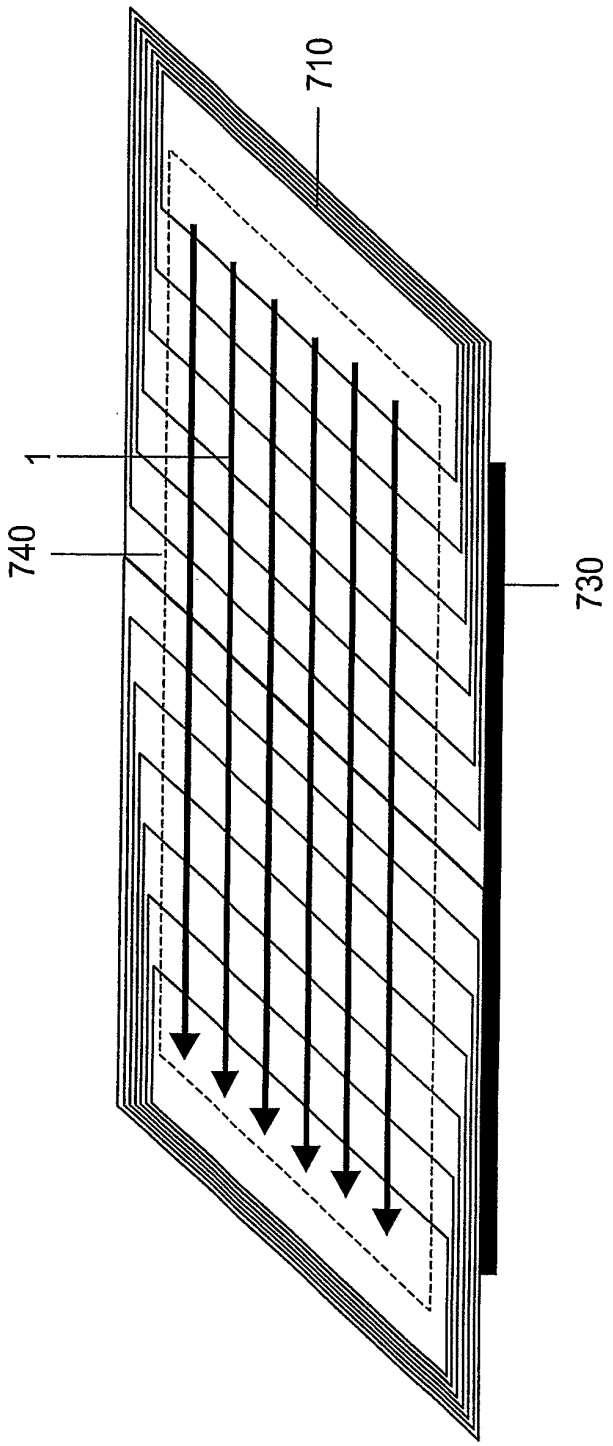


Figure 4a

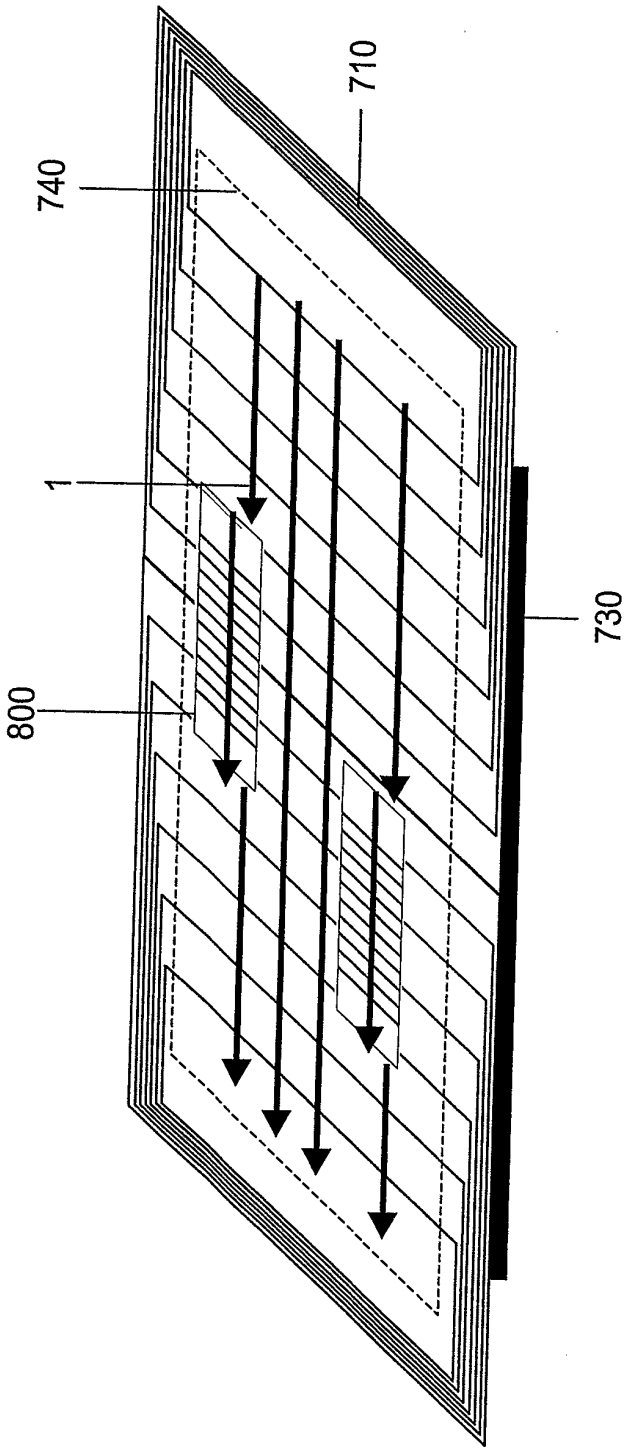


Figure 4b

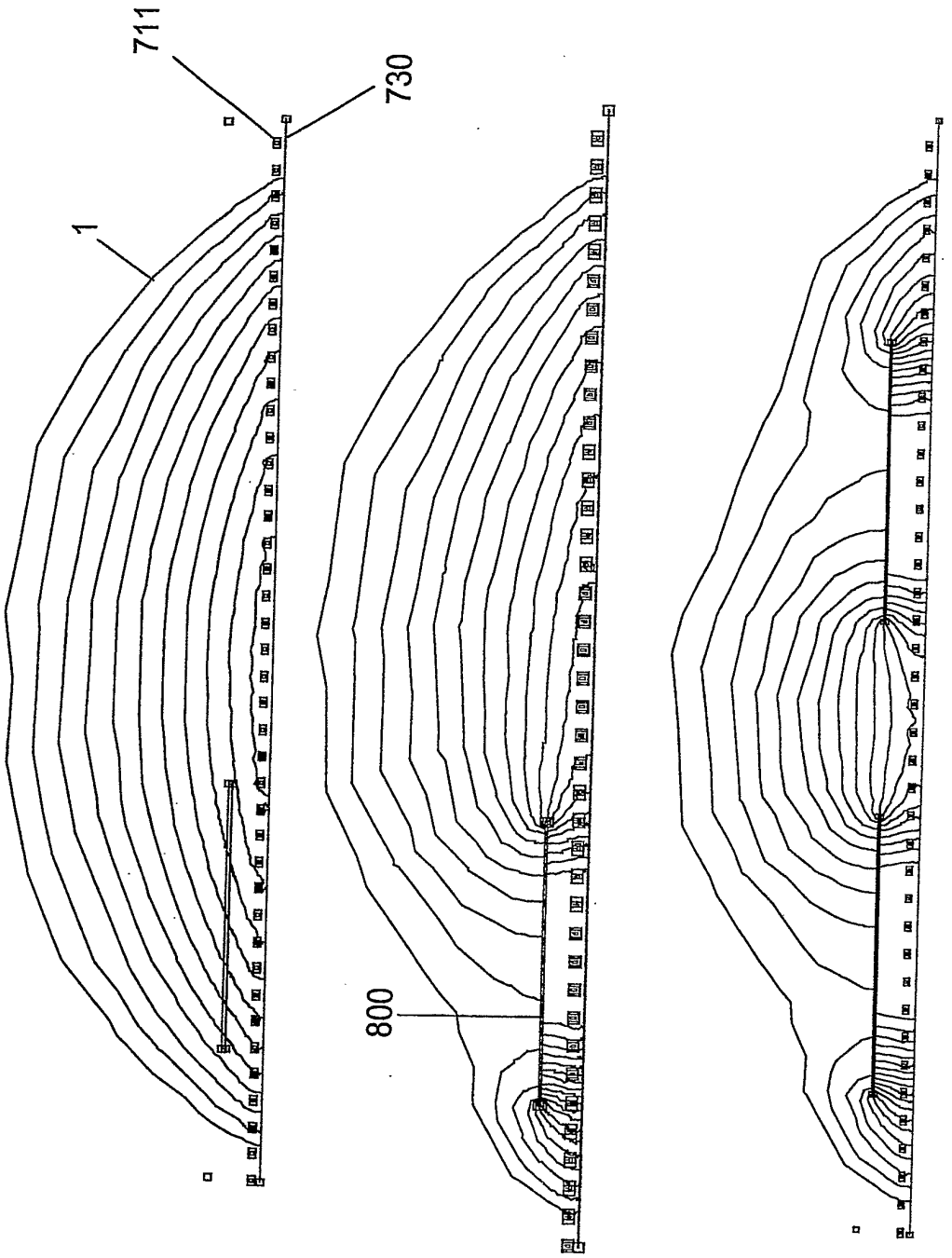


Figure 4c

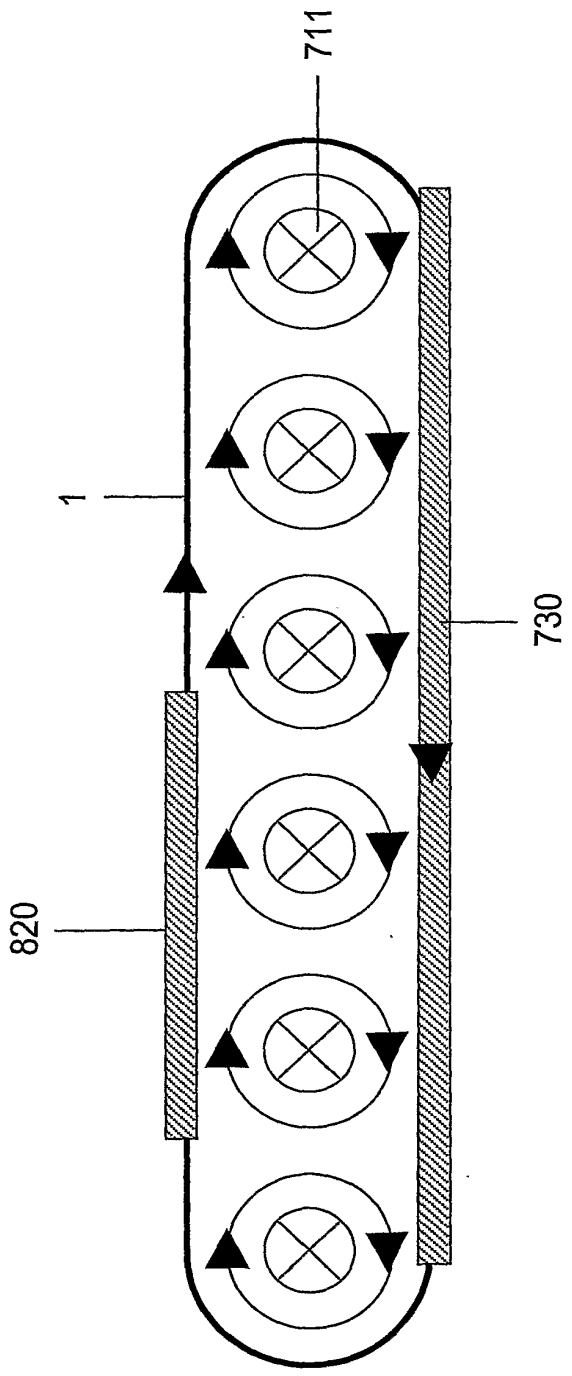


Figure 4d

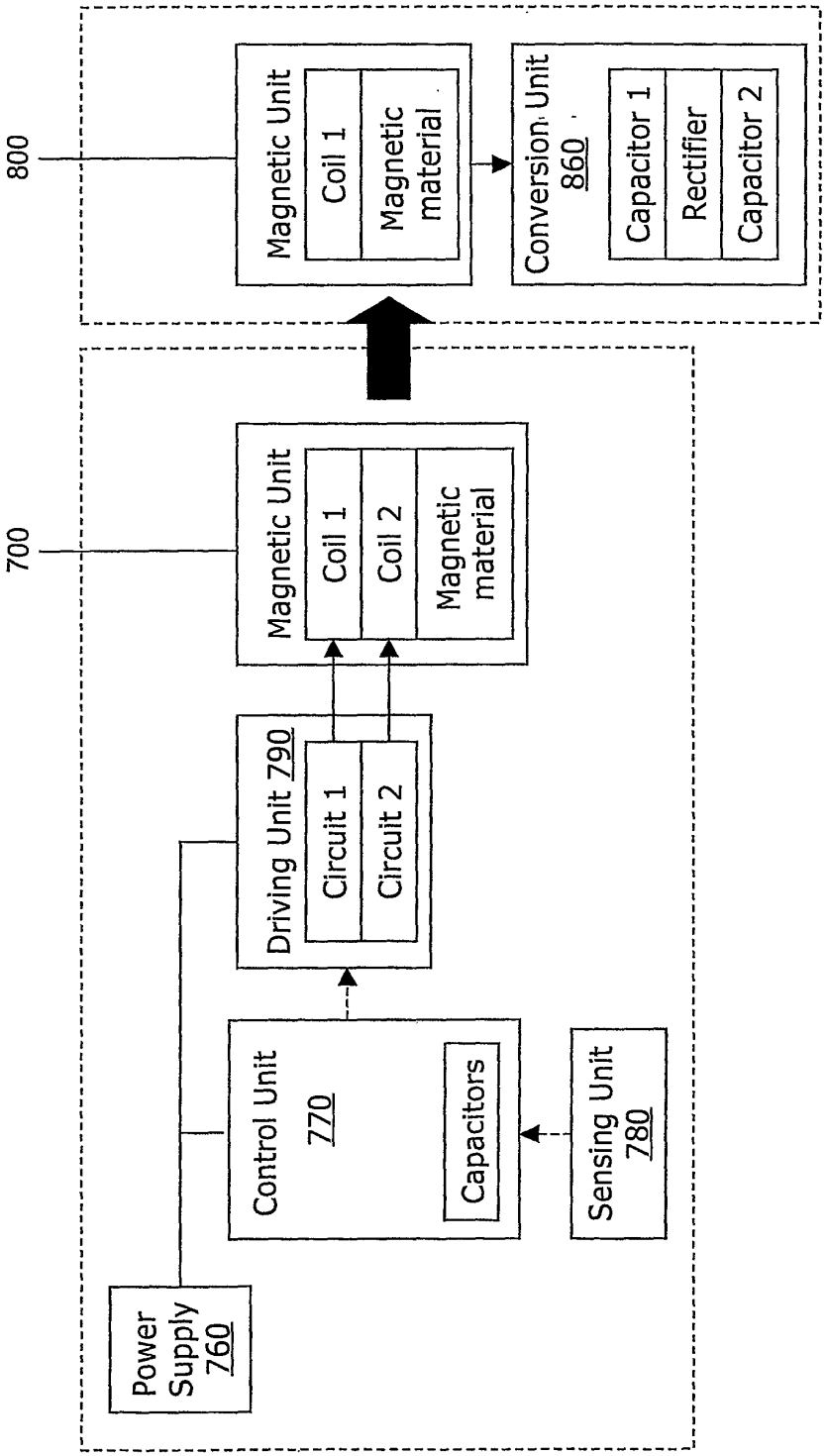

800
Magnetic Unit
Coil 1
Magnetic material
Conversion Unit 860
Capacitor 1
Rectifier
Capacitor 2
700
Magnetic Unit
Coil 1
Coil 2
Magnetic material
Driving Unit 790
Circuit 1
Circuit 2
Control Unit 770
Capacitors
Sensing Unit 780
Power Supply 760

Figure 5

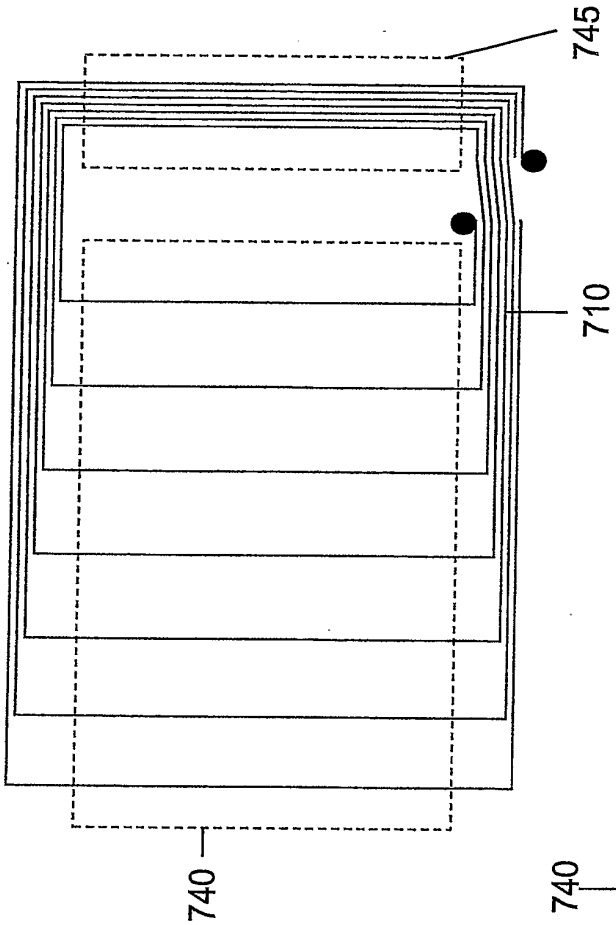


Figure 6a

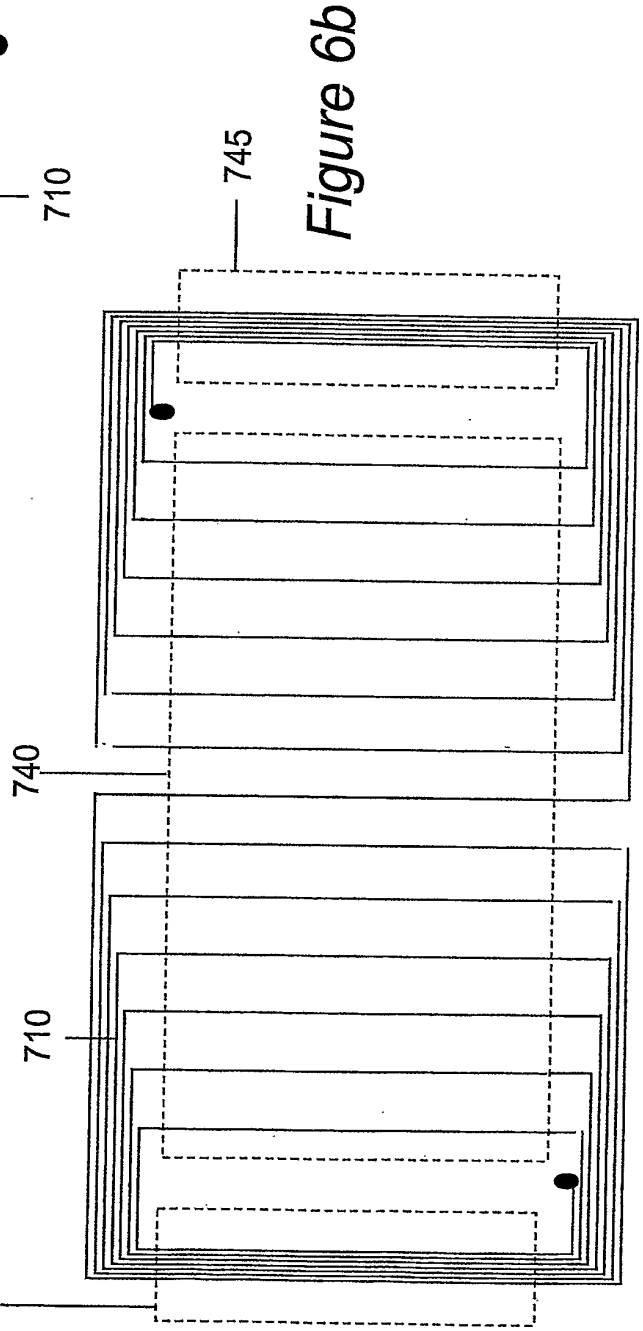


Figure 6b

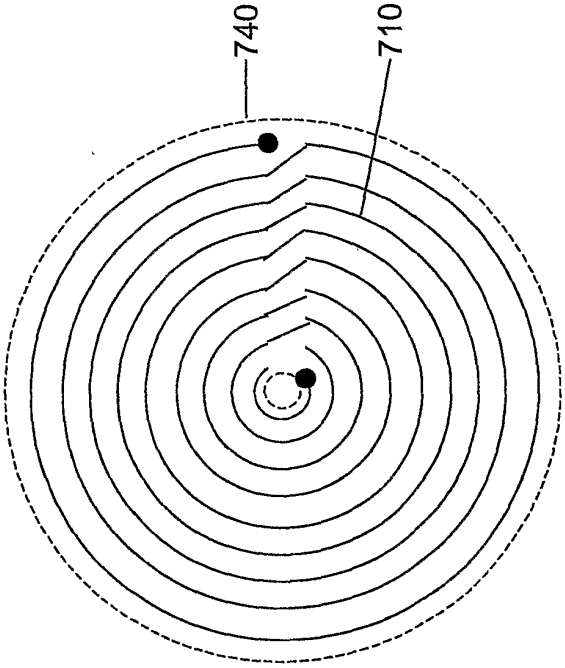


Figure 6c

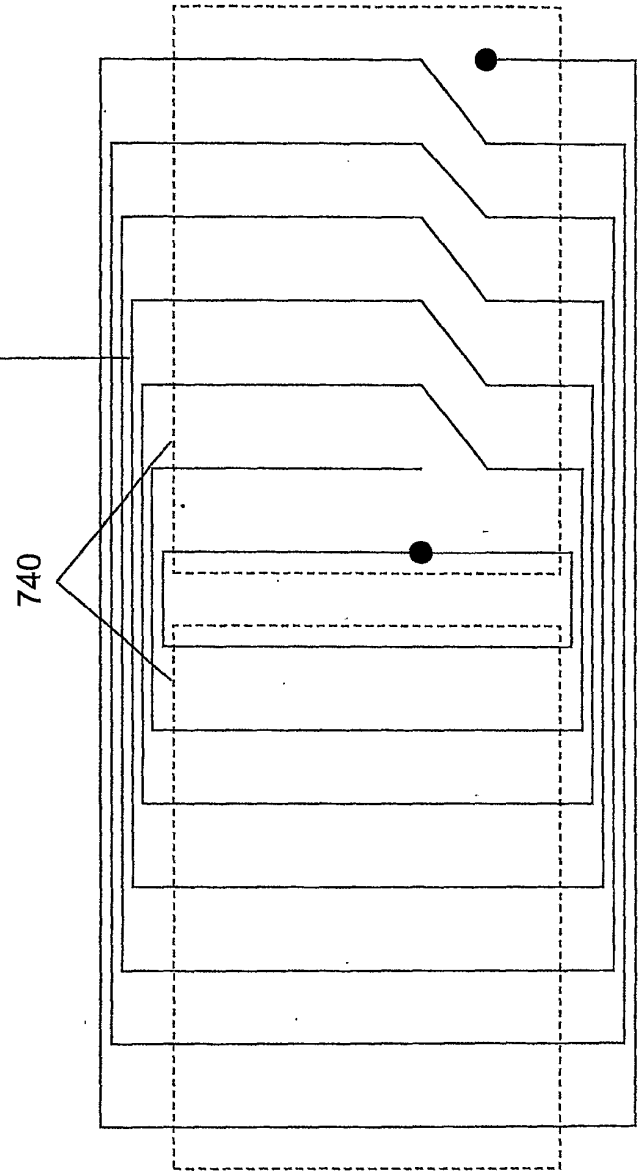


Figure 6d

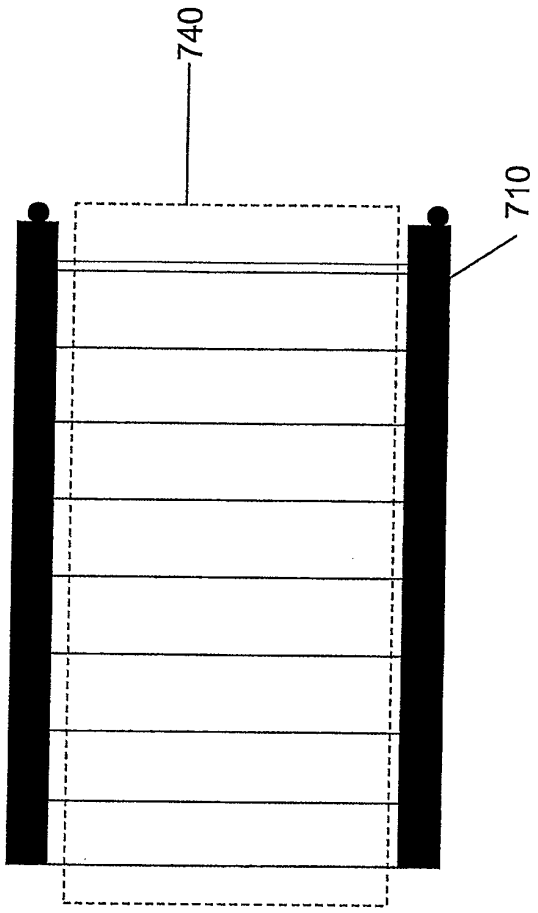


Figure 6e

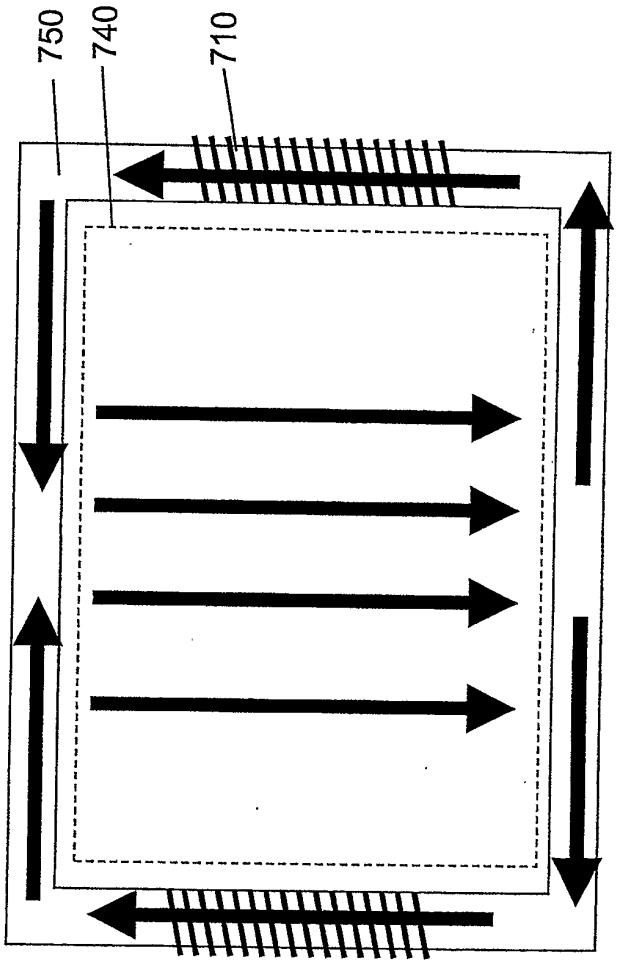


Figure 6f

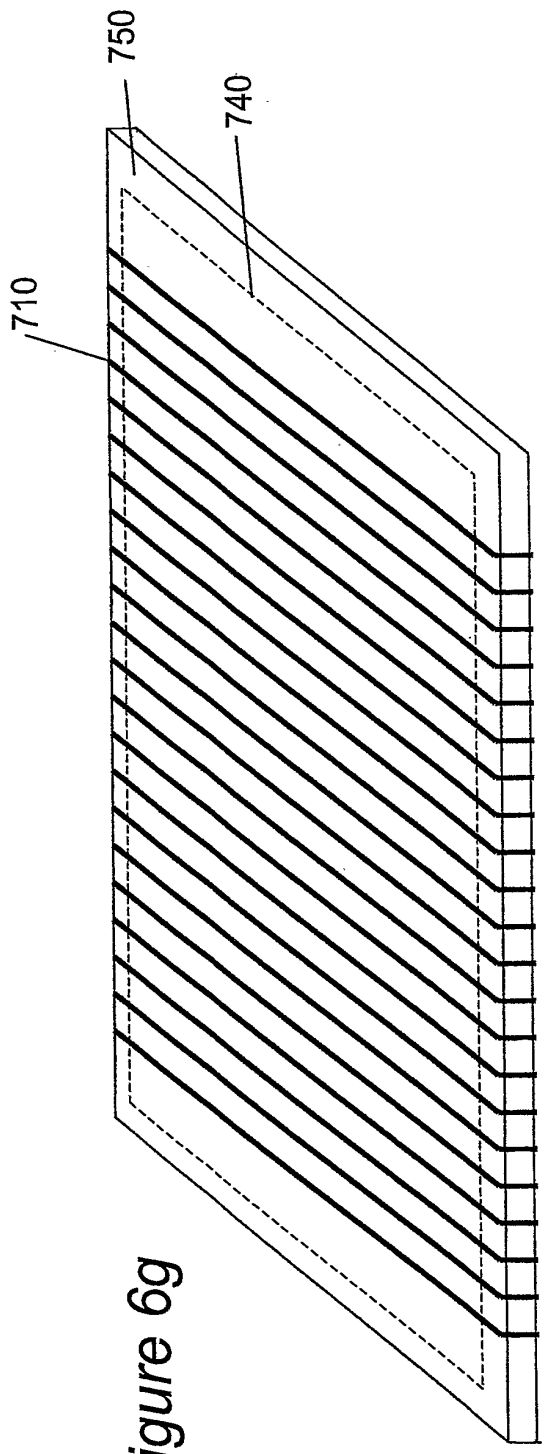


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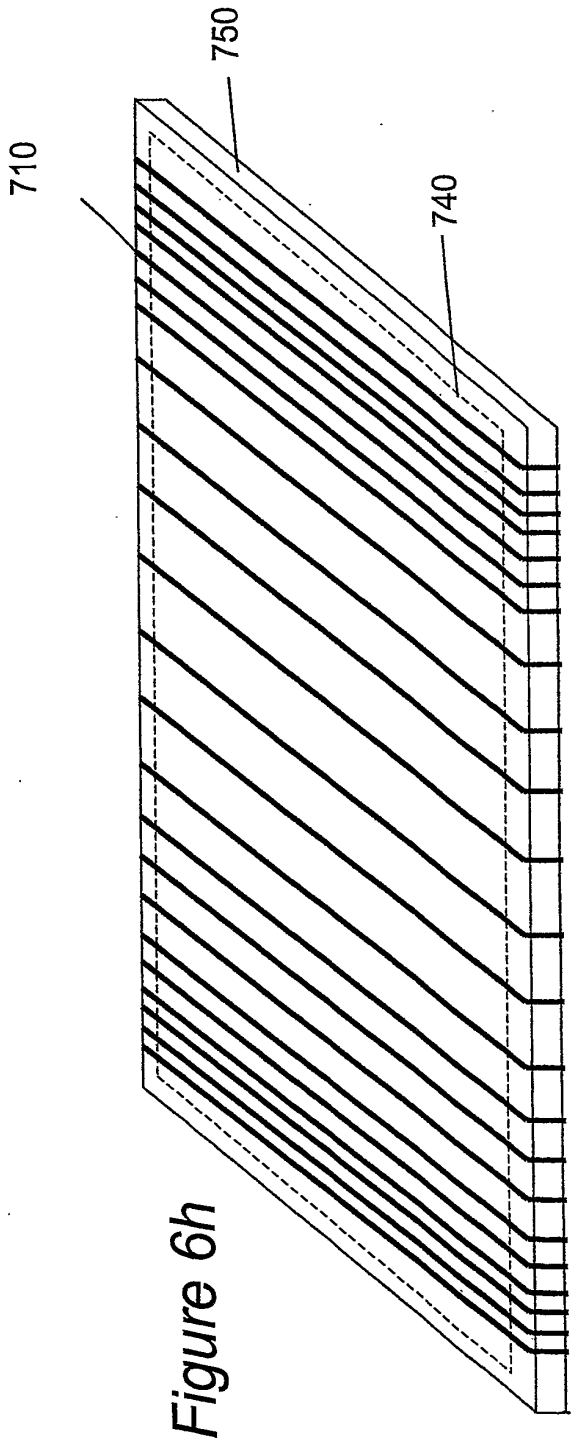


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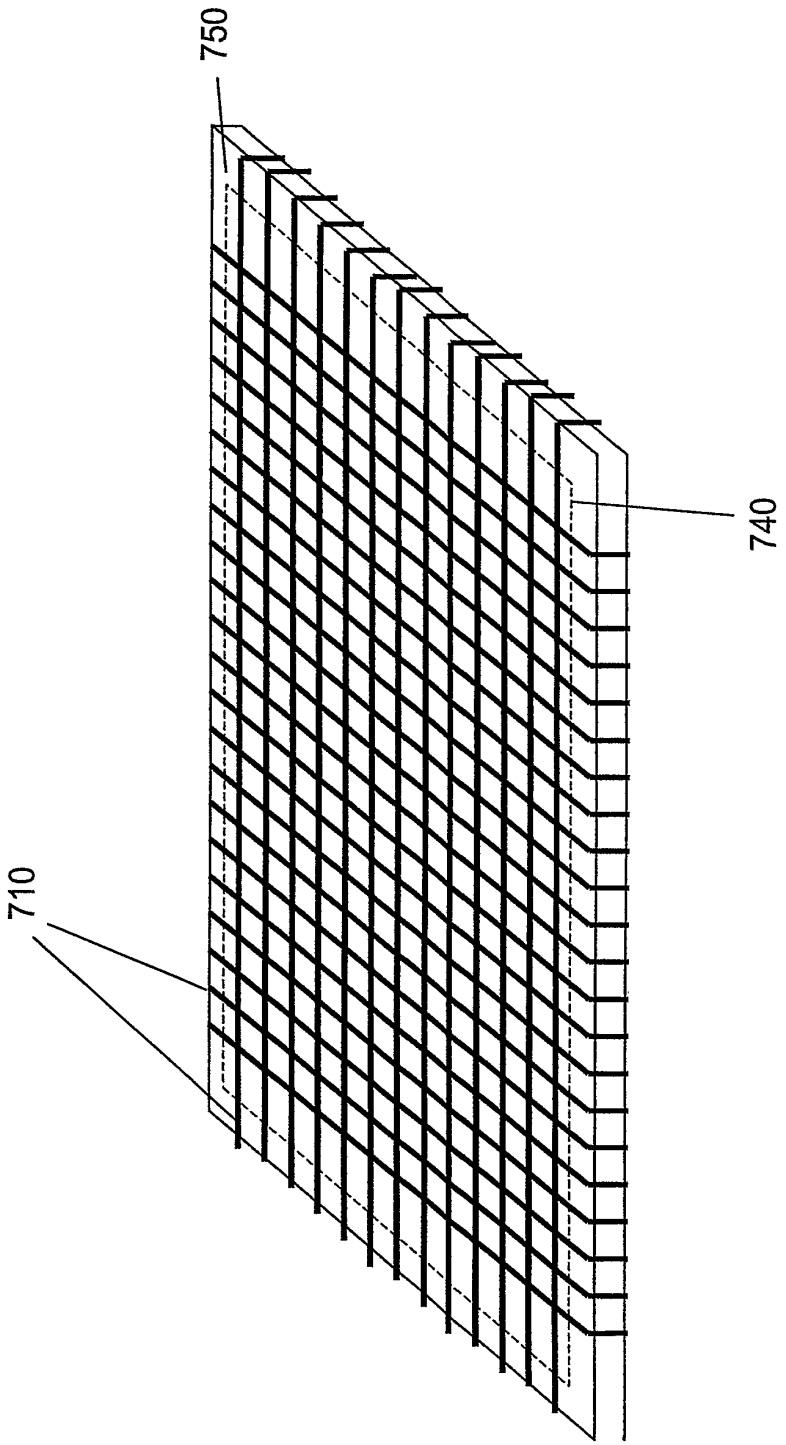


Figure 6i

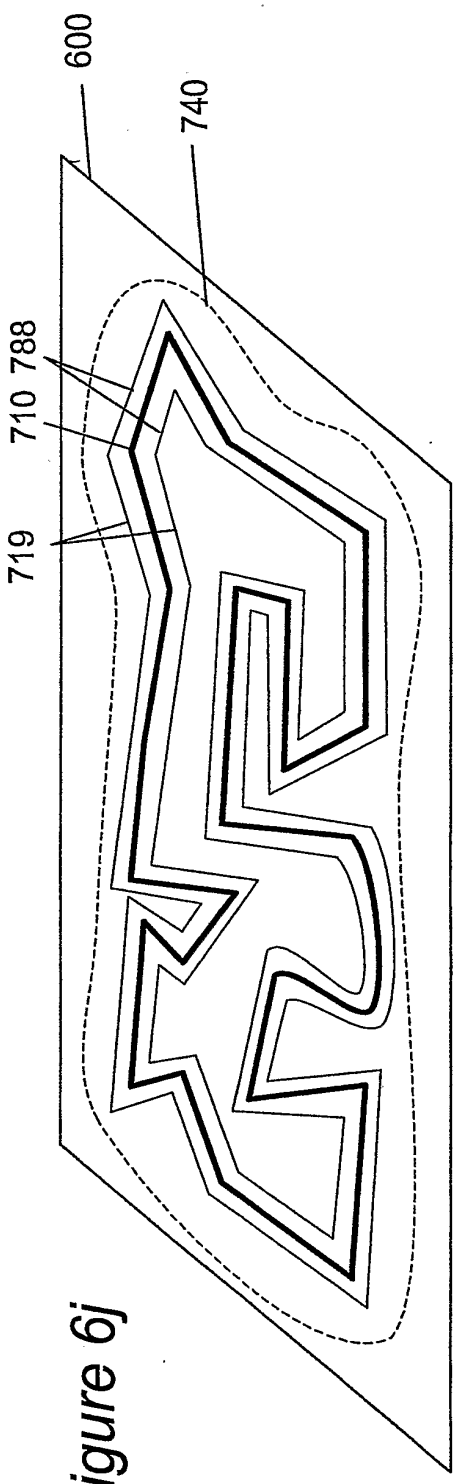


Figure 6j

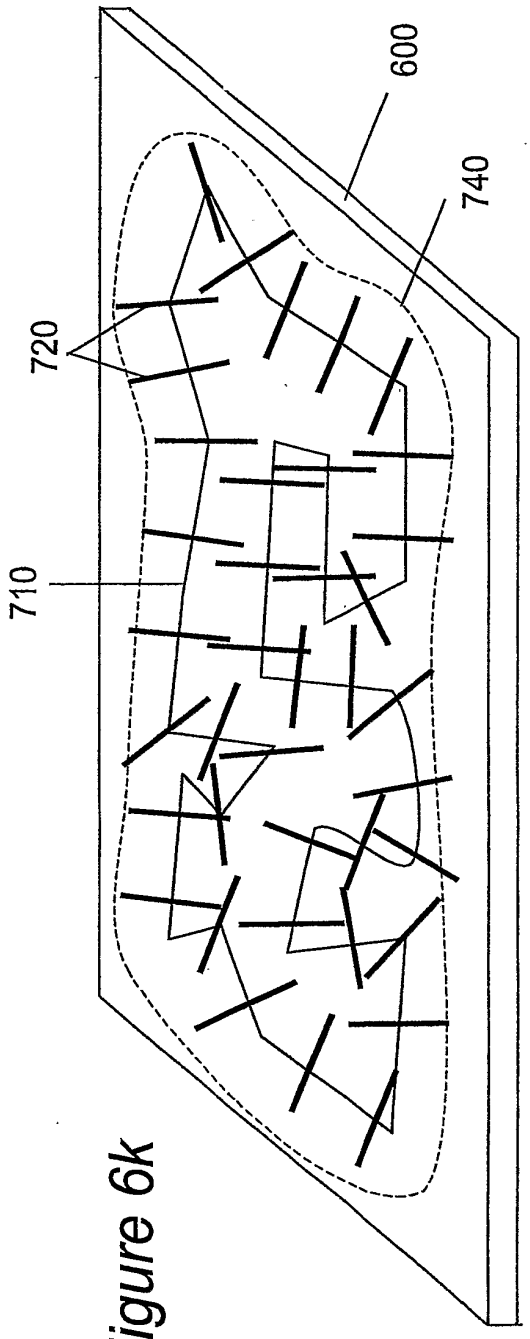


Figure 6k

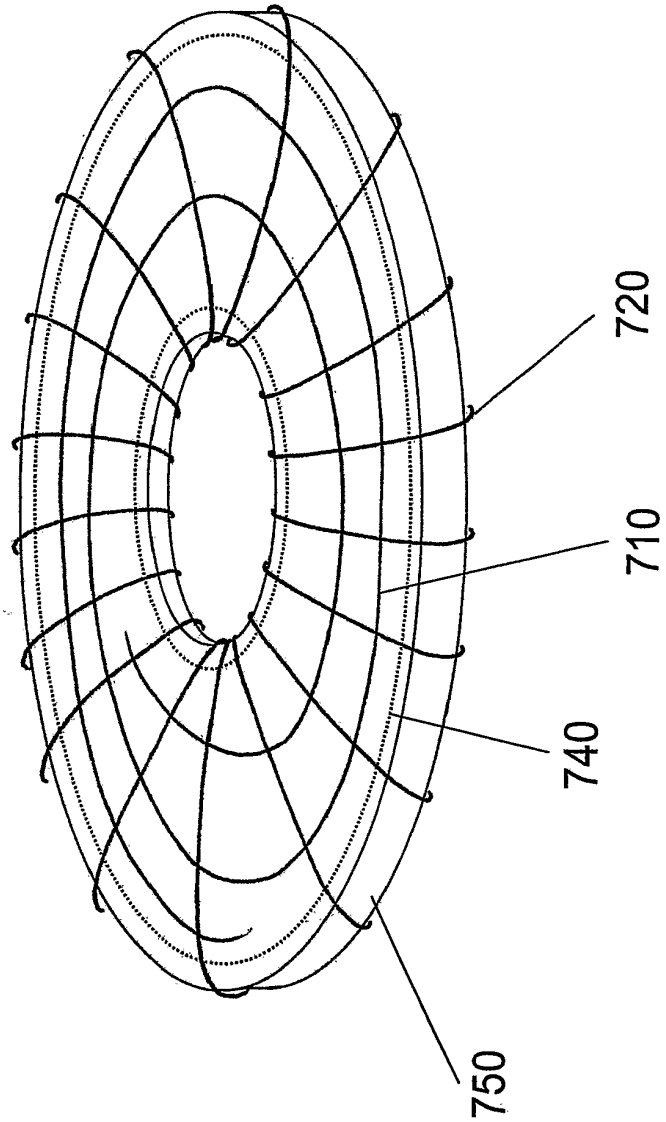


Figure 6L

Figure 7a

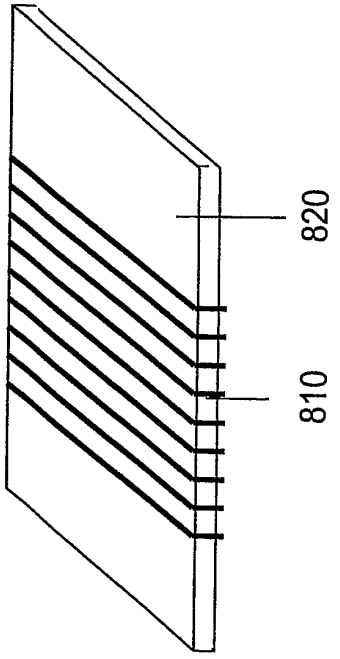
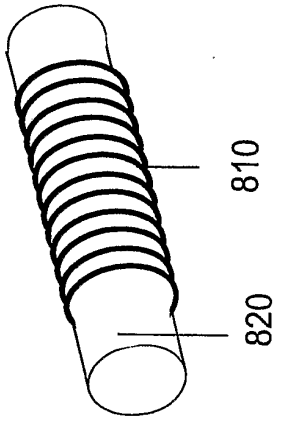


Figure 7b



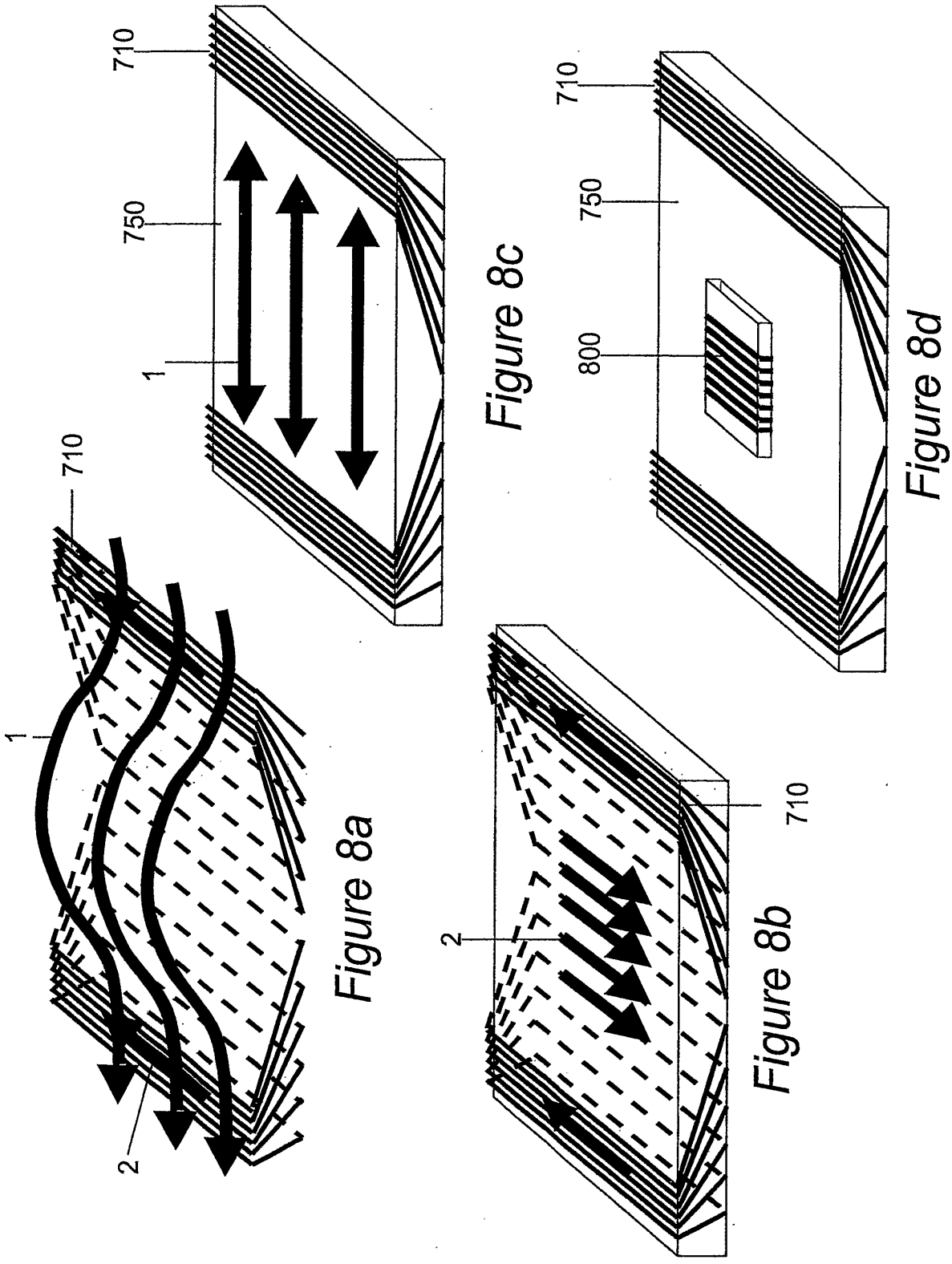


Figure 8a

Figure 8b

Figure 8c

Figure 8d

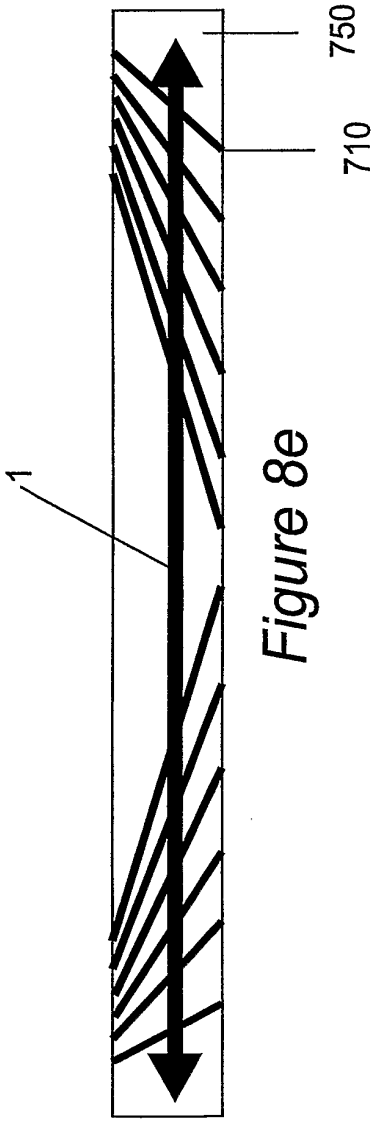


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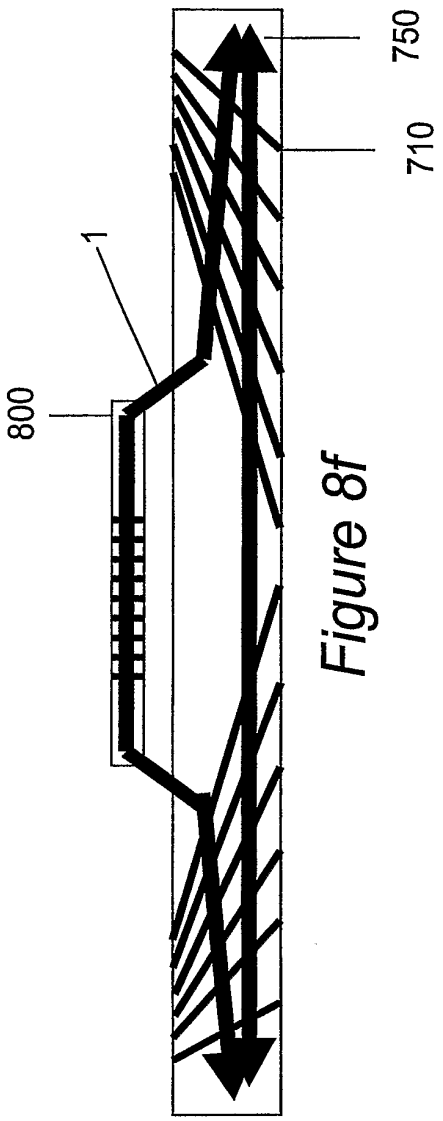


Figure 8f

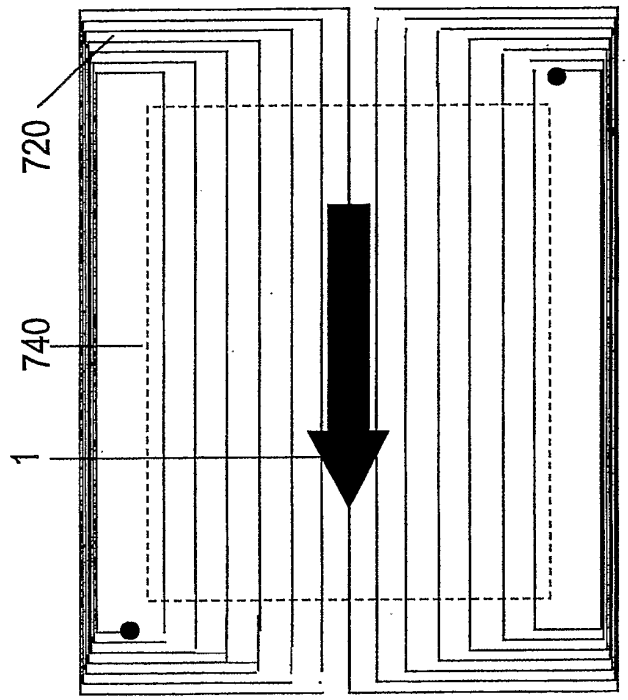


Figure 9b

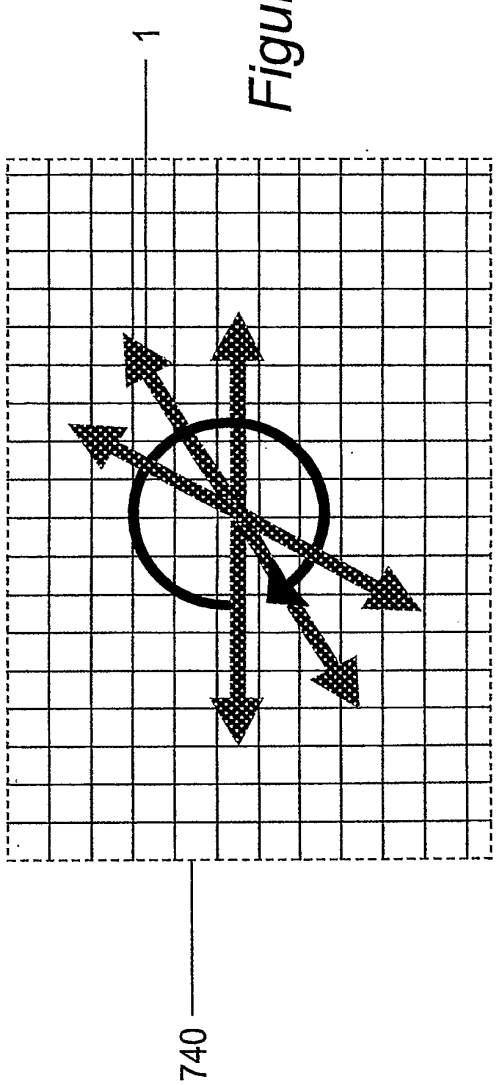


Figure 9c

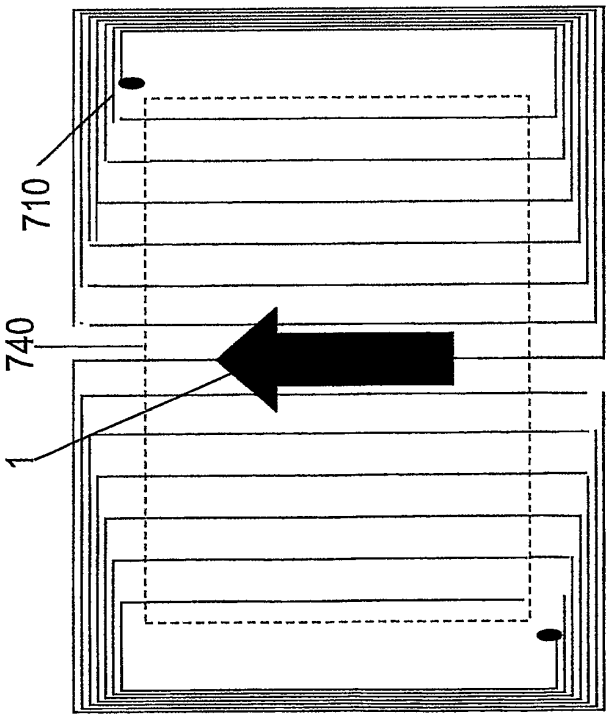


Figure 9a

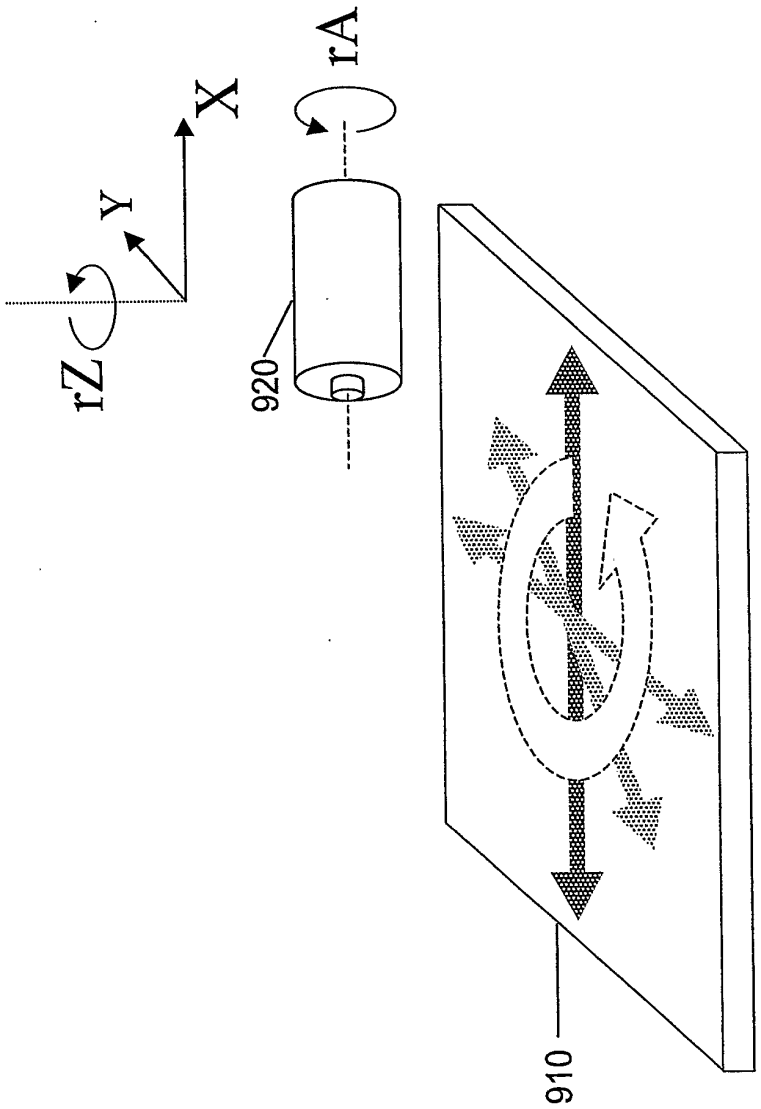


Figure 10

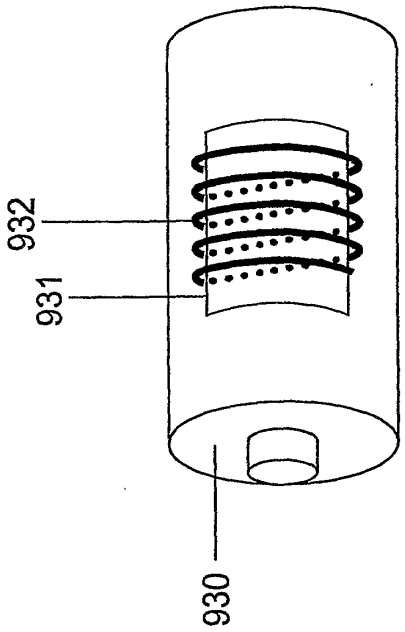


Figure 11b

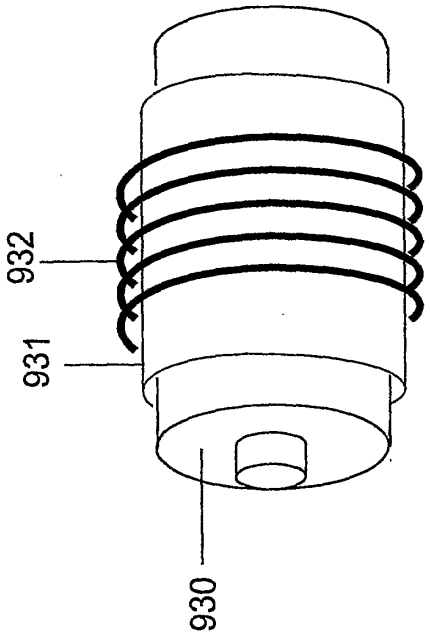


Figure 11a

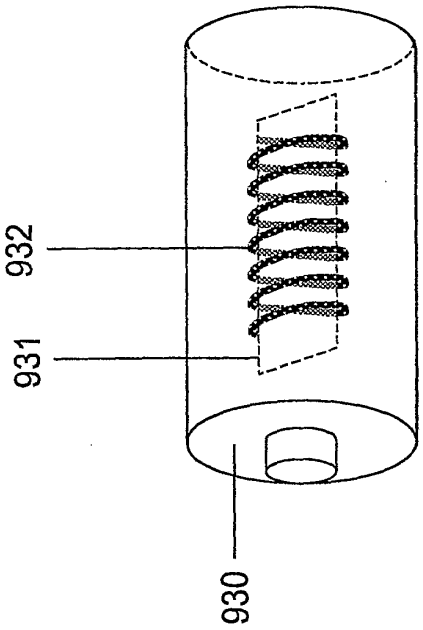


Figure 11c

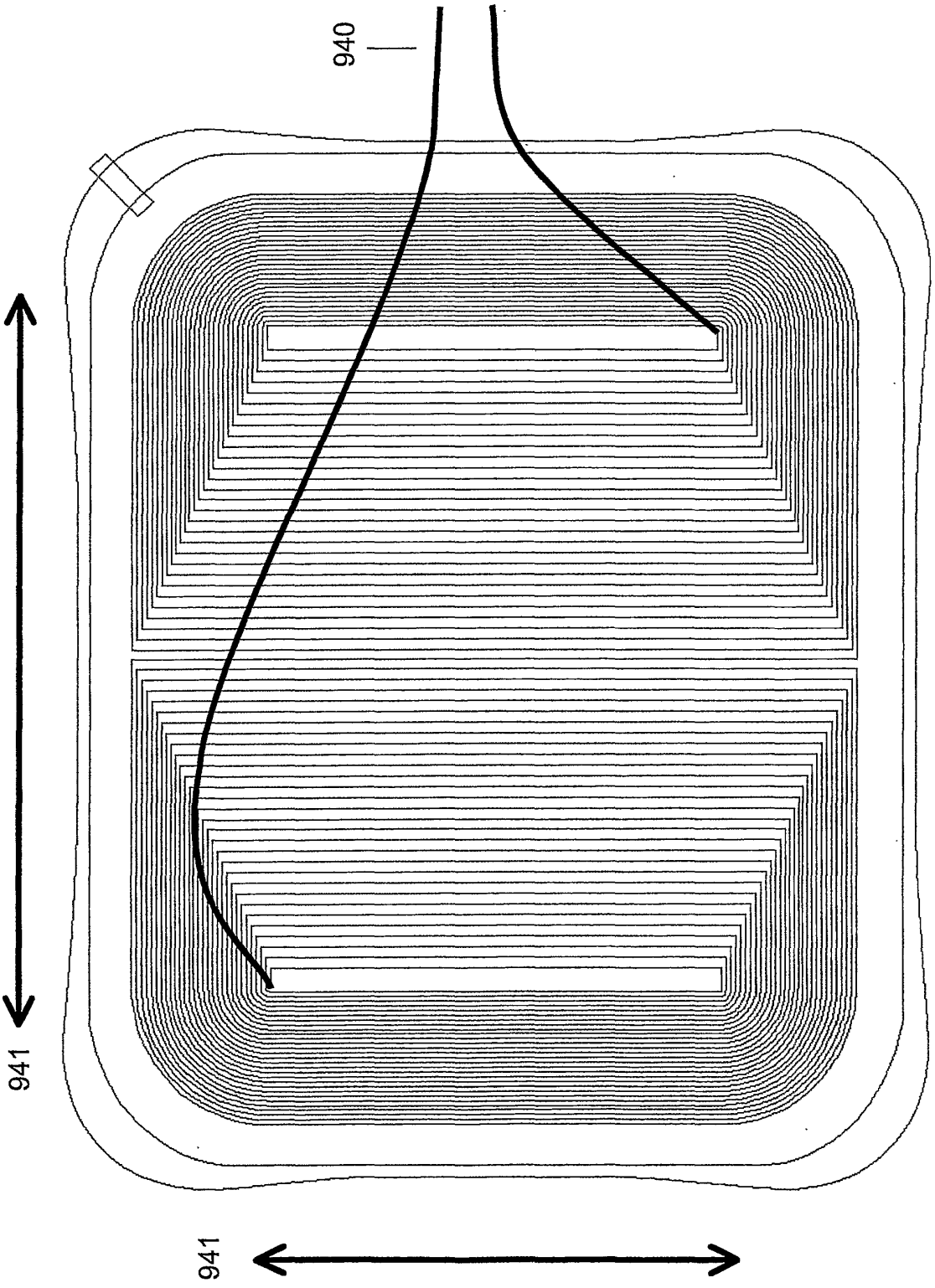


Figure 12a

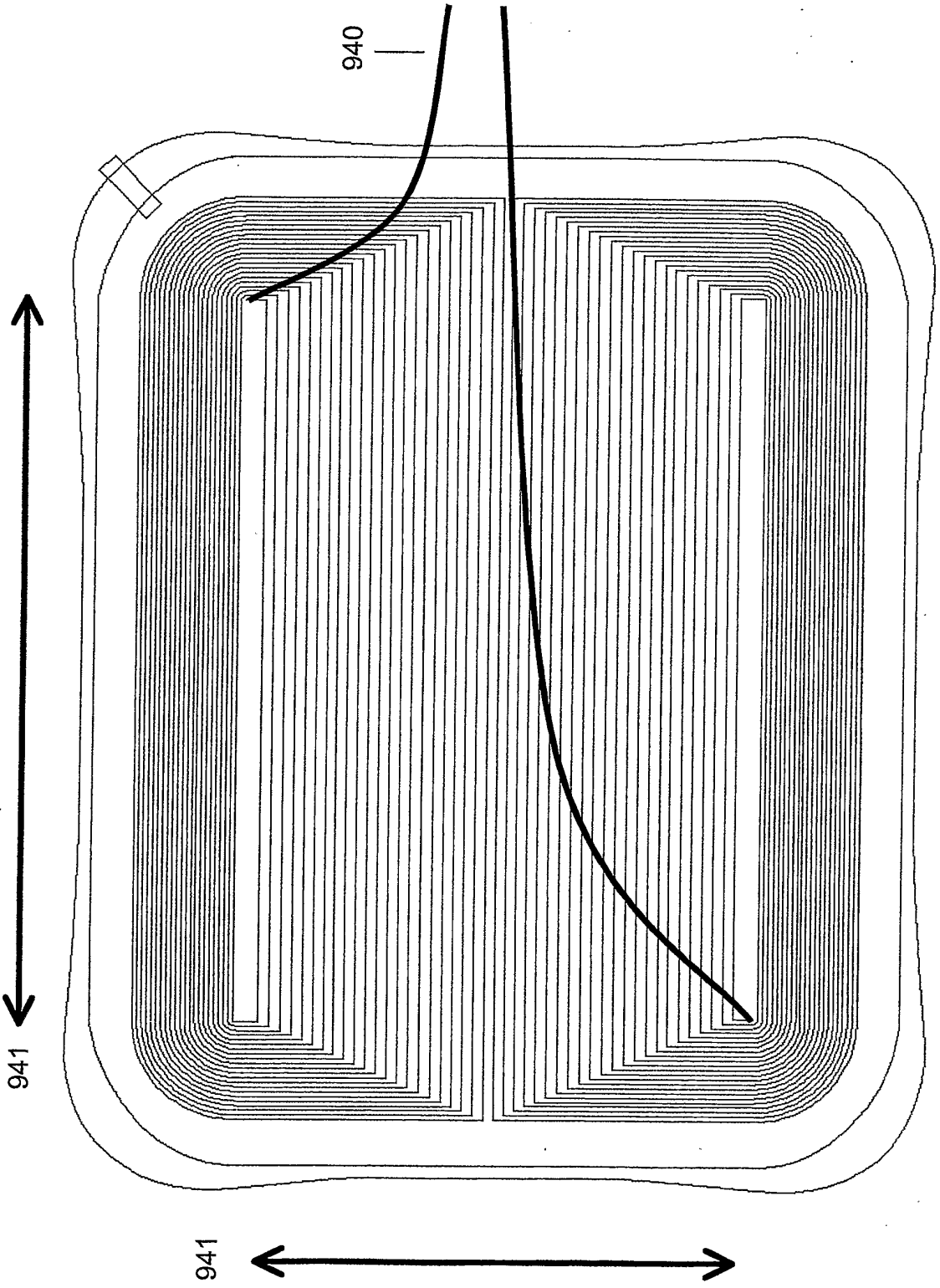
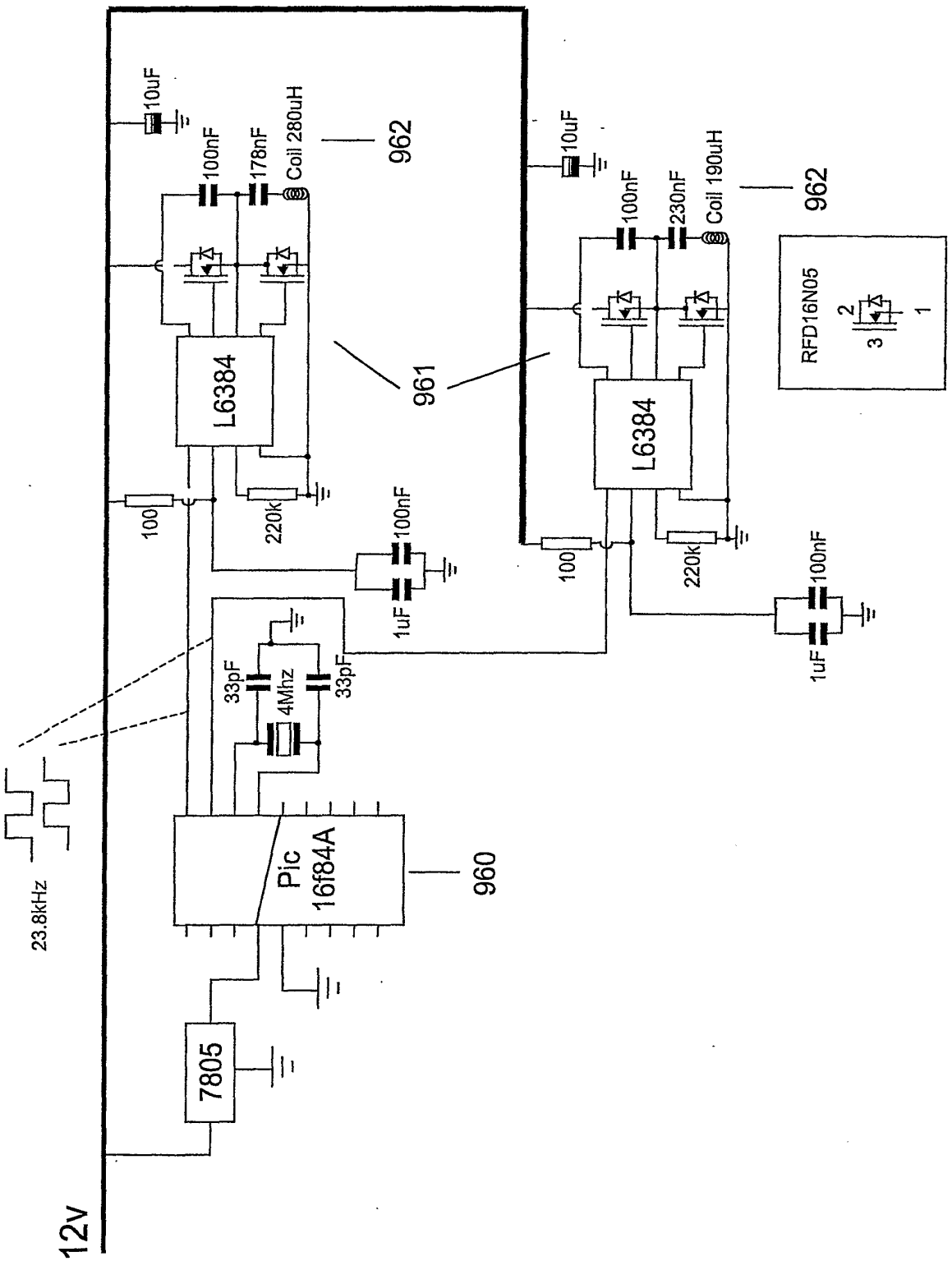


Figure 12b


12v
7805
Pic 16f84A
960
23.8kHz
33pF
4Mhz
33pF
961
L6384
10uF
100nF
178nF
Coil 280uH
962
100
220k
100nF
1uF
L6384
10uF
100nF
230nF
Coil 190uH
962
100
220k
100nF
1uF
RFD16N05
2
3
1

Fiaure 13

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(71) Applicant *(for all designated States except US)*: **CITY UNIVERSITY OF HONG KONG** [—/—]; Tat Chee Avenue, Kowloon Tong, Kowloon, Hong Kong (CN).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **HUI, Ron, Shu-yuen** [AU/—]; 2B, Block 29, Greenwood Terrace, 26-28 Sui Wo Road, Shatin, New Territories, Hong Kong (CN).

(74) Agent: **HODGKINSON OLD MCINNES**; Level 3, 20 Alfred Street, Milsons Point, NSW 2061 (AU).

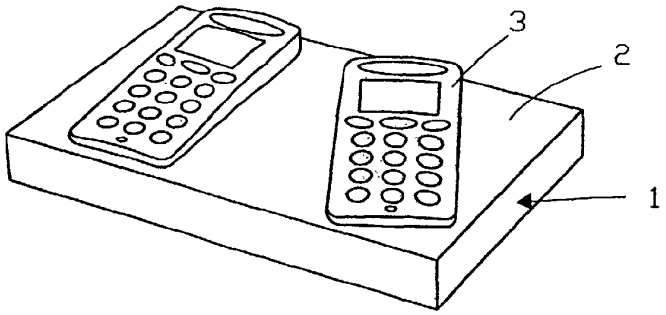
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

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(54) Title: PLANAR INDUCTIVE BATTERY CHARGER



(57) Abstract: There is provided a planar inductive battery charging system designed to enable electronic devices to be recharged. The system includes a planar charging module having a charging surface on which a device is placed. Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that couple energy inductively to a secondary winding formed in the device. The invention also provides secondary modules that allow the system to be used with conventional electronic devices not formed with secondary windings.

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PLANAR INDUCTIVE BATTERY CHARGER

FIELD OF THE INVENTION

This invention relates to a battery charger, and in particular to a battery charger having a planar surface on which one or more battery powered devices may be placed for battery recharging through induction. The invention also extends to a battery charging system for use with conventional electronic devices and that allows conventional electronic devices to be charged using the battery charging system of the present invention.

BACKGROUND OF THE INVENTION

Portable electronic equipment such as mobile phones, handheld computers, personal data assistants, and devices such as a wireless computer mouse, are normally powered by batteries. In many cases, rechargeable batteries are preferred because of environmental and economical concerns. The most common way to charge rechargeable batteries is to use a conventional charger, which normally consists of an AC-DC power supply (in case of using the ac mains) or a DC-DC power supply (in case of using a car battery). Conventional chargers normally use a cord (an electric cable for a physical electrical connection) to connect the charger circuit (a power supply) to the battery located in the portable electronic equipment. The basic schematic of the conventional battery charger is shown in Fig.1.

PRIOR ART

Inductive electronic chargers without direct physical electrical connection have been developed in some portable electronic equipment such as electric toothbrushes

where because they are designed to be used in the bathroom in the vicinity of sinks and water, it is not safe to provide a conventional electrical connection. US6,356,049, US6301,128, US6,118,249, also all describe various forms of inductive chargers. These inductive type chargers, however, use traditional transformer designs with windings wound around ferrite magnetic cores as shown in Fig.2. The main magnetic flux between the primary winding and secondary winding has to go through the magnetic core materials. Other contactless chargers proposed also use magnetic cores as the main structure for the coupled transformer windings.

A contactless charger using a single primary printed winding without any EMI shielding has been proposed by Choi et al in "A new contactless battery charger for portable telecommunications/computing electronics" ICCE International Conference on Consumer Electronics 2001 Pages 58-59. However, the magnetic flux distribution of a single spiral winding has a major problem of non-uniform magnetic flux distribution. As illustrated further below, the magnitude of the magnetic field in the centre of the core of a spiral winding is highest and decreases from the centre. This means that if the portable electronic device is not placed properly in the central region, the charging effect is not effective in this non-uniform field distribution. Furthermore, without proper EMI shielding, undesirable induced currents may flow in other metallic parts of the portable electronic equipment.

SUMMARY OF THE INVENTION

According to the present invention there is provided a battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer,

said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

In a preferred embodiment the primary winding is formed on a planar printed circuit board.

Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface. In this way the precise position and orientation of the electronic device on the charging surface is not critical. To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array.

In a preferred embodiment the primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface. This shielding may include a sheet of ferrite material, and more preferably also may further include a sheet of conductive material such as copper or aluminium

It is an advantage of the present invention that in preferred embodiments the planar charging surface may be large enough to receive two or more electronic devices, and the primary charging circuit is adapted to charge two or more devices simultaneously. In this way it is possible to charge more than one device simultaneously. For example the planar charging surface may be divided into a plurality of charging regions, which regions may be defined by providing a plurality of primary transformer windings arranged in a regular array and connecting the windings in groups to define said charging regions. A further advantage of the present invention is that it enables the possibility of allowing a device to move over the charging surface while being charged

at the same time. This possibility is particularly useful to a device which is designed to be moved such as a wireless computer mouse

Viewed from another aspect the present invention provides a battery charging system comprising a charging module comprising a primary charging circuit and being formed with a charging surface for receiving an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device.

Preferably, the shielding comprises a sheet of ferrite material and a sheet of conductive material such as copper.

Preferably the winding is formed integrally with a back cover of said device.

An important aspect of the present invention is that it provides a battery charging system that employs a localised charging concept. In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged. In other words, when a device is placed on a planar charging surface that is greater in size than the device, energy is only transferred from that part of the planar charging surface that is directly beneath the device, and possibly also immediately adjacent areas that are still able to couple to the secondary coil.

Viewed from another aspect the present invention provides a battery charging system comprising a primary module and at least one secondary module, said primary

module comprising means for connecting to a mains supply, and at least one primary winding adjacent to a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent to a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

According to another aspect the invention also extends to a secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Fig.1 is a schematic view of a conventional prior art battery charger with direct electrical connection,

Fig.2 is a schematic view of a conventional magnetic core-based transformer as used in prior art inductive battery charger systems,

Fig.3 is a schematic view of a planar transformer with shielding,

Figs.4(a)-(c) are (a) a perspective view of a battery charger system according to an embodiment of the present invention, (b) a view similar to (a) but showing

the structure of the primary charging system, and (c) a view similar to (a) and (b) but showing the top cover removed for clarity,

Figs.5(a) & (b) show the structure of the primary charger with the top cover removed for clarity, and in Fig.5(a) with the structure shown in exploded view,

Figs.6(a) & (b) show (a) a single spiral PCB winding, and (b) the measured magnetic field distribution of a single spiral winding,

Figs.7(a) & (b) illustrate the use of a magnetic core to control magnetic field distribution,

Fig.8 shows an embodiment of the invention in which a plurality of primary windings are arranged in an array structure,

Figs.9(a) & (b) shows (a) a 4 x 4 primary winding array, and (b) the resulting magnetic field distribution,

Figs.10(a)-(c) illustrate an embodiment of the invention in which primary windings are arranged in groups with Fig.10(c) showing the equivalent circuit,

Fig.11 shows an example of the back cover of an electronic device designed to be recharged using an embodiment of the present invention,

Figs.12(a)-(d) show exploded views of the back cover of Fig.11,

Figs.13(a) & (b) show views of a watch that may be recharged in accordance with an embodiment of the invention,

Fig.14 shows a charging module in accordance with an alternative embodiment of the invention,

Fig.15 shows a first layer of a 4x5 winding array for use in a multi-layer embodiment,

Fig.16 shows a second layer of a 3x4 winding array for use in conjunction with the layer of Fig.15 in a multi-layer embodiment,

Fig.17 shows the layers of Fig.15 and Fig.16 in the two-layer structure,

Fig.18 is simplified version of Fig.15,

Fig.19 is a simplified version of Fig.16,

Fig.20 is a simplified version of Fig.17,

Fig.21 is a plot showing the smoothing effect of the two-layer structure,

Fig.22 shows a hexagonal spiral winding,

Fig.23 is a simplified form of Fig.22,

Fig.24 shows a single-layer of hexagonal spiral windings,

Fig.25 shows two adjacent hexagonal spiral windings,

Fig.26 shows the mmf distribution of the adjacent windings of Fig.25,

Fig.27 shows three adjacent hexagonal spiral windings and the peaks and minima of the flux distribution,

Fig.28 shows two overlapped layers of hexagonal spiral windings,

Fig.29 shows the location of the peak flux in the structure of Fig.28,

Fig.30 corresponds to Fig.29 but also shows the location of the flux minima,

Fig.31 shows an embodiment of the invention formed with three overlapped layers,

Fig.32 corresponds to Fig.31 but shows the location of the flux peaks,

Fig.33 is a plot showing the uniformity of the flux distribution along a line,

Fig.34 shows a square spiral winding,

Fig.35 is a simplified version of Fig.34,

Fig.36 shows a first layer of square spiral windings,

Fig.37 corresponds to Fig.36 but shows the location of the flux maxima and minima,

Fig.38 shows two overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.39 shows three overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.40 shows four overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.41 illustrates a battery charging system according to a further embodiment of the invention,

Fig.42 is a view similar to Fig.41 but part broken away to show the primary winding,

Fig.43 is a view similar to Fig.42 but of an alternate embodiment,

Figs.44(a) and (b) illustrate possible magnetic cores for use in the embodiment of Fig.42,

Fig.45 shows an equivalent circuit for the charging system of an embodiment of the invention,

Fig.46 illustrates an example of a secondary module for use in an embodiment of the invention,

Fig.47 shows a part broken away view of secondary module of an embodiment of the invention,

Fig.48 is a view similar to Fig.47 but of a further embodiment,

Fig.49 is a view showing the complete charging system according to an embodiment of the invention,

Fig.50 is a view similar to Fig.49 but showing how the charging system according to an embodiment of the invention can be used to charge multiple devices having different forms of charging connections, and

Fig.51 is a view illustrating how an embodiment of the present invention can be used to enable a conventional electronic device to be charged using an inductive charging platform as shown in Fig.4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described in respect of a preferred embodiment in the form of an inductive battery charger for portable electronic equipment such as mobile phones, handheld computers and personal digital assistants (PDA), and devices such as a wireless computer mouse.

Referring firstly to Fig.4, the inductive charger system comprises two modules, a power delivering charger module that contains the primary circuit of a planar isolation transformer and a secondary circuit that is located in the portable electronic equipment to be charged. In this embodiment of the invention, the charger circuit is located within a housing 1 that is formed with a flat charging surface 2. The secondary circuit is formed in the portable equipment to be charged (in this example a mobile phone 3) and the equipment is formed with at least one planar surface. As will be seen from the following description the equipment is charged simply by placing the equipment on the surface so that the planar surface on the equipment is brought into contact with the flat charging surface 2. It is a particularly preferred aspect of the present invention that the equipment to be charged does not have to be positioned on the charging surface in any special orientation. Furthermore, in preferred embodiments of the invention two or more mobile devices may be charged simultaneously on the same charging surface, and/or a device that is designed to be moved (such as a wireless computer mouse) can be charged while being moved over the charging surface (which could be integrated into a computer mouse pad). It will also be seen from the following description that the energy

transfer is "localised" in the sense that energy is only transferred from the charging surface to the device from that part of the charging surface that is directly beneath the device (and possibly to a lesser extent regions adjacent thereto).

Referring in particular to Fig.4(b) the primary charging module comprises a printed circuit board 4 formed with at least one spiral conductive track formed thereon as a primary winding. It will be understood, however, that the primary winding need not necessarily be formed on a PCB and could be formed separately. Alternatively, multiple PCBs each formed with at least one winding could be "stacked" on top of each other to increase the total flux. Preferably, as will be described further below, there are in fact a plurality of such spiral tracks disposed in an array as shown in Fig.4(c) in which a top insulating sheet has been removed for clarity. Beneath the PCB 4 (ie the side of the PCB away from the charging surface) is provided EMI shielding comprising firstly a ferrite sheet 5 adjacent the PCB 4, and then a conductive sheet 6 which in this example may be a copper sheet. Beneath the copper sheet 6 may be provided any suitable form of substrate material 7, eg a plastics material. Above the PCB 4 may be provided a sheet of insulating material 8 which forms the charging surface. Preferably the PCB 4, the EMI shielding sheets 5,6, the substrate 7 and the insulating cover sheet 8 may also be generally the same size and shape, for example rectangular, so as to form the primary charging module with the charging surface being large enough to accommodate at least one, and more preferably two or more, devices to be charged. Figs.5(a) and (b) also show the structure of the charging module without the cover sheet and without any devices to be charged thereon for the sake of clarity.

As shown in Fig.4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings. The secondary winding is also planar and is located in the

portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit. The rectified DC voltage is applied to the battery via mechanical contacts provided in an integrated back cover as will be described further below. No physical electrical connection between the primary charger circuit and the portable electronic equipment is needed.

The primary charger circuit has (1) a switched mode power electronic circuit, (2) the primary side of a planar transformer that consists of a group of primary windings connected in series or in parallel or a combination of both, (3) an EMI shield and (4) a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The schematic of the primary charger system is shown in Fig.5(a) and (b) without the insulating cover.

The battery charging system can be powered by AC or DC power sources. If the power supply is the AC mains, the switched mode power electronic circuit should perform a low-frequency (50 or 60Hz) AC to DC power conversion and then DC to high-frequency (typically in the range from 20kHz to 10MHz) AC power conversion. This high-frequency AC voltage will feed the primary planar windings of the primary charger circuit. If the power supply is a battery (e.g. a car battery), the switched mode power supply should perform a DC to high-frequency AC power conversion. The high-frequency voltage is fed to the primary windings of the planar transformer.

Preferably, the charger should be able to charge one or more than one items of portable electronic equipment at the same time. In order to achieve such a function, the AC magnetic flux experienced by each item of portable equipment placed on the charging surface should be as even as possible. A standard planar spiral winding as

shown in Fig.6(a) is not suitable to meet this requirement because its flux distribution is not uniform as shown in Fig.6(b) when the winding is excited by an AC power source. The reason for such non-uniform magnetic flux distribution is that the number of turns in the central region of the single spiral winding is largest. As the magnitude of the magnetic flux and the magnetomotive force (mmf) is proportional to the product of the number of turn and the current in the winding, the magnetic flux is highest in the centre of the winding.

One method to ensure uniform magnetic flux or mmf distribution is to use a concentric primary winding with a planar magnetic core as shown in Fig.7(a). This magnetic core-based approach allows the magnetic flux to concentrate inside the core and typical magnetic flux distribution is shown in Fig.7(b). In general, the flat charging interface surface of the primary charger should be larger than the total area of the portable electronic equipment.

In order to ensure that more than one item of portable electronic equipment can be placed on the flat charging surface and charged simultaneously, a second and more preferred method proposed is to ensure that the magnetic flux distribution experienced by each items of portable electronic equipment is as uniform as possible. This method can be realized by using a "distributed" primary planar transformer winding array structure as shown in Fig.8. This planar winding array consists of many printed spiral windings formed on the PCB. These printed spiral windings can be hexagonal, circular, square or rectangular spirals, and can be connected in series, in parallel or a combination of both to the high-frequency AC voltage generated in the power supply in the primary charger circuit. The array should comprises relatively closely spaced coils so as to be able to generate the required near-uniform magnetic flux distribution, as an array of widely spaced apart coils may not generate such a near-uniform field.

Fig.9(a) shows a practical example with the transformer winding array connected in series so that all the fluxes created in the windings point to the same direction. Fig.9(b) show the measured flux distribution of one planar transformer when the windings in the transformer array are connected in series. This measurement confirms the near uniform magnetic flux distribution of the array structure. Comparison of Fig.6(b) and Fig.9(b) confirms the improvement of the uniform magnetic field distribution using the transformer array structure. In addition, this transformer array structure provides for the possibility of multiple primary transformer windings being provided for localized charging as will now be explained.

The primary transformer windings can also take the form of a combination of series and parallel connections if desired. Such an arrangement allows the charging surface to be divided into various charging regions to cater for different sizes of the secondary windings inside the portable electronic equipment. Fig.10(a) illustrates this localized charging zone principle. Assume that the transformer array is divided into 4 zones (A, B, C, and D). The transformer windings within each zone are connected in series to form one primary winding group with the distributed magnetic flux feature. There will be four primary windings in the equivalent circuit as shown in Fig.10(c). If the portable electronic equipment is placed on Zones A and B as shown in Fig.10(b), the equivalent electrical circuit is shown in Fig.10(c). Only the parallel primary transformer winding groups for Zones A and B are loaded because they can sense a nearby secondary winding circuit in the portable electronic equipment. Therefore, they will generate magnetic flux in Zones A and B. Primary transformer windings C and D are not loaded because they have no secondary transformer circuit close to them and their equivalent secondary circuits are simply an open-circuit (Fig.10(c)). As a result, power transfer between the primary charger circuit and the secondary windings inside the

portable electronic equipment takes place basically through the coupled regions (areas) of the charging interface surface covered by the portable electronic equipment. The non-covered area of the charging surface will transfer virtually no energy. This special design avoids unnecessary electromagnetic interference. A further advantage of this localised energy transfer concept, is that it enables a movable device (such as a wireless computer mouse) to be continually charged as it moves over the charging surface. In the case of a wireless computer mouse, for example, the primary charging circuit could be integrated into a mousepad and the mouse may be charged as it rests on and/or moves over the mousepad.

The back cover of the portable electronic equipment is a detachable back cover shown in Fig.12(a) that covers the battery and which may be removed when the battery is replaced. In preferred embodiments of the present invention, this back cover has a built-in secondary planar transformer winding 10, a diode rectifier circuit 13 and preferably a thin EMI shield 11,12 as shown in Fig.12(b) & (c). When the back cover side of the portable equipment is placed near the flat charging surface of the primary charger circuit, this secondary winding couples the energy from the nearby primary transformer winding or windings. The rectifier circuit rectifies the coupled AC voltage into a DC voltage for charging the battery through mechanical contacts 14. This rectifier circuit also prevents the battery from discharging into the secondary winding. In order to avoid induced circuit from circulating in other metal parts inside portable electronic circuit, it is preferable to include a thin EMI shield as part of the integrated back cover structure as shown in Fig.12. This EMI shield can be a thin piece of ferrite material (such as a flexible ferrite sheet developed by Siemens) or ferrite sheets, or more preferably a combination of a ferrite sheet 11 and then a thin sheet 12 of copper of another conductive material such as aluminium..

It will thus be seen that, at least in its preferred forms, the present invention provides a new planar inductive battery charger for portable electronic equipment such as mobile phones, handheld computers, personal data assistant (PDA) and electronic watches, and wireless computer mice. The inductive charger system consists of two modules, including (1) a power delivering charger circuit that contains the primary circuit of a planar isolation transformer and a flat charging surface and (2) a separate secondary transformer circuit that consists of a printed winding, a rectifier and preferably a thin EMI shield and which is located in the portable electronic equipment to be charged.

An advantage of the present invention, at least in preferred forms, is that the primary charger circuit system has the primary side of a planar transformer and a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The secondary circuit can be integrated into the back cover of the portable electronic device or separately placed inside the electronic device. The invention also extends to a back cover design with an in-built secondary circuit for the portable equipment. The secondary winding of the planar transformer can be EMI shielded and integrated into the back cover adjacent to the battery in the portable electronic device. As long as the back cover sides of the portable electronic device are placed on the charger surface, one or more portable electronic devices can be charged simultaneously, regardless of their orientations.

Figs.13(a) and (b) show how an embodiment of the invention may be used to recharge a watch battery. A watch is formed with a basic watch mechanism 20, which is powered by a rechargeable battery 21. The watch mechanism is shielded from electrical interference in the charging process by an EMI shield consisting of, for example, a copper sheet 22 and a ferrite sheet 23 (with the copper sheet closer to the watch

mechanism than the ferrite sheet). The other side of the EMI shield is provided a planar coreless transformer secondary winding 24 formed with electrical contacts 26 for connection to the battery 21 and with a rectifier circuit to prevent discharge of the battery. Finally, the watch structure is completed by the provision of a planar back cover 25 formed of non-metallic material. It will be understood that the watch battery may be recharged by placing the watch on the charging surface of a battery charging system as described in the above embodiments such that the back cover 25 lies flat on the planar charging surface. Electrical energy is then coupled from the primary winding(s) in the battery charging module to the secondary winding in the watch and then to the rechargeable battery.

In the embodiments described above the charging module is formed as a single integral unit (as shown for example in Figs.4 and 5). However, in some situations it may be desirable to separate the electronic charging circuit from the planar charging surface. This possibility is shown in Fig.14 in which the electronic charging circuit 30 is connected by a cable 31 to the charging surface 32. The charging surface 32 includes an insulating top cover, the planar primary windings printed on a PCB, and a bottom EMI shield formed of ferrite and a conductive sheet such as copper. This embodiment has the advantage that the charging surface is relatively thin, and therefore may be useful for example when the device to be charged is a wireless computer mouse because the charging surface can double as a mousepad as well as a charging surface.

In the embodiments described above a single layer of transformer arrays is provided. However, in order to generate a more uniform magnetic field distribution, multi-layer transformer arrays can be used. The following embodiments describe how multiple layers of transformer arrays may be used that can provide a very uniform magnetic field distribution on the charging surface.

Fig.15 shows a 4x5 primary planar transformer winding array which consists of square-sprial winding patterns. This can be fabricated on one layer of the printed circuit board structure. It should be noted that, for an individual winding pattern in the array, the magnitude of the magnetic flux is highest in the center of the spiral winding. The magnitude of the magnetic flux is smallest in the small gap between adjacent winding patterns.

A second layer with a 3x4 transformer winding array is shown in Fig.16. The individual winding patterns in both layers are identical. As shown in Fig.17, by having the two layers of arrays arranged in such a manner that the center (region of maximum magnetic flux magnitude) of a winding pattern on one layer is placed on the gap (region of minimum magnetic flux magnitude) between adjacent winding patterns on the other layer, the variation of the magnetic field magnitude can be minimized and the magnetic flux magnitude can therefore be made as even as possible over the overlapped surface. The essence of the multi-layer transformer arrays is to have a displacement between the individual winding patterns of the two layers so that the regions of the maximum magnetic field magnitude of one layer is "evened out" by the regions of the minimum magnetic field magnitude.

In order to examine the 'uniform magnetic field magnitude' feature of the proposed overlapped multi-layer transformer arrays, this 'magnitude smoothing' concept is illustrated in simplified diagrams in Fig.18 to 20. Fig.18 is a simplified version of Fig.15. Each solid square in Fig.18 represents a square-spiral winding pattern in the first layer (Fig.15). Fig.19 is a simplified version of the Fig.16. Each dotted square represents a square-spiral winding pattern in the second layer (Fig.16). The simplified version of the multi-layer array structure is shown in Fig.20. From Fig.20, it can be seen that the overlapped array structure (with correct displacement between the

two layers) divides each square-spiral winding pattern into four smaller sub-regions. The important feature is that the four sub-regions are identical in terms of winding structure. Despite that fact that the distribution of the magnetic field magnitude on the surface of each individual square-spiral winding is not uniform, the distribution of the resultant magnitude field magnitude on the surface of each sub-region is more or less identical because of the overlapped multi-layer winding structure. The concept of the generating uniform magnetic field magnitude over the charging surface is illustrated in Fig.21.

In this example, a multi-layer transformer winding array structure that can provide a uniform magnetic field magnitude distribution is described. This example is based on square-spiral winding patterns. In principle, winding patterns of other shapes can also be applied as long as the resultant magnetic field magnitude distribution is as uniform as possible.

The use of two layers of transformer arrays can reduce the variation in the magnetic flux over the charging surface. However, there may still be some variations and the use of a three or four layer structure may provide a still more uniform flux distribution as described in the following embodiments.

The following embodiment is a structure comprising three layers of planar winding arrays. This PCB winding structure can generate magnetomotive force (*mmf*) of substantially even magnitude over the charging surface. Each winding array consists of a plurality spiral windings each of which are of an hexagonal shape. A spiral winding arranged in a hexagonal shape is shown in Fig.22. For simplicity, it will be represented as a hexagon as shown in Fig.23. A plurality of hexagonal spiral windings can be arranged as an array as shown in Fig.24. These windings can be connected in parallel, in series or a combination of both to the electronic driving circuit. If a current passes

through each spiral winding pattern, a magnetomotive force (*mmf*), which is equal to the product of the number of turns (*N*) and current (*I*) (i.e. *NI*), is generated. Fig.25 shows two spiral winding patterns adjacent to each other and the per-unit *mmf* plot over the distance (dotted line) can be linearized as shown in Fig.26. It can be seen that the *mmf* distribution over the distance is not uniform. The maximum *mmf* occurs in the center of the hexagonal pattern and the minimum *mmf* occurs in the edge of the pattern.

Fig.27 shows three adjacent windings. The maximum *mmf* region is labelled by a symbol 'P' (which stands for Peak *mmf*). The minimum *mmf* region at the junction of two patterns is labeled as 'V' (which stands for Valley of the *mmf* distribution). In order to generate a uniform *mmf* distribution over the planar charging surface, two more layers of PCB winding arrays should be added. This principle is explained firstly by adding a second layer of PCB winding array to the first one as shown in Fig.28. The second layer is placed on the first one in such a way that the peak *mmf* positions (P) of the patterns of one layer are placed directly over the valley positions (V) of the patterns in the other layer. Fig.29 highlights the peak positions of the patterns that are directly over the valley positions of the other layer for the two overlapped PCB layers in Fig.28.

It can be observed from Fig.29, however, that the use of two layers of PCB winding arrays, while presenting an improvement over a single layer, does not offer the optimal solution for generating uniform *mmf* over the inductive charging surface. For each hexagonal pattern in the 2-layer structure, the peak positions occupy the central position and three (out of six) vertices of each hexagon. The remaining three vertices are valley positions (V) that need to be filled by a third layer of PCB winding arrays. These valley positions are shown in Fig.30 as empty squares.

Careful examination of Fig.30 shows that there are six peak positions (P) surrounding each valley position. Therefore, a third layer of a hexagonal PCB winding

array can be used to fill up all these remaining valley positions. By placing the central positions (peak *mmf* positions) of the hexagonal winding patterns of the third layer of the PCB winding array over the remaining valley positions of the two-layer structure, an optimal three-layer structure is formed as shown in Fig.31. Fig.32 highlights the peak *mmf* positions of the three-layer structure. It can be observed that all central positions and vertices of all hexagonal patterns have peak *mmf*.

In order to confirm that the *mmf* over the surface has uniform *mmf* distribution, any distance between any two adjacent peak *mmf* positions can be considered as illustrated in Fig.33. If the winding patterns are excited in the same manner and polarity so that the *mmf* generated by each layer of the winding array are always in the same direction at any moment, the resultant *mmf* is simply the sum of the *mmf* generated by each layer. The dotted line in Fig.33 shows that the resultant *mmf* over the distance between any two adjacent peak positions in Fig.33 is equal to 1.0 per unit. This confirms that the proposed three-layer PCB winding array structure can be used to generate highly uniform *mmf* over the inductive charging surface. When used as a contactless, inductive charging surface, this uniform *mmf* distribution feature ensures that, for a given airgap, a secondary PCB coupling winding can always couple the same amount of magnetic flux regardless of the position of the secondary (coupling) PCB on the inductive charging surface. In addition, the voltage induced in the secondary winding would be the same over the inductive charging surface.

In another embodiment, the three-layer PCB winding array structure can be constructed as a four-layer PCB, with one of the four layers accommodating the return paths of the spiral windings to the electronic driving circuit.

A further embodiment is based again on square spiral winding patterns. In this embodiment four layers of square-spiral winding arrays are used to generate highly

uniform *mmf* over the PCB surface. As in the hexagonal embodiment described above, for convenience of illustration each square-spiral winding pattern (Fig.34) is simplified as a square symbol (Fig.35) in the following description.

Fig.36 shows the first layer of the square-spiral PCB winding array. The *mmf* in the central region of each square pattern is highest. These regions are highlighted as 'Peak' or (P) in Fig.37. The regions of the minimum *mmf* (i.e. the valleys) occurs along the edges of the square patterns. These regions are highlighted with dots (•) in Fig.37.

In order to reduce the *mmf* ripples on the surface, the peak (P) positions of a second layer of square-spiral PCB winding array can placed over some of the valley positions (•) as shown in Fig.38. When a third layer of square-spiral PCB winding array is added to the structure in Fig.38, the resultant layout is shown in Fig.39. It can now be observed that one more layer of the square-spiral PCB windings is needed to fill up all the valleys with peaks as shown in Fig.40.

The inductive battery charging platform described above, which can be regarded as the primary circuit of a transformer system (or the primary inductive charging system), can be used as a standard battery charging platform for portable electronic equipment with compatible inbuilt secondary circuitry in the electronic equipment to be charged. However, existing electronic equipment that is not designed for compatibility with the abovedescribed battery charging platform cannot take advantage of the convenience offered by the battery charging platform. Another embodiment of the present invention therefore provides both a battery charging system that can stand independently and can be used to charge existing conventional devices, and a means by which a conventional electronic device can be charged using the charging platform described above.

Referring firstly to Fig.41 there is shown therein a perspective view of a part of a battery charging system according to an embodiment of the present invention. The part of the charging system shown in Fig.41 may be termed the primary inductive charging system since as will be explained below it comprises at least one primary winding. The part of the battery charging system shown in Fig.41 may also be considered to be an extension system since in preferred forms it may be adapted to charge multiple devices and is therefore analogous to a conventional extension lead that allows multiple items of electronic equipment to share the same power socket.

The charging system is provided with multiple charging slots 100,101,102 for receiving secondary charging modules to be described further below. As will be explained further below each charging slot is provided with a primary winding. Fig.41 shows a schematic of the primary inductive charging extension system with three charging slots. However, it should be noted that the number of slots is not restricted to three and can be as few as a single charging slot, or can be more than three. It will be understood that the number of charging slots dictate the number of devices that can be charged simultaneously. The primary charging extension system is connected to the mains through a plug 103 and includes a power electronic circuit 104 that provides a high-frequency (typically in the range of 1kHz to 2MHz) AC voltage to the primary windings that are located under the charging slot surfaces. It should be noted that the surfaces of the slots are flat and the slots are separated from each other by dividing walls. Each slot is therefore the same size as the surface of a housing of a secondary module to be described below, and the separating walls and mechanical switches to be described below together act to engage a secondary module and hold it in a correct orientation for efficient charging.

Each primary winding can be a coil 105 as shown in Fig.42 or a printed-circuit-board (PCB) winding 106 as shown in Fig.43. If the primary winding is a coil 105, the coil 105 is preferably accommodated in a space 107 defined by a magnetic structure 108 such as the two examples shown in Fig.44(a) and (b) in which the coil is wound around a magnetic core 108. If a PCB winding is used, appropriate electromagnetic (EM) shielding, such as the combined use of ferrite and copper sheets described in US 6501364, can be placed under the PCB winding in order to ensure that the magnetic flux generated in the PCB winding will not penetrate through the base of the primary inductive charging extension system. Preferably, mechanical switches 109 can be provided in each charging slot that when closed activate the primary winding to the high-frequency AC voltage source when the secondary charging module (to be described below) is inserted in that particular slot. As discussed above, the mechanical switches may also serve to engage and hold the secondary module in place. This mechanism ensures that only windings in the slots used by the secondary modules are excited by the high-frequency AC voltage source. The equivalent circuit is shown in Fig.45.

It will also be understood that the primary winding could be constructed as a multiple layer structure as discussed above in order to provide a particularly preferred even flux distribution over the charging surface.

Fig.46 shows a typical secondary charging module 200 for use with the primary charging extension system shown in Fig.41. Each secondary module has a conventional cable 201 and charger connecter 202 that is adapted to be received within the charging socket of a conventional electronic device. It will be understood that different secondary charging modules 200 may be provided differing only by the type of the connector 202. Each secondary charging module 200 is provided with a housing 203 that contains a

secondary circuit to be described below. The housing is preferably rectangular (but of course could be any suitable shape) and of such a size that it may be received in one of the slots 100-102 of the primary charging extension system. The housing 203 should have at least one preferably flat surface for placing on the charging slot of the primary charging extension system. This flat surface is preferably parallel to the plane of the secondary winding within the housing such that when the secondary module is placed in a slot of the primary extension system the secondary winding is substantially parallel to the primary winding beneath the surface of the slot. The housing 203 of the secondary module should preferably be made of non-conductive and non-ferromagnetic material so that no current will be induced in the housing material.

As can be seen from Figs.47 and 48 inside each secondary charging module 200 are at least one secondary winding 204 and charger circuitry 205 that receives the induced AC voltage in the secondary winding and provides a regulated DC output voltage for the charging purpose. The secondary winding should be kept inside the housing. The secondary winding can be a coil (Fig.47) or it can be printed on a PCB (Fig.48). The function of the secondary winding is to act as the secondary winding of a transformer system to pick up the changing magnetic flux generated by the primary winding of the primary charging extension system.

The secondary coil or PCB winding should be placed close to the (preferably flat) surface of the housing of the secondary charging module so as to pick up maximum changing AC magnetic flux from the primary inductive charging extension system or platform. According to Faraday's Law, an AC voltage will be induced across the secondary winding if the secondary winding senses a changing magnetic flux (that can be generated by the primary winding in the primary inductive charging system).

The terminals of the secondary winding are connected to the input terminals of an electronic circuit 205 that (1) performs the AC-DC power conversion function (i.e. rectifying the AC voltage into DC) and (2) preferably also regulate the DC voltage to a desired value (typically in the range from 3V to 24V) within a certain tolerance. Through a cable and a charger connector for connecting to charging socket in the portable equipment, this DC voltage can be used to charge the portable equipment a shown in Fig.49.

The secondary winding design (such as number of turns and dimensions of windings), the DC regulated voltage level and the type of connector can be designed according to the charging requirements of specific electronic products. Therefore, different secondary charging modules can be designed for different ranges of products, but all secondary modules are compatible with the same primary charging extension system as shown in Fig.50 in which two different types of secondary modules adapted for charging different devices and having different connectors 202,202' are shown in adjacent slots of the primary charging extension system. As the primary inductive charging extension system preferably has several charging slots for accommodating the secondary charging modules, it can be used to charge several items of conventional portable electronic equipment simultaneously.

A further advantage of the secondary charging module is that it allows a conventional electronic device to be charged using the inductive battery charging platform described above. Although a conventional electronic device cannot be charged by placing it directly on the charging platform surface because it does not have the in-built secondary winding, instead a secondary charging module can be placed in the inductive charging system and charge the conventional device therefrom as shown in Fig.51

In principle, the housing of the secondary charging module can have more than one preferably flat interface surface. If the housing is a cuboid it will have two large opposed interface surfaces (eg upper and lower surfaces of a relatively thin flat cuboid structure a shown in the Figures) and with this cuboid design, either interface surface of the secondary module housing can be placed on the charging slots of the primary inductive charging extension system or other charging platform. This cuboid design makes the secondary charging modules very user-friendly because it does not matter which way up the housing of the secondary module is placed on the primary charging surface.

In summary, a preferred embodiment of the secondary charging module consists of

(i) a non-conductive housing that has at least one surface (and preferably two surfaces) for placing on the charging slot of the primary charging extension system or the charging platform and that accommodates the secondary winding and circuitry for charging the electronic equipment,

(ii) A secondary winding, that can either be printed in a printed-circuit-board (PCB) or a conductor coil,

(iii) an AC-DC power conversion circuit that converts the ac induced voltage picked by the secondary winding from the primary AC voltage excitation into a regulated or unregulated DC voltage, typically in the range from 3V to 24V,

(iv) a conventional cable that connects the DC voltage output of the secondary circuitry to a connector that is compatible with the charging socket in the conventional electronic equipment.

It will thus be seen that, at least in preferred forms, the charging system of the present invention including the proposed secondary charging modules offers users a

convenient and user-friendly battery charging system for a wide range of portable electronic equipment. Using the appropriate charger connectors that are compatible with different portable equipment, the proposed charging system enables one single charging system (that occupies only one power point or socket in the ac mains) to charge a wide range of electronic equipment.

The present invention, at least in preferred forms, provides a new charging system allows more than one piece of equipment to be charged simultaneously, and regardless of their orientations on the charging surface, and allows a movable device to be charged while it moves over the charging surface.

CLAIMS

1. A battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer, said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

2. A battery charger system as claimed in claim 1 wherein said transformer primary winding is formed on a printed circuit board.

3. A battery charging system as claimed in claim 1 wherein the magnetic flux generated by said primary winding is substantially uniform over at least a major part of said planar charging surface.

4. A battery charging system as claimed in claim 1 wherein said charging module comprises a plurality of primary windings.

5. A battery charging system as claimed in claim 4 wherein said primary windings are disposed in a regular array.

6. A battery charging system as claimed in claim 4 wherein said primary windings are formed in a multi-layer structure comprising at least two layers and with each said layer including an array of primary windings.

7. A battery charging system as claimed in claim 6 wherein the array of a first said layer is offset relative to the array of a second said layer whereby regions of said first layer generating maximum magnetic flux coincide with regions of said second layer that generate minimum magnetic flux.

8. A battery charging system as claimed in claim 6 comprising three layers of hexagonal windings.

9. A battery charging system as claimed in claim 6 comprising four layers of square windings.

10. A battery charging system as claimed in claim 5 wherein said primary windings are hexagonal, circular, rectangular, square or polygonal in shape.

11. A battery charger system as claimed in claim 1 wherein said shielding includes a sheet of ferrite material.

12. A battery charging system as claimed in claim 11 wherein said shielding further includes a second sheet of conductive material.

13. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to receive two or more electronic devices, and wherein said primary charging circuit is adapted to charge two or more devices simultaneously.

14. A battery charging system as claimed in claim13 wherein said planar charging surface is divided into a plurality of charging regions.

15. A battery charging system as claimed in claim 14 wherein said primary charging circuit comprises a plurality of primary transformer windings arranged in a regular array and wherein said windings are connected in groups to define said charging regions.

16. A battery charging system as claimed in claim 1 wherein said primary charging circuit comprises an array of primary windings, and wherein when a device is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

17. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to enable a said device to be moved over said charging surface while being charged.

18. A charging module for a battery charging system, said module comprising a primary charging circuit and being formed with a charging surface for receiving

an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

19. A charging module as claimed in claim 18 wherein when an electronic device to be charged is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

20. A charging module as claimed in claim 18 wherein said transformer primary windings are connected to each other in series and/or in parallel.

21. A charging module as claimed in claim 18 wherein said primary transformer windings are planar and substantially parallel to a planar charging surface.

22. A charging module as claimed in claim 21 wherein said primary windings are formed in at least two planes, each said plane including an array of said windings.

23. A charging module as claimed in claim 22 wherein the array of a first said plane is offset relative to the array of a second said plane whereby regions of said first array that generate maximum magnetic flux coincide with regions of said second array that generate minimum magnetic flux.

24. A charging module as claimed in claim 22 comprising three layers of hexagonal windings.

25. A charging module as claimed in claim 22 comprising four layers of square windings.

26. A charging module as claimed in claim 21 wherein said primary windings are formed on a printed circuit board.

27. A charging module as claimed in claim 21 wherein electromagnetic shielding is provided on the side of said primary windings opposite from said planar charging surface.

28. A charging module as claimed in claim 27 wherein said shielding comprises a sheet of ferrite material.

29. A charging module as claimed in claim 28 wherein said shielding further comprises a second sheet of conductive material.

30. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow two or more devices to be charged thereon simultaneously.

31. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow a device to be moved over the charging surface while being charged.

32. A battery powered portable electronic device comprising a rechargeable battery, and wherein said device includes a planar secondary winding for receiving

electrical energy from a battery charger, and electromagnetic shielding between said winding and the major electronic components of said device.

33. An electronic device as claimed in claim 32 wherein said shielding comprises a sheet of ferrite material and a sheet of conductive material.

34. An electronic device as claimed in claim 32 wherein said winding is formed integrally with a back cover of said device.

35. A battery charging system comprising a primary module and at least one secondary module, said primary module comprising means for connecting to a mains supply, and at least one primary winding adjacent a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

36. A battery charging system as claimed in claim 35 wherein said primary charging module comprises a plurality of primary windings each associated with a respective charging surface whereby said primary charging module is able to receive a plurality of secondary charging modules simultaneously.

37. A battery charging system as claimed in claim 36 wherein said charging surfaces are provided with engagement means for engaging a secondary module.

38. A battery charging system as claimed in claim 37 wherein said engagement means include a mechanical switch whereby power is supplied to said primary winding only when a secondary module is engaged by a charging surface.

39. A battery charging system as claimed in claim 35 wherein said primary winding is formed by a coil.

40. A battery charging system as claimed in claim 39 wherein said coil is wound on a magnetic structure.

41. A battery charging system as claimed in claim 39 wherein said coil is parallel to said charging surface.

42. A battery charging system as claimed in claim 35 wherein said primary winding is printed in a printed circuit board.

43. A battery charging system as claimed in claim 42 wherein said printed circuit board is parallel to said charging surface.

44. A battery charging system as claimed in claim 35 wherein said secondary winding is formed by a coil.

45. A battery charging system as claimed in claim 44 wherein said coil is parallel to said charging surface.

46. A battery charging system as claimed in claim 1 wherein said secondary winding is printed on a printed circuit board.

47. A battery charging system as claimed in claim 46 wherein said printed circuit board is parallel to said charging surface.

48. A secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

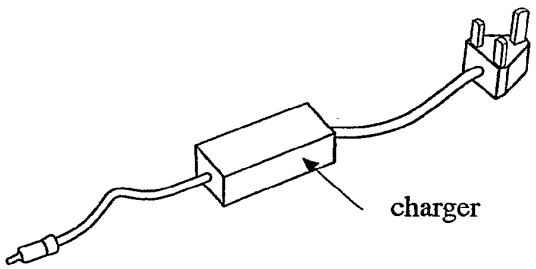


FIG.1 (PRIOR ART)

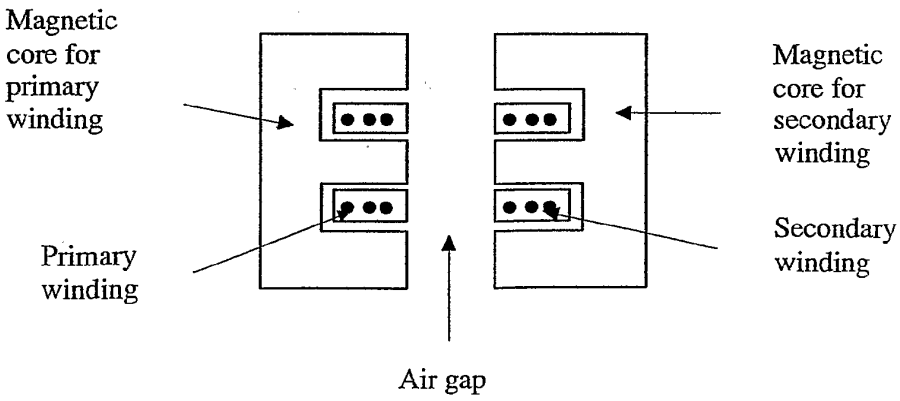


FIG.2 (PRIOR ART)

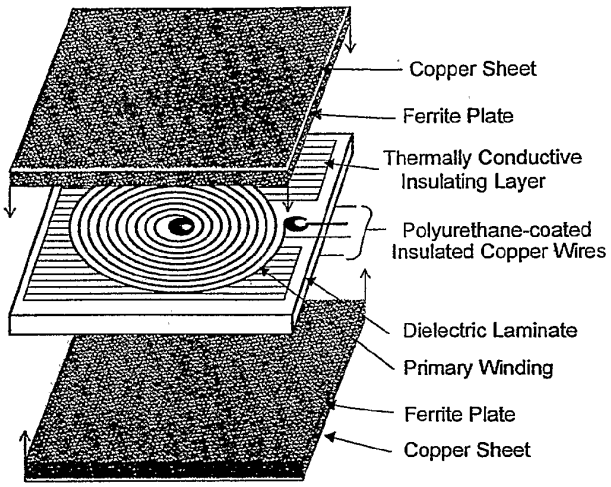


FIG.3 (PRIOR ART)

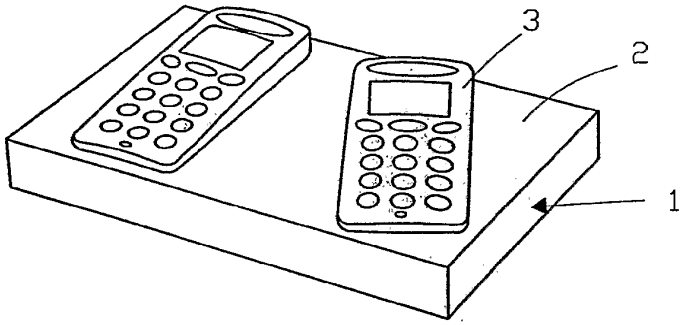


FIG.4(a)

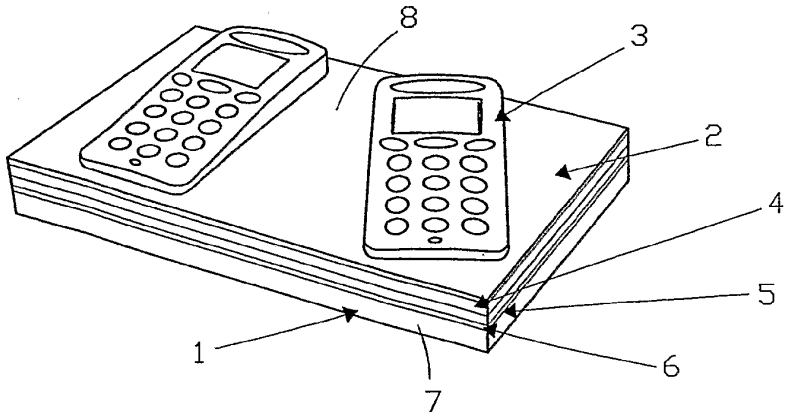


FIG.4(b)

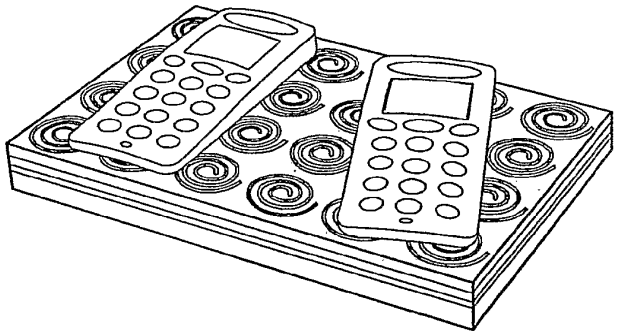


FIG.4(c)

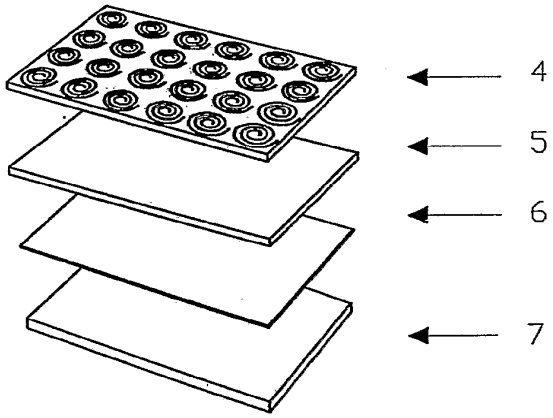


FIG.5(a)

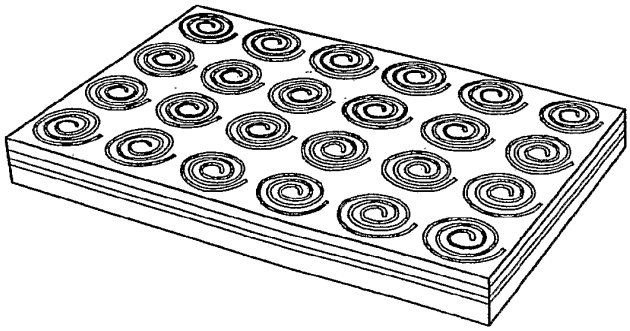


FIG.5(b)

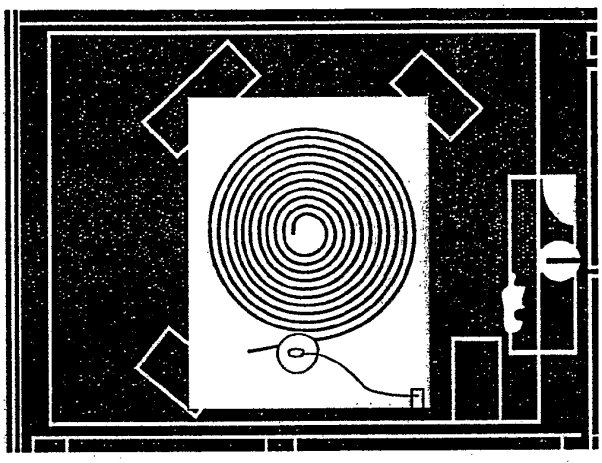


FIG.6(a)

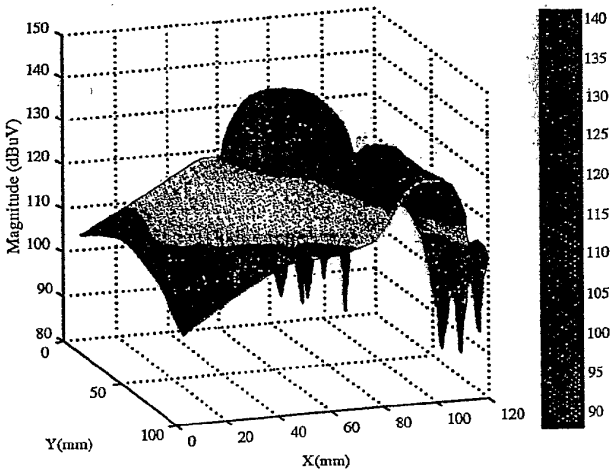

Magnitude (dBuV)
150
140
130
120
110
100
90
80
0
50
100
Y(mm)
0
20
40
60
80
100
120
X(mm)
140
135
130
125
120
115
110
105
100
95
90

FIG.6(b)

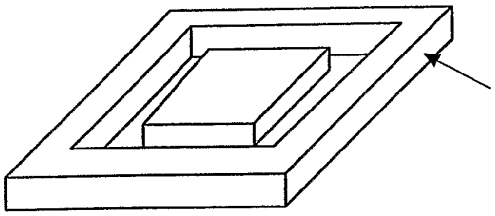


FIG.7(a)

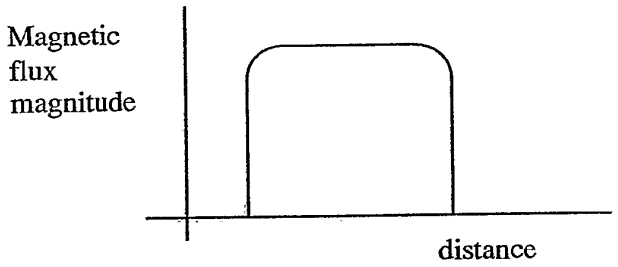


FIG.7(b)

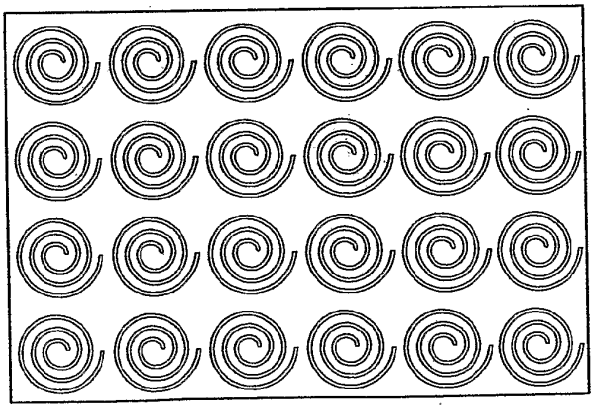


FIG.8

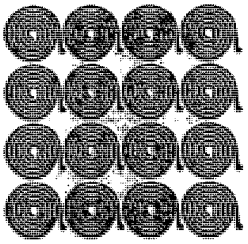


FIG.9(a)

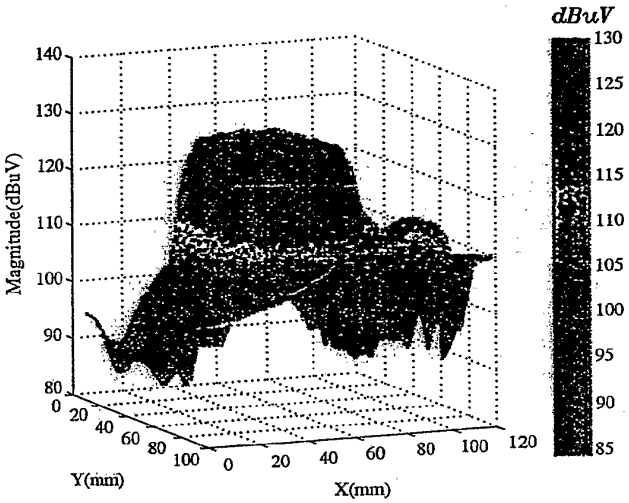

dBuV
130
125
120
115
110
105
100
95
90
85
Magnitude(dBuV)
140
130
120
110
100
90
80
0
20
40
60
80
100
Y(mm)
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20
40
60
80
100
120
X(mm)

FIG.9(b)

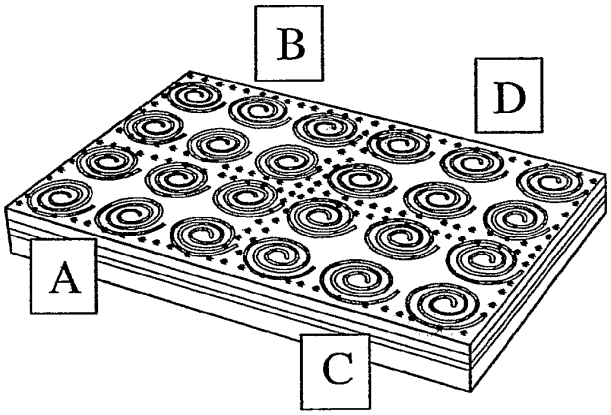


FIG.10(a)

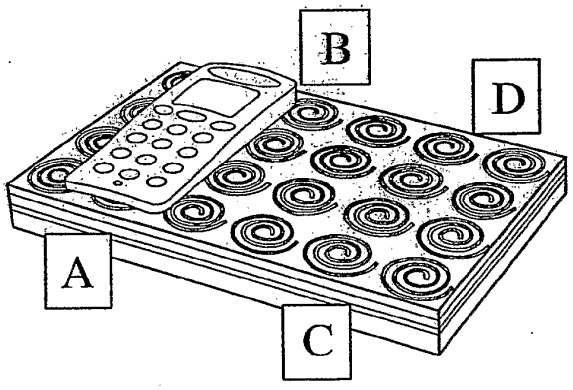


FIG.10(b)

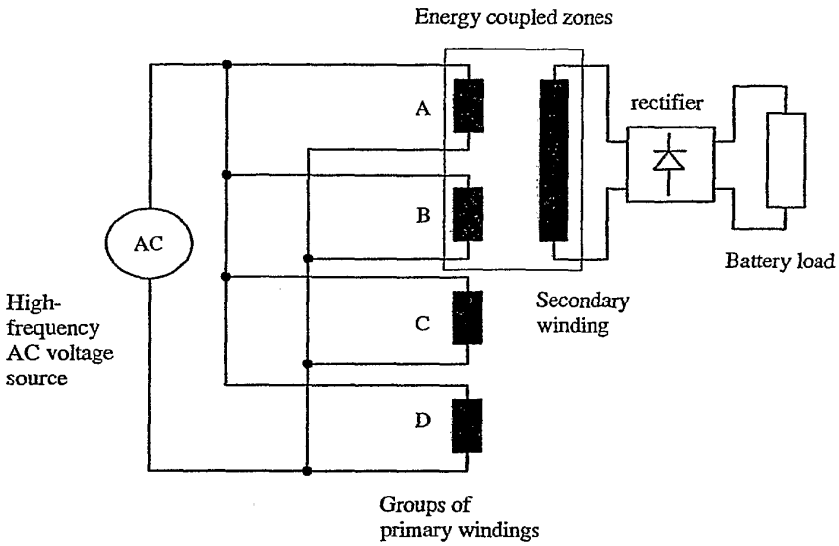


FIG.10(c)

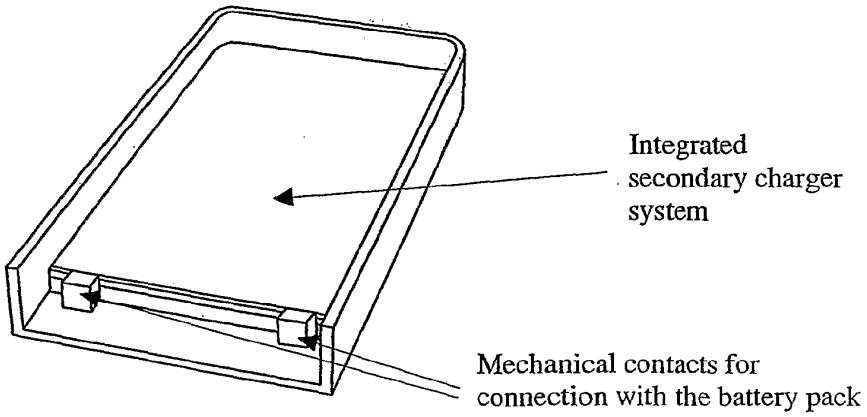


FIG.11

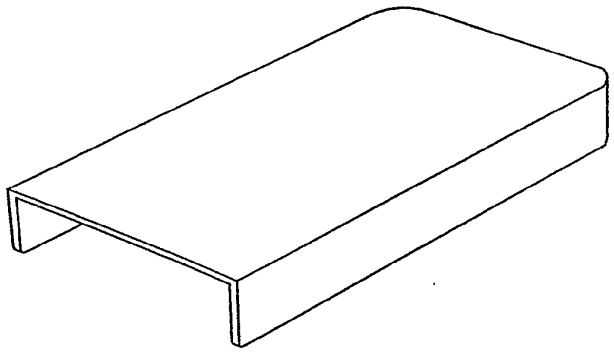


FIG.12(a)

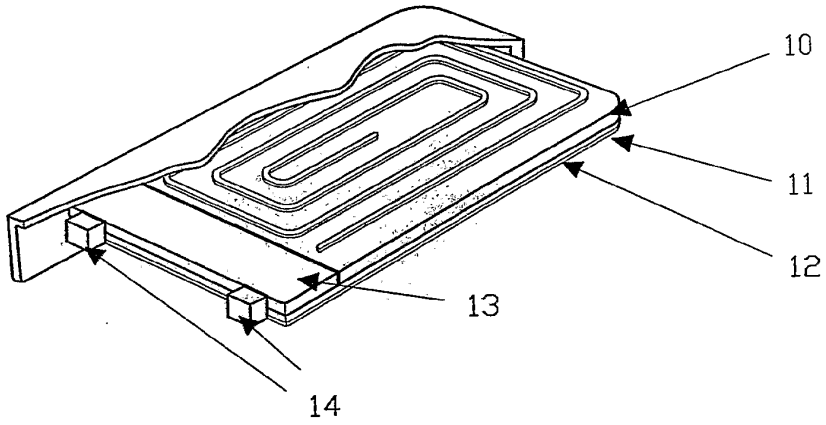


FIG.12(b)

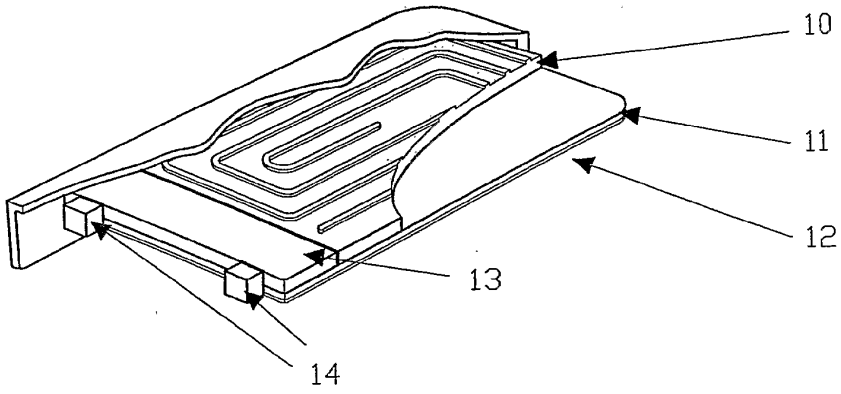


FIG.12(c)

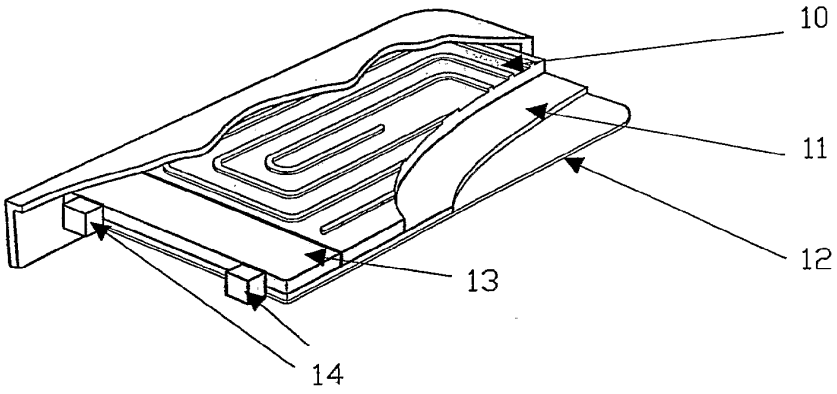


FIG.12(d)

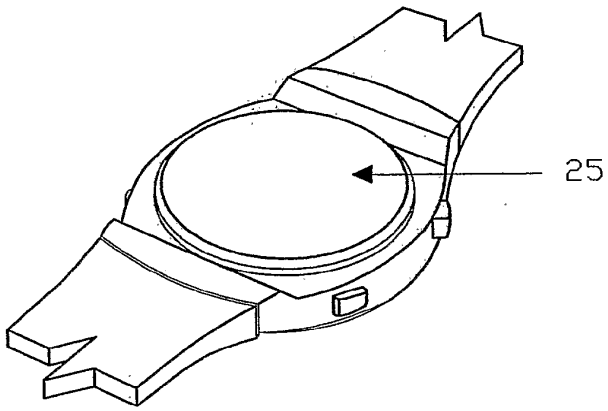


FIG.13(a)

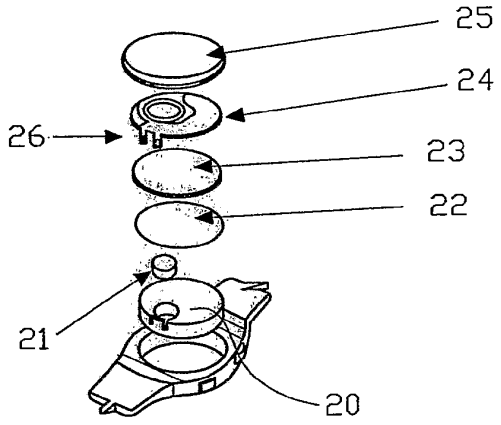


FIG.13(b)

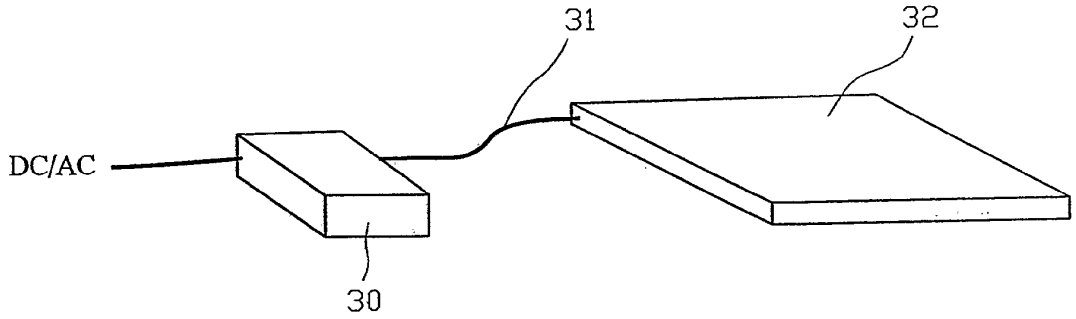


FIG.14

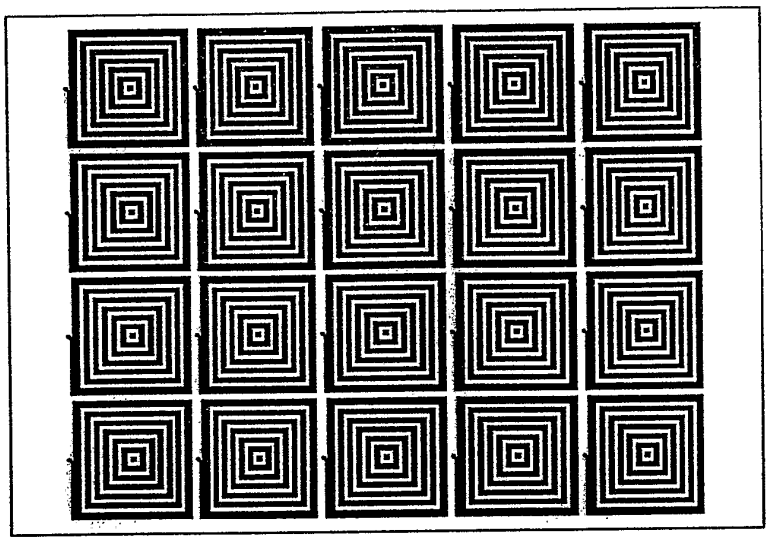


FIG.15

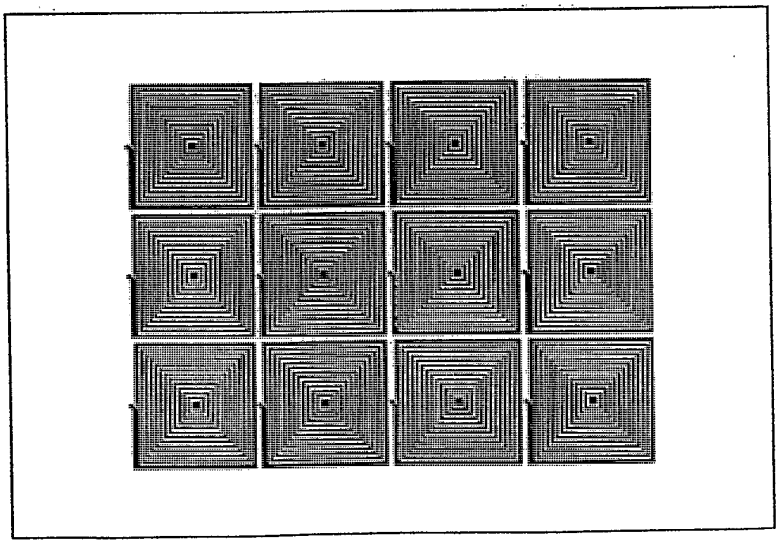


FIG.16

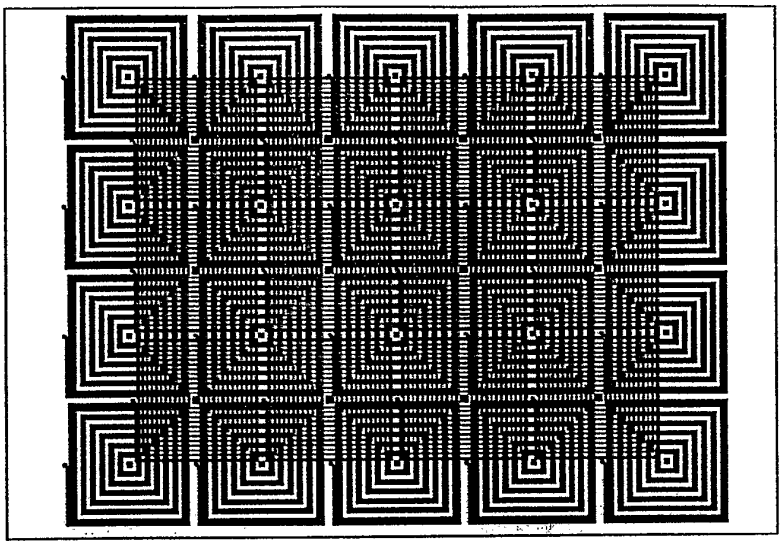


FIG.17

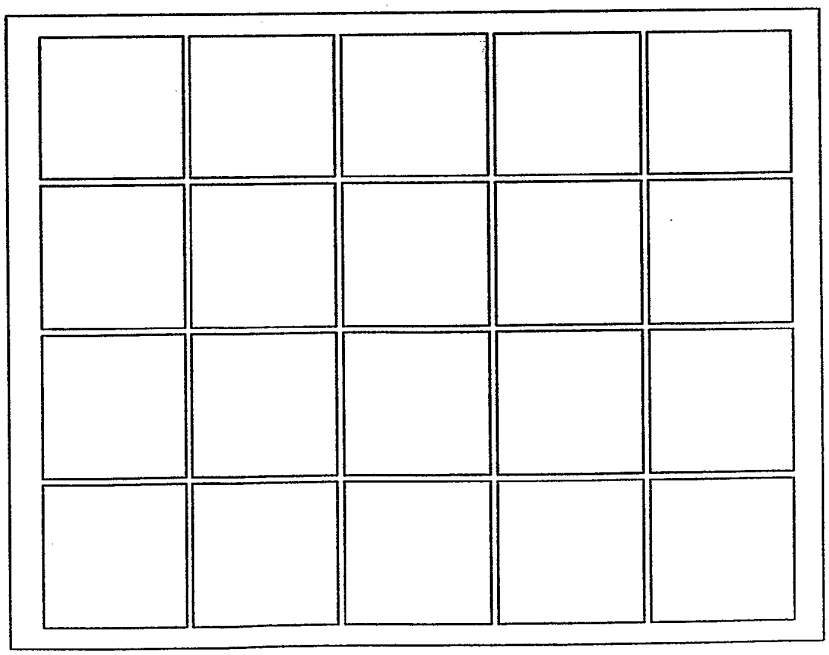


FIG.18

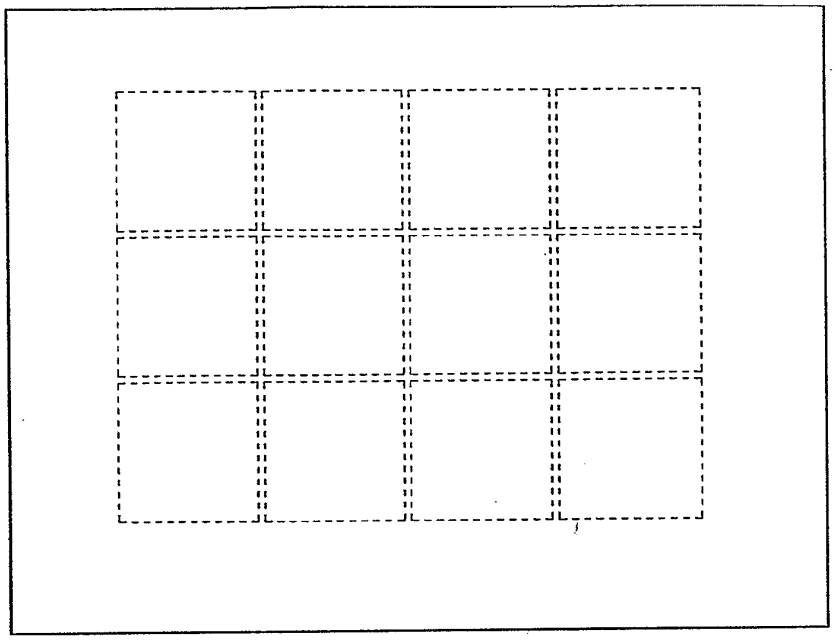
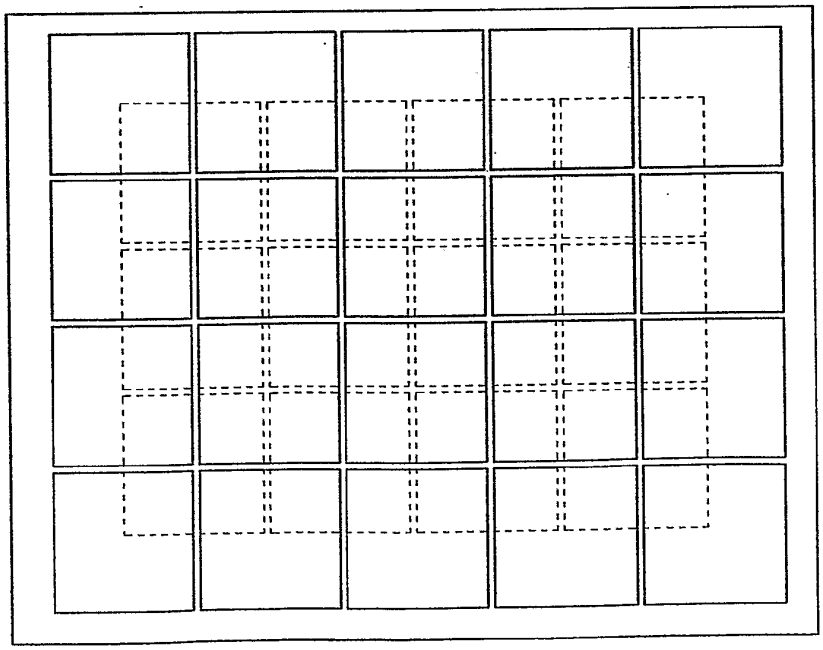


FIG.19



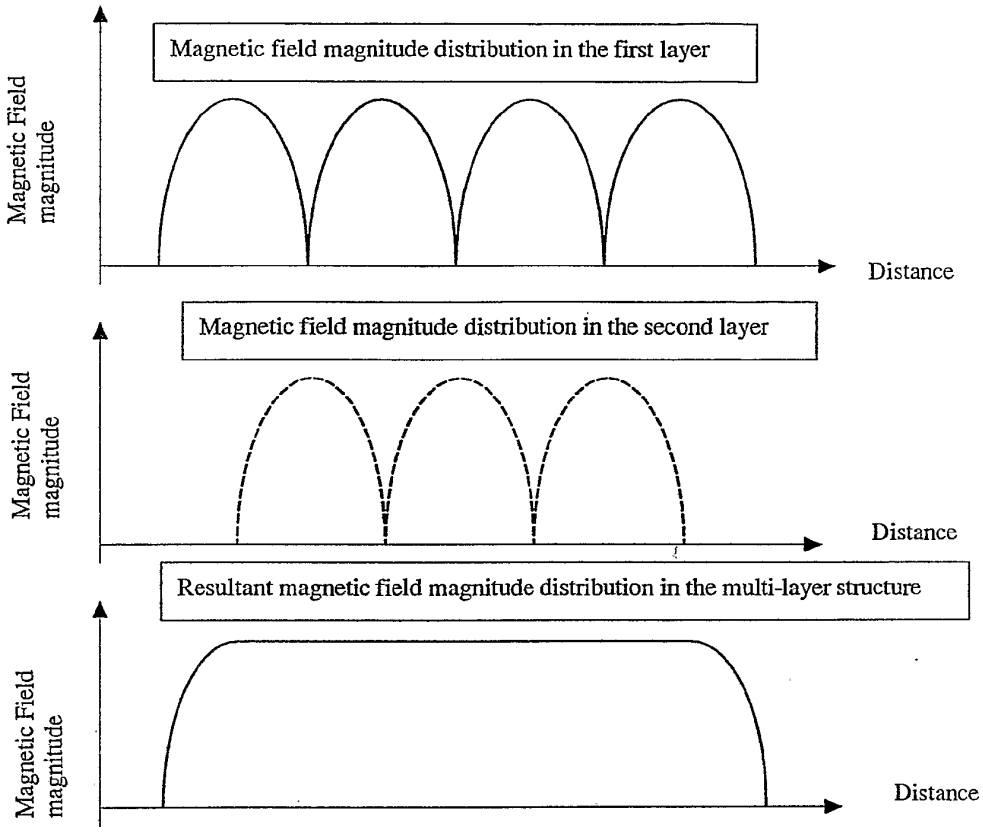


FIG.21

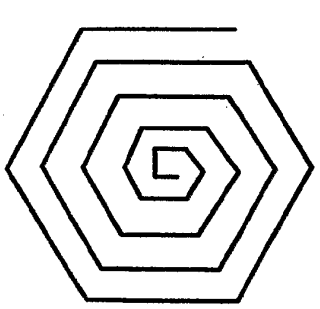


FIG.22

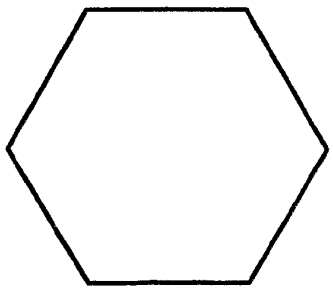


FIG.23

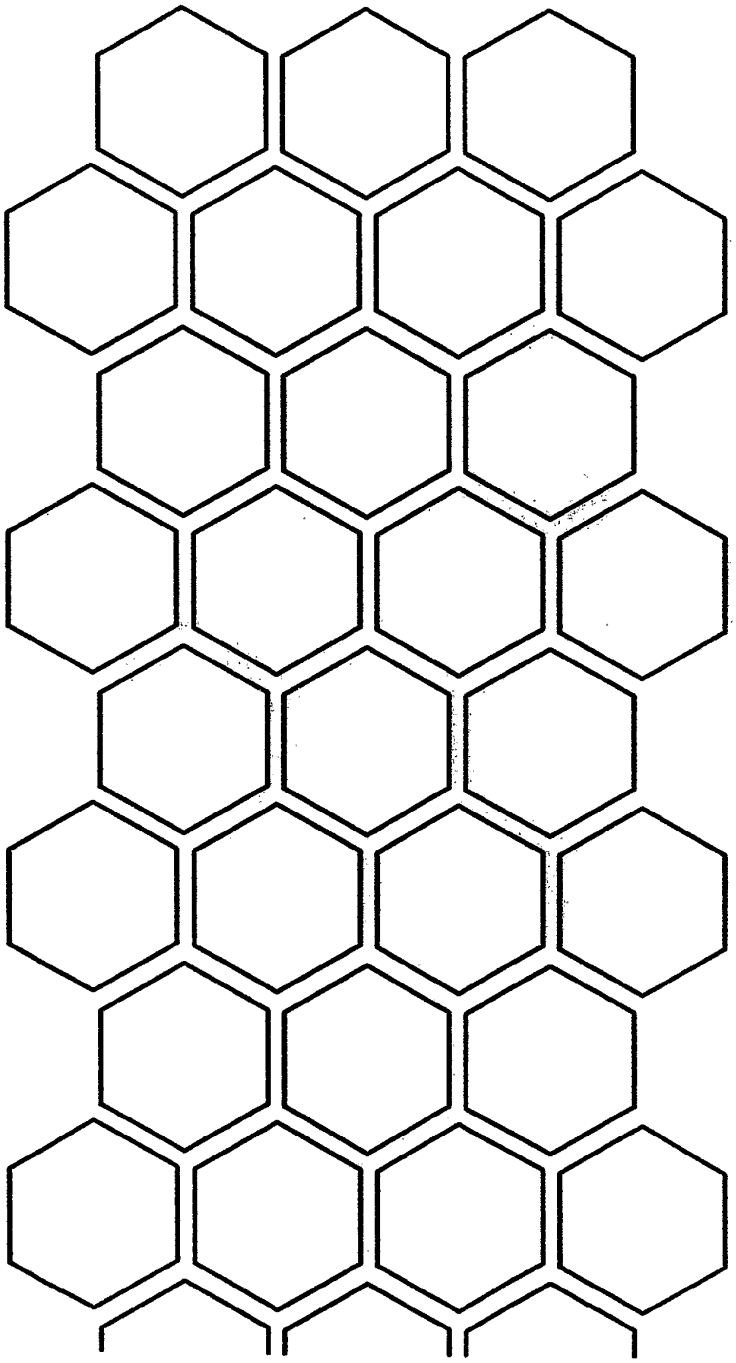


FIG.24

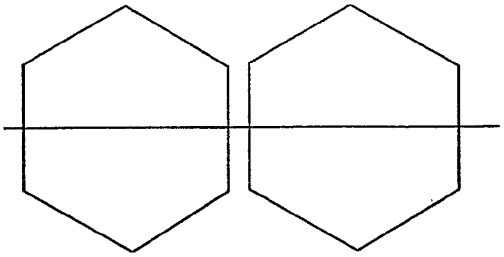


FIG.25

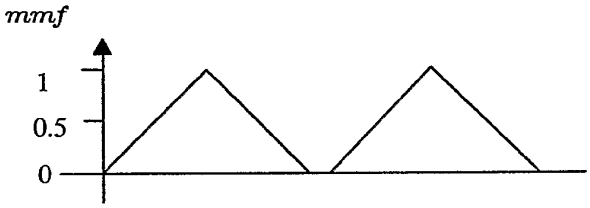


FIG.26

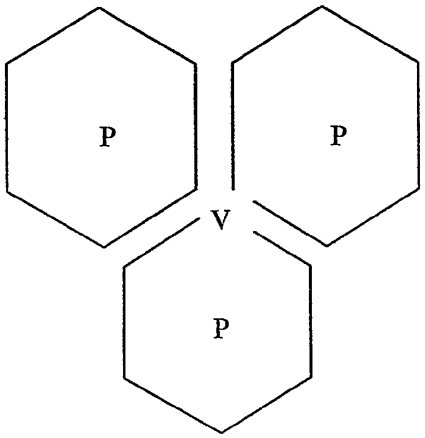


FIG.27

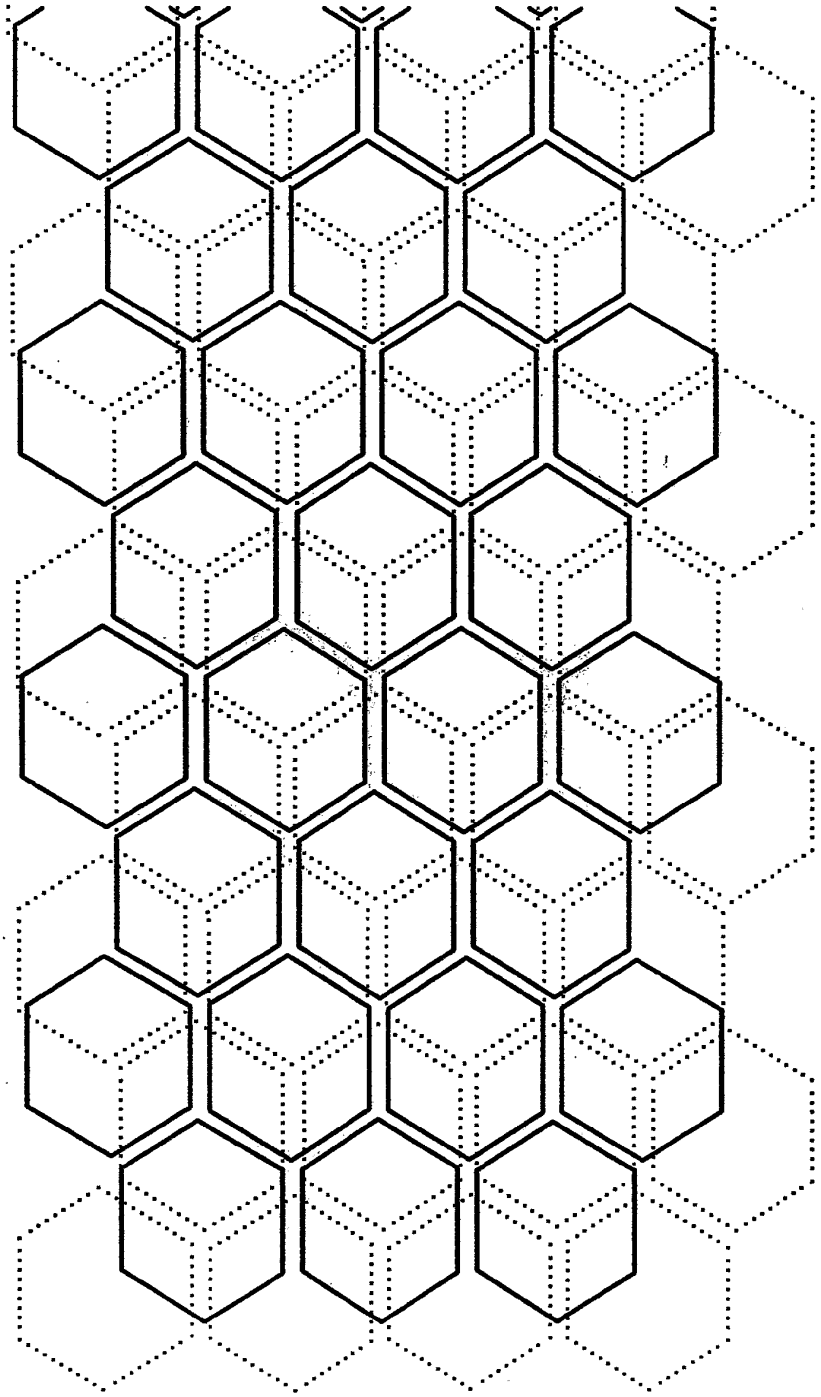


FIG.28

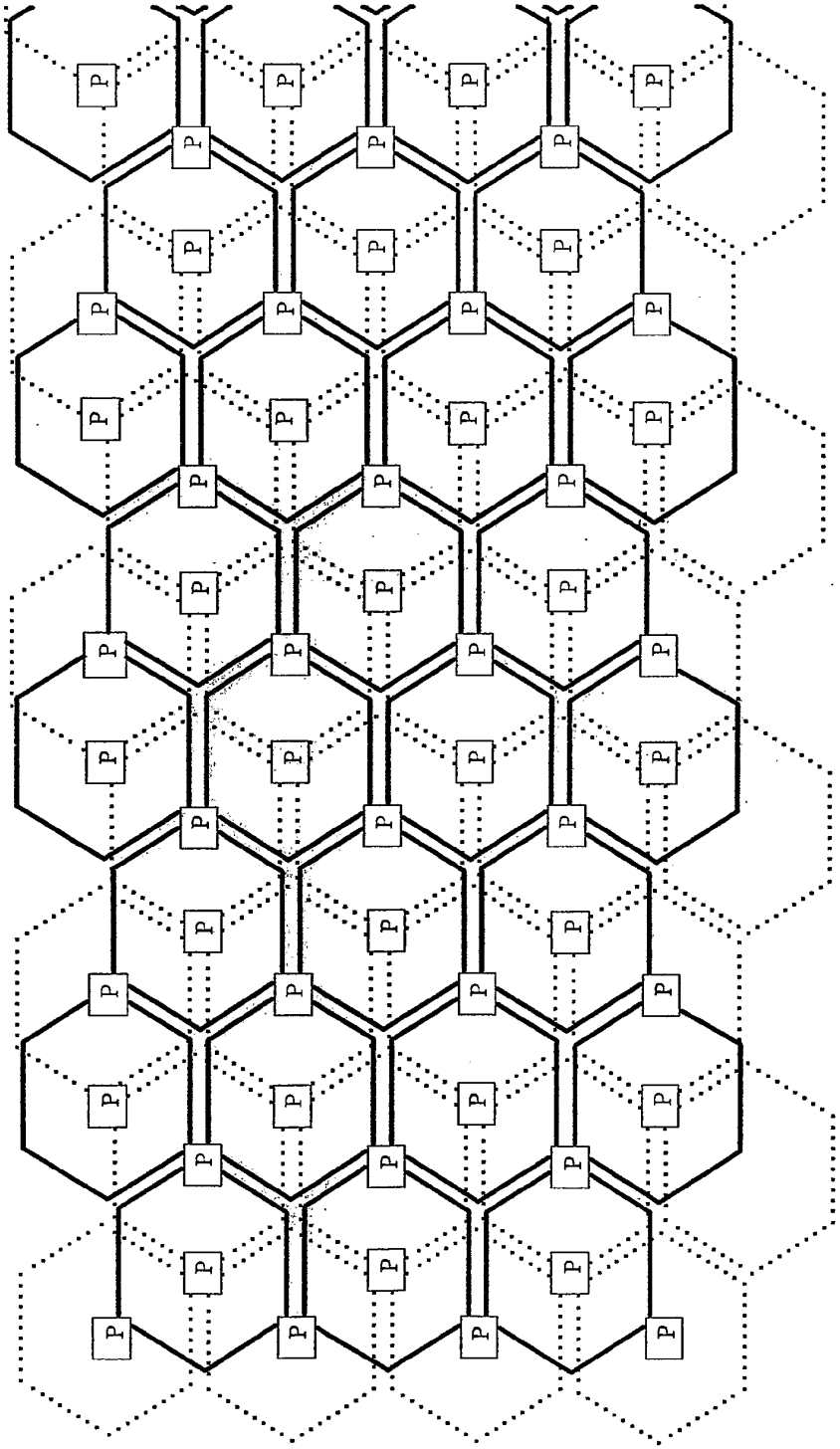


FIG.29

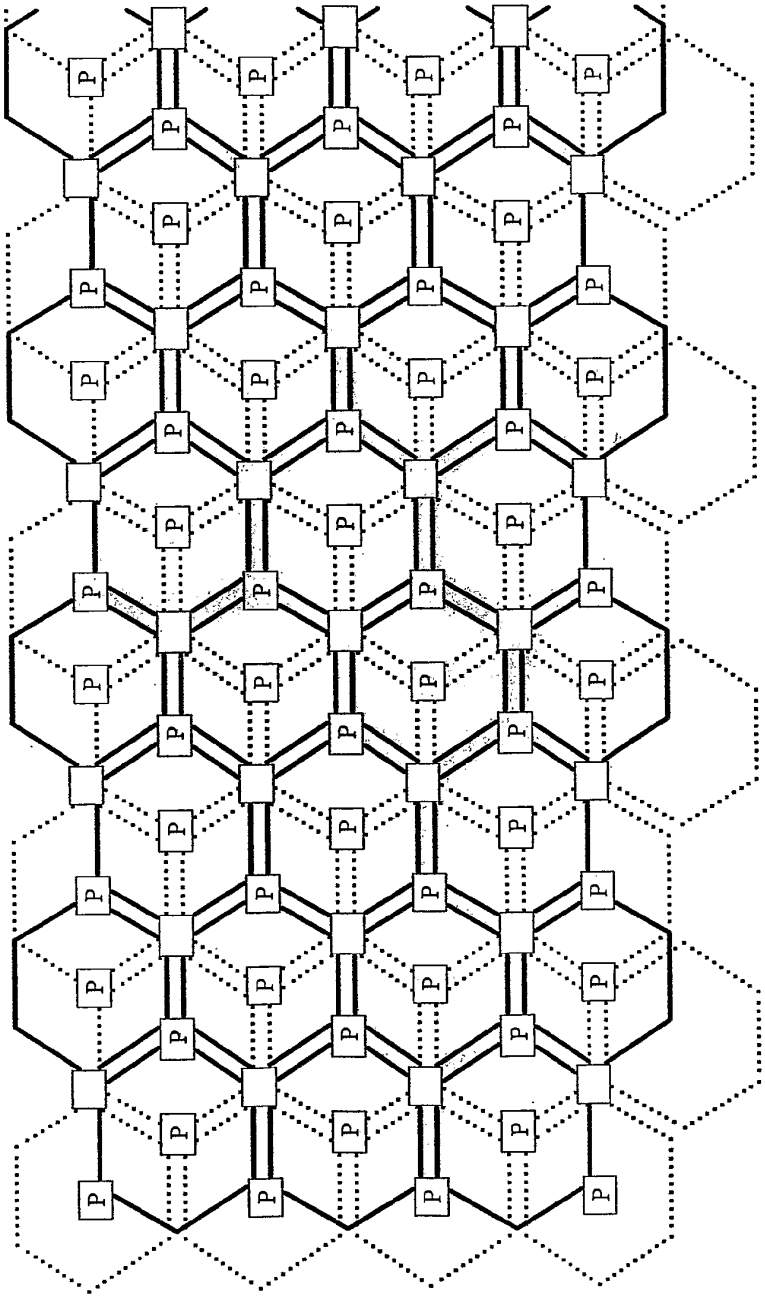


FIG.30

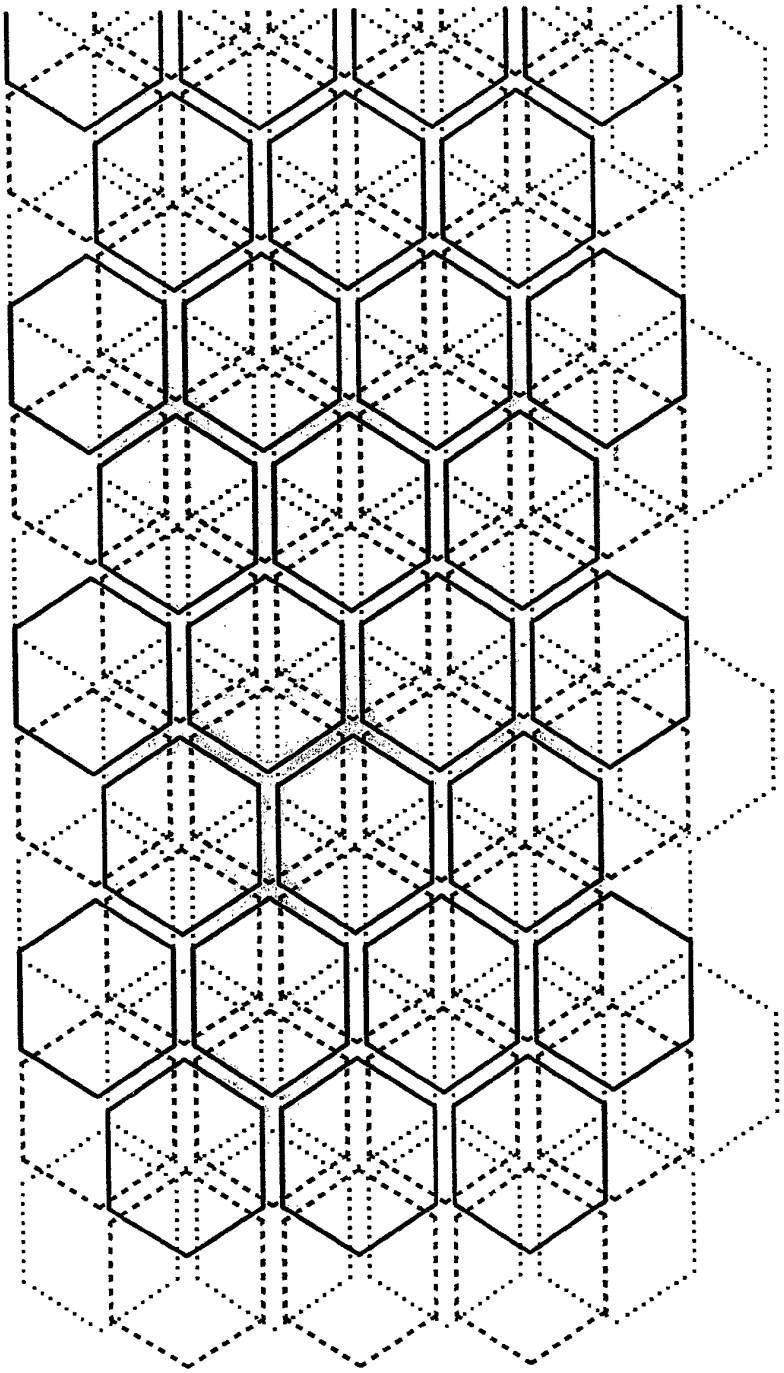


FIG.31

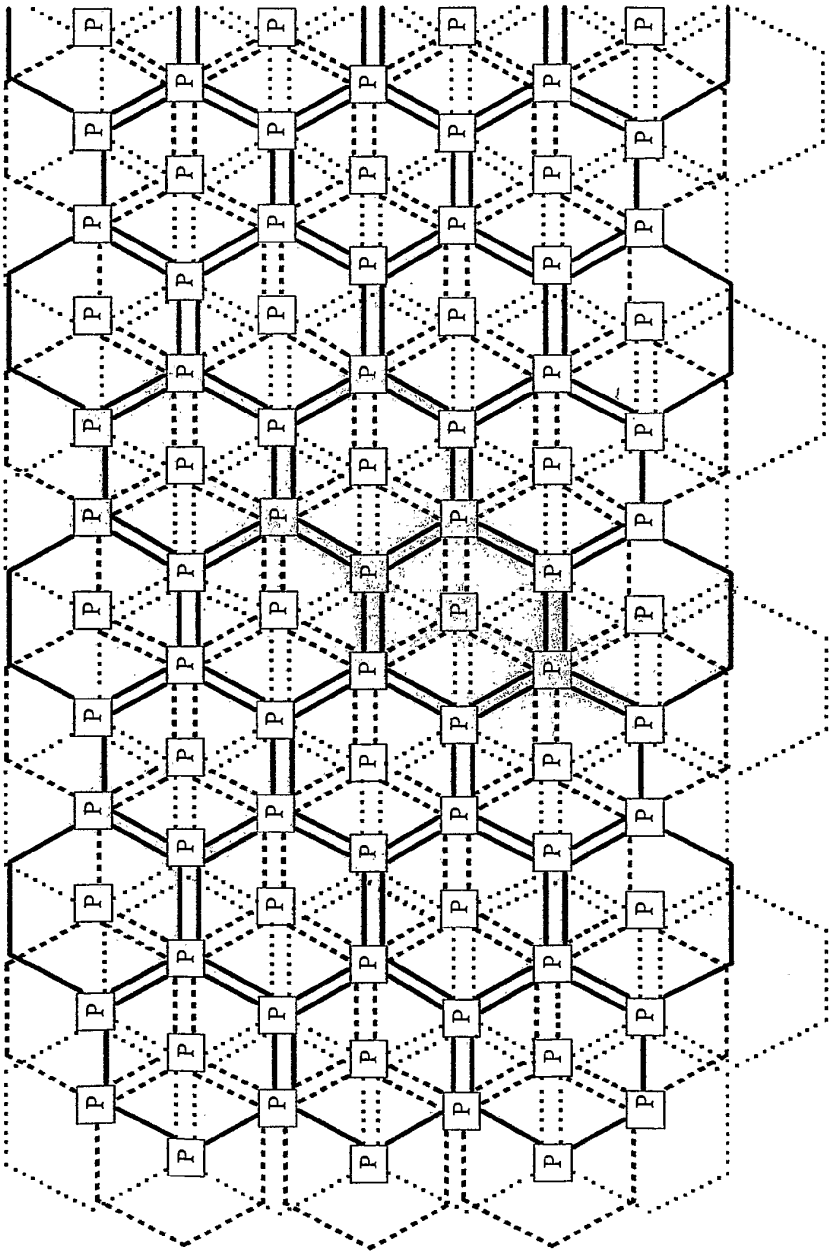


FIG.32

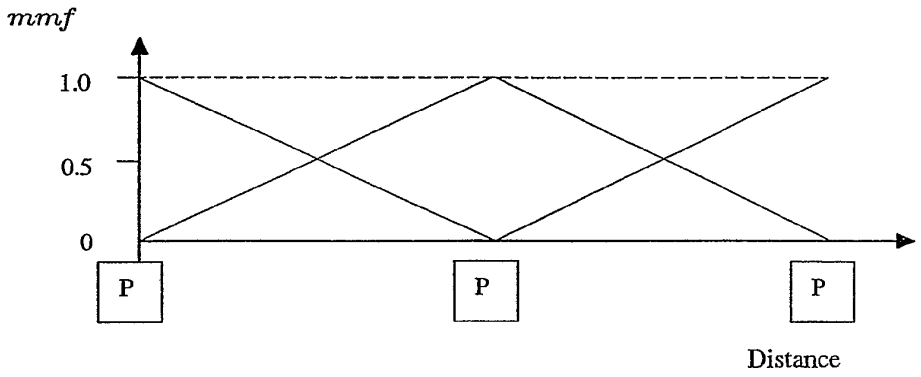


FIG.33

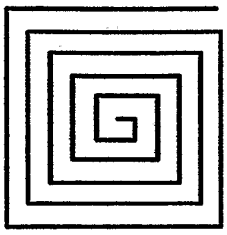


FIG.34

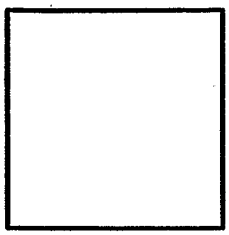


FIG.35

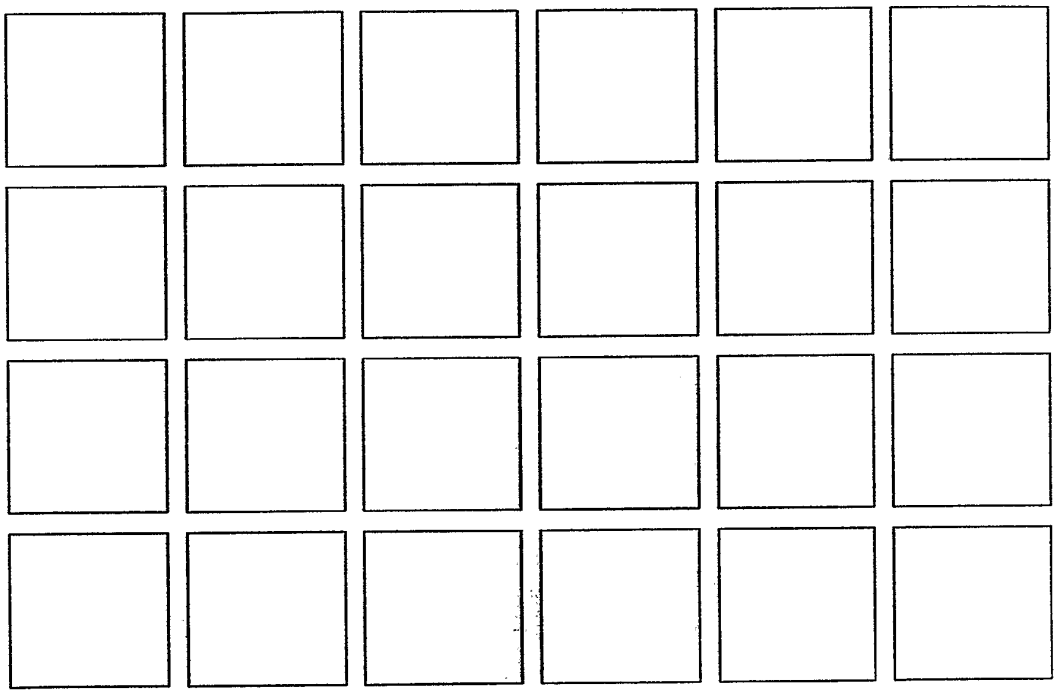


FIG.36

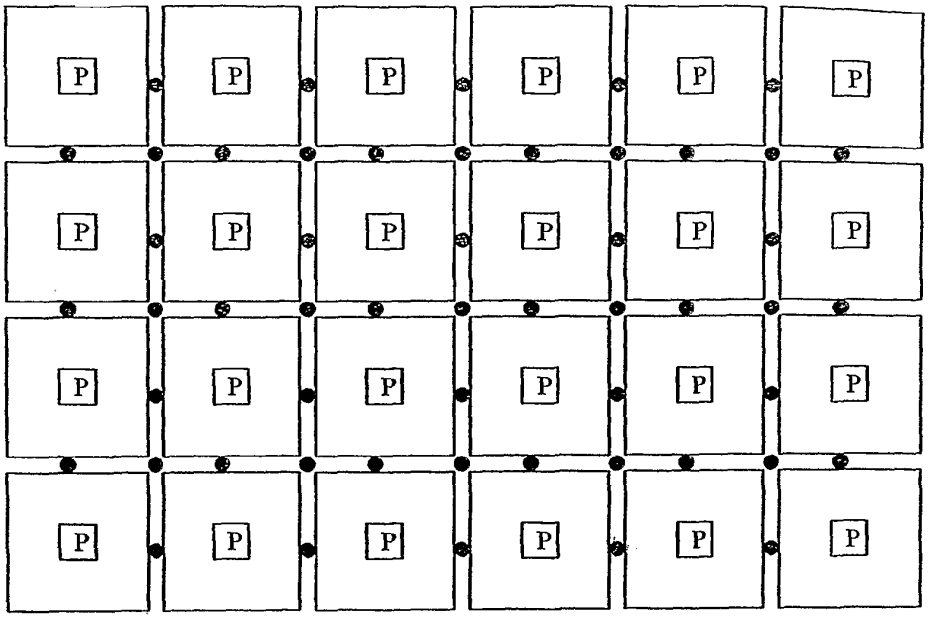


FIG.37

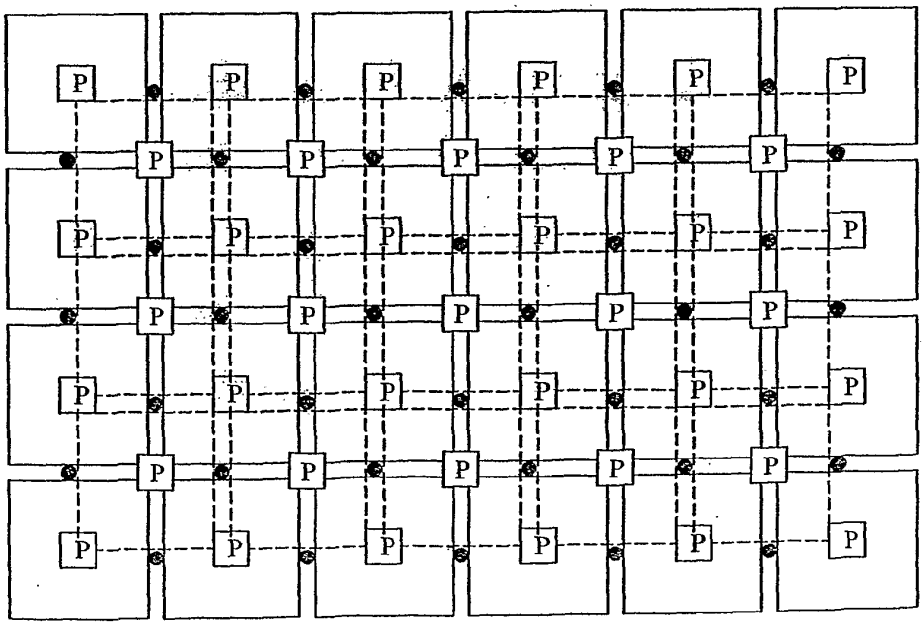


FIG.38

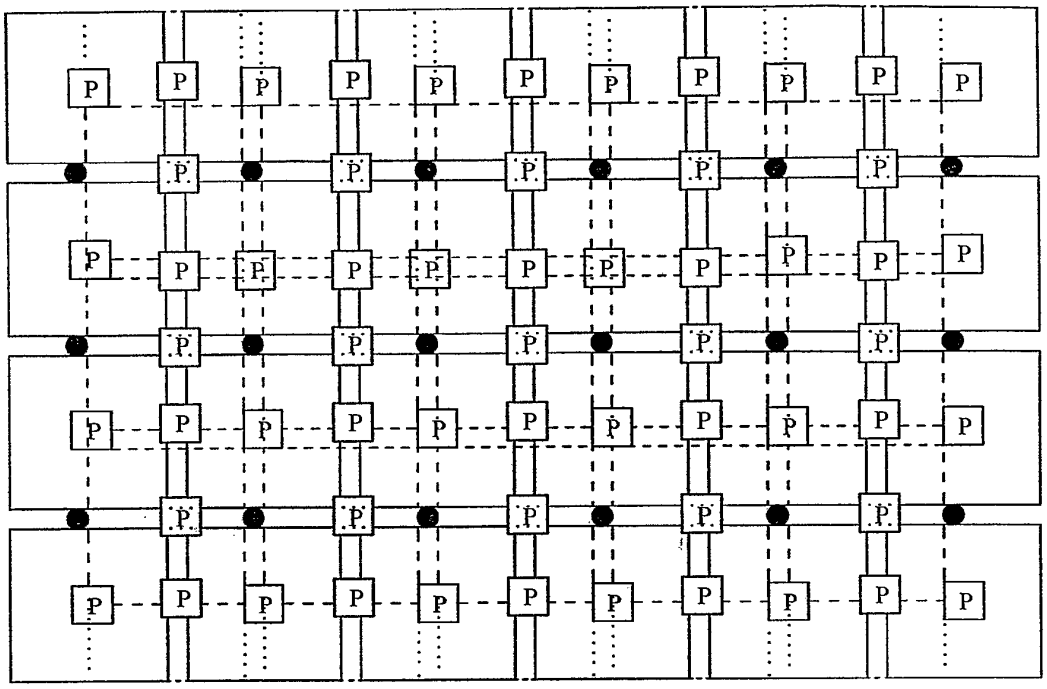


FIG.39

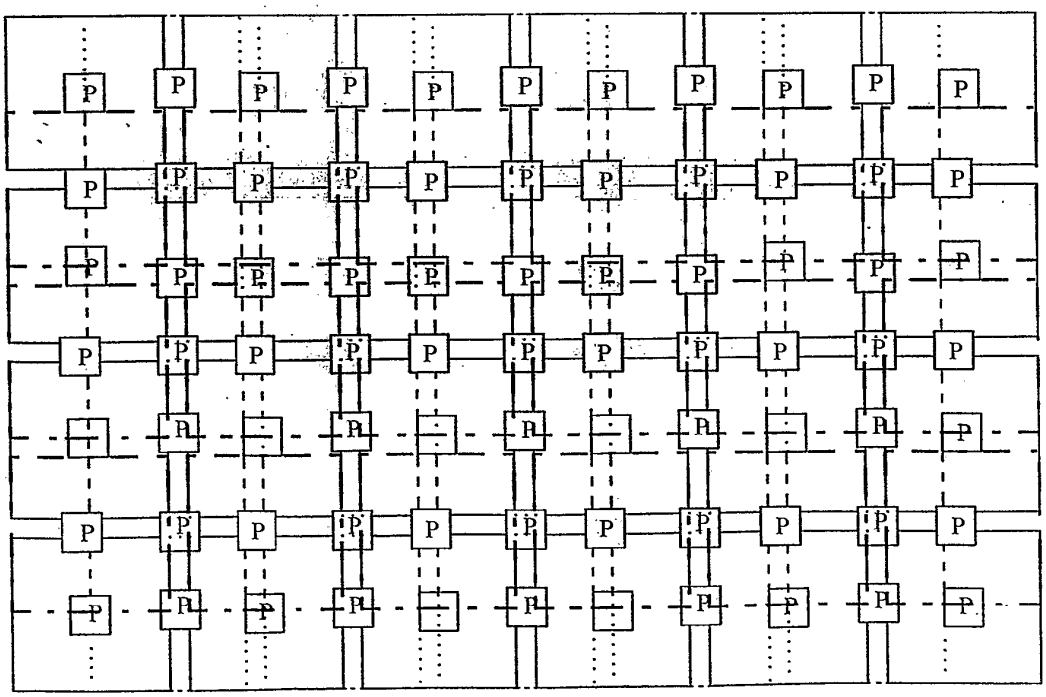


FIG.40

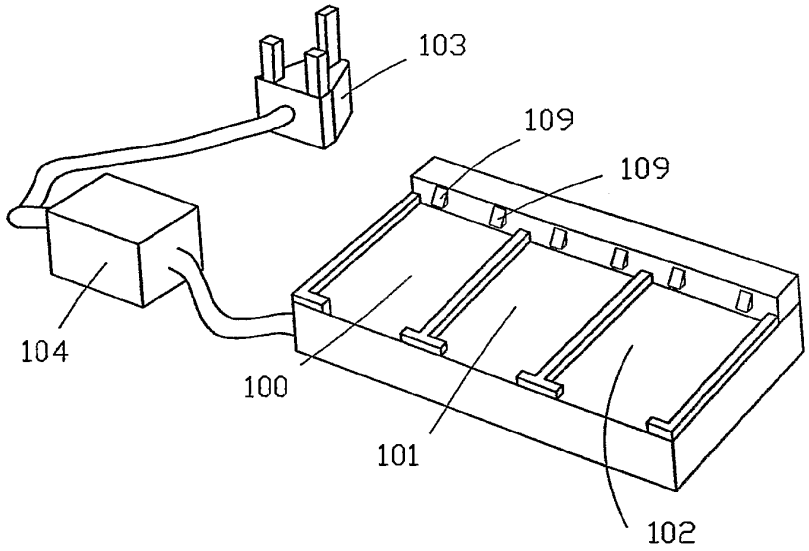


FIG.41

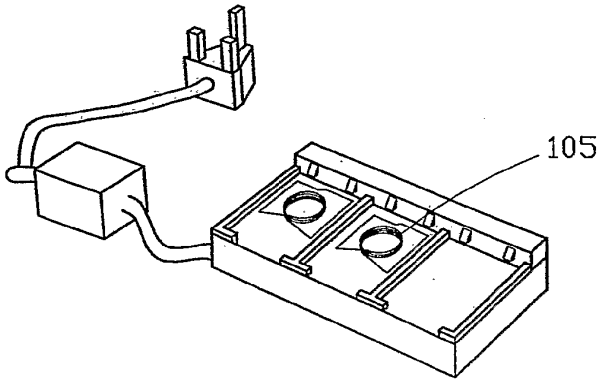


FIG.42

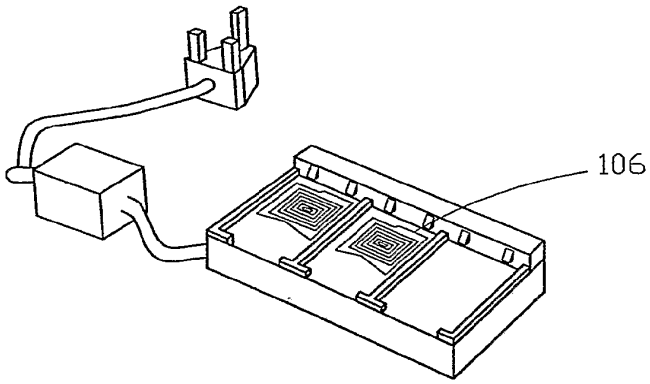


FIG.43

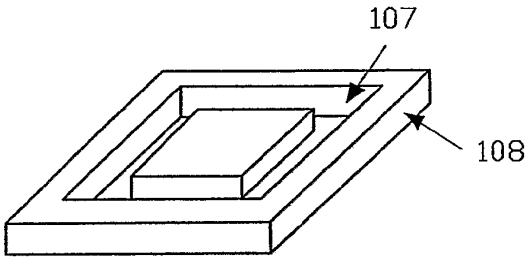


FIG.44(a)

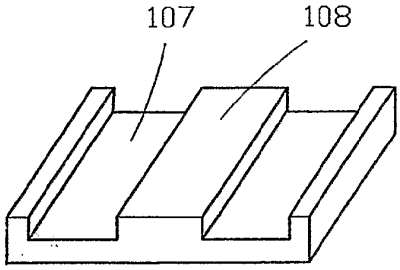


FIG.44(b)

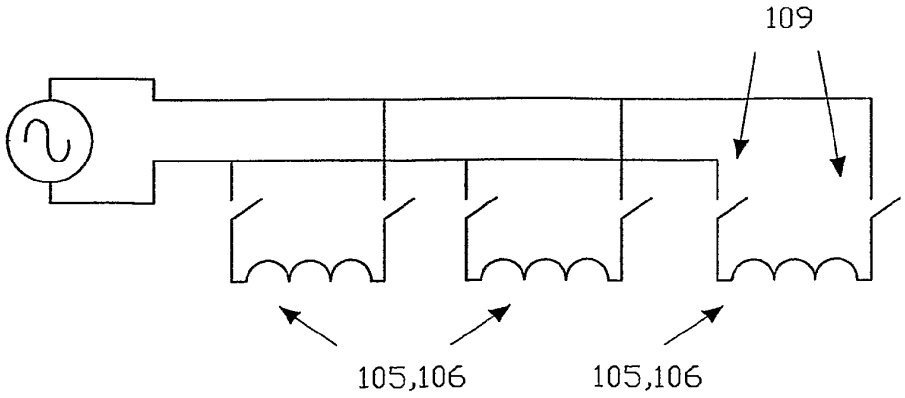


FIG.45

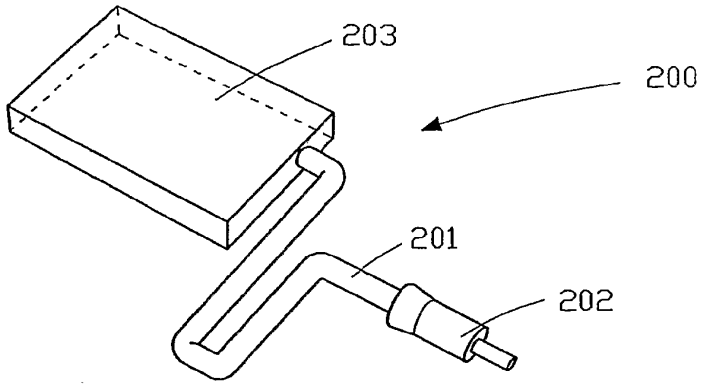


FIG.46

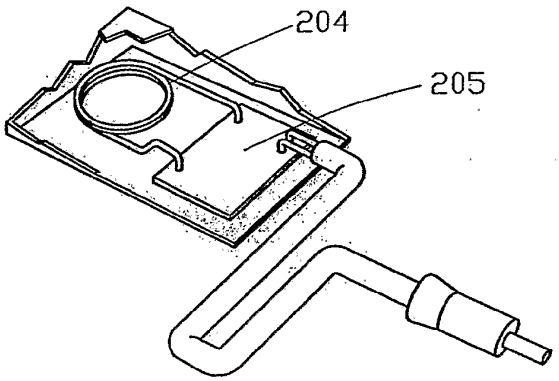


FIG.47

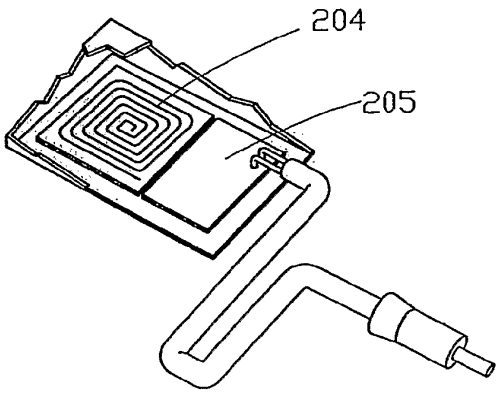


FIG.48

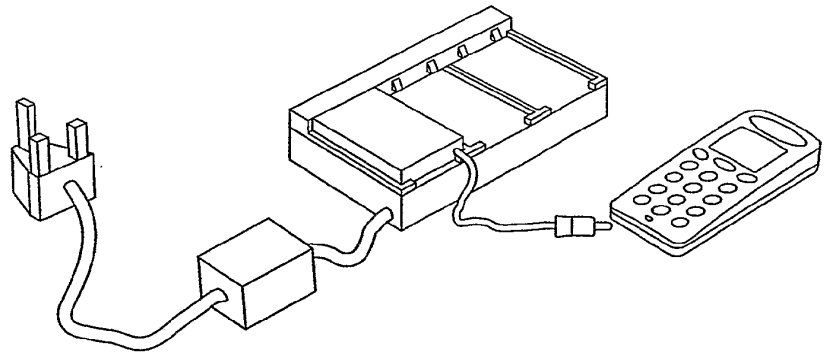


FIG.49

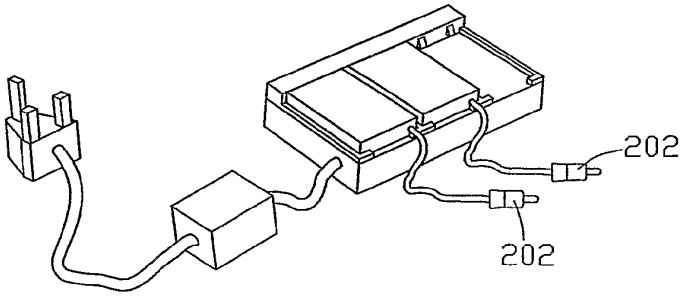


FIG.50

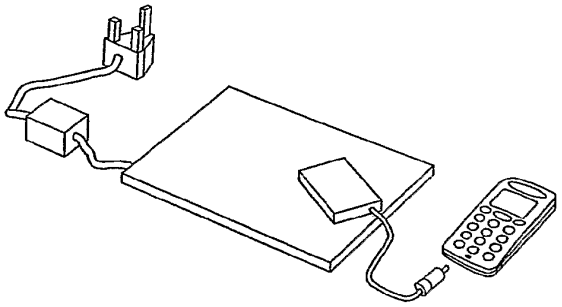


FIG.51

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: H02J 7/00, H01F 38/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI, IEEE (battery, charger, coils, flat, shield)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	HATANAKA, K. et al. "Power Transmission of a desk with a cord-free power supply" IEEE Transactions on Magnetics Volume: 38, Issue: 5, September 2002 Pages 3329-3331	18-21,31
X	HATANAKA, K. et al. "Characteristics of the desk with cord-free power supply" INTERMAG 2002, DIGEST OF TECHNICAL PAPERS 28 April-2 May 2002 Abstract, whole document	18
X Y	EP 298707 B (SEIKO EPSON CORPORATION) 28 September 1994 Whole document Column 4 line17-22, column 3 lines 11-26	1,4,11,32 2,3

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2003	- 9 JUL 2003
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **DALE E. SIVER** Telephone No : (02) 6283 2196

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6008622 A (NAKAWATASE) 28 December 1999 Column 1 lines 39-43, column 2 lines 5-17, 21-23, 49-55	1,4,11,32
Y	US 6265789 B (HONDA et al.) 24 July 2001 Abstract, figures, claim 8, column 7 lines 8-23, column 11 lines 62-66	2,3
Y	WO 00/02212 A (ABIOMED, INC.) 13 January 2000 Abstract, Figure 1,7, page 2 lines 5-9	1,11,32,33
A	US 6172884 B (LANNI) 9 January 2001 Abstract, figures, column 18 line 63 to column 19 line 60	35-36,42,48

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU03/00721

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	298707	JP	62260735	EP	245999	ES	2003287
		US	5246734				
US	6008622	JP	11103531				
US	6265789	EP	977297	WO	9927603		
WO	200002212	AU	48613/99	CA	2336725	EP	1095384
		US	6324430	US	2002055763	US	6389318
		US	2002058971				
US	6172884	US	5479331	US	5636110	US	5838554
		US	5949213	US	6091611	US	6266261
		US	2003042881	AU	200153089	CA	2403856
		EP	1273093	WO	200176051		

END OF ANNEX

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

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17 November 2005 (17.11.2005)

PCT

(10) International Publication Number
WO 2005/109598 A1

(51) International Patent Classification[7]: H02J 5/00

(21) International Application Number:
PCT/GB2005/001833

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(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0410503.7 11 May 2004 (11.05.2004) GB

(71) Applicant *(for all designated States except US)*: **SPLASH-POWER LIMITED** [GB/GB]; The Jeffreys Building, Cowley Road, Cambridge CB4 0WS (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **STEVENS, Michael, Craig** [AU/GB]; 90 Mill Road, Cambridge CB1 2BD (GB). **KNILL, Alexander, Charles** [GB/GB]; 53 Blackthorn Close, Cambridge CB 1FZ (GB). **DUNTON, John, Robert** [GB/GB]; 19 Chivers Road, Haverhill, Suffolk CB9 9DS (GB).

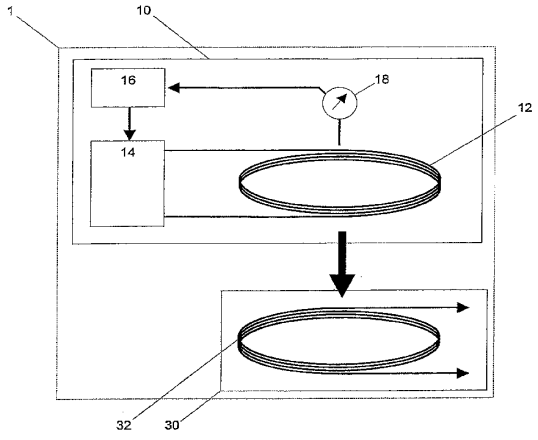
(74) Agent: **HITCHING, Peter, Matthew**; Haseltine Lake, 5th Floor, Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO,

[Continued on next page]

(54) Title: CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS



(57) Abstract: An inductive power transfer system comprises a primary unit (10), having a primary coil (12) and an electrical drive unit (14) which applies electrical drive signals to the primary coil so as to generate an electromagnetic field. The system also comprises at least one secondary device (30), separable from the primary unit and having a secondary coil (32) which couples with the field when the secondary device is in proximity to the primary unit. A control unit (16) causes a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition. In this condition the application of the drive signals to the primary coil by the electrical drive unit is suspended so that energy stored in the circuit decays over the course of the period. A decay measurement unit (18) takes one or more measures of such energy decay during the measurement period. In dependence upon said one or more energy decay measures, the control unit controls the electrical drive unit so as to restrict or stop inductive power transfer from the primary unit.

WO 2005/109598 A1

SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS

The present invention relates to controlling inductive power transfer systems for use, for example, to power portable electrical or electronic devices.

Inductive power transfer systems suitable for powering portable devices may consist of two parts:

- A primary unit having at least one primary coil, through which it drives an alternating current, creating a time-varying magnetic flux.
- A secondary device, separable from the primary unit, containing a secondary coil. When the secondary coil is placed in proximity to the time-varying flux created by the primary coil, the varying flux induces an alternating current in the secondary coil, and thus power may be transferred inductively from the primary unit to the secondary device.

Generally, the secondary device supplies the transferred power to an external load, and the secondary device may be carried in or by a host object which includes the load. For example the host object may be a portable electrical or electronic device having a rechargeable battery or cell. In this case the load may be a battery charger circuit for charging the battery or cell. Alternatively, the secondary device may be incorporated in such a rechargeable cell or battery, together with a suitable battery charger circuit.

A class of such an inductive power transfer systems is described in our United Kingdom patent publication GB-A-2388716. A notable characteristic of this class of systems is the physically "open" nature of the magnetic system of the primary unit – a significant part of the magnetic path is through air. This is necessary in order that the primary unit can supply power to different shapes and sizes of secondary device, and to multiple secondary devices simultaneously. Another example of such an "open" system is described in GB-A-2389720.

Such systems may suffer from some problems. A first problem is that the primary unit cannot be 100% efficient. For example, switching losses in the electronics and I^2R losses in the primary coil dissipate power even when there is no secondary device present, or when no secondary devices that are present require charge. This wastes energy. Preferably the primary unit should enter a low-power "standby mode" in this situation.

A second problem in such systems is that it is not possible to mechanically prevent foreign objects from being placed into proximity with the primary coil, coupling to the coil. Foreign objects made of metal will have eddy-currents induced therein. These eddy currents tend to act to exclude the flux, but because the material has resistance, the flowing eddy currents will suffer I^2R losses which will cause heating of the object. There are two particular cases where this heating may be significant:

- If the resistance of any metal is high, for example if it is impure or thin.
- If the material is ferromagnetic, for example steel. Such materials have high permeability, encouraging a high flux density within the material, causing large eddy currents and therefore large I^2R losses.

In the present application, such foreign objects that cause power drain are termed "parasitic loads". Preferably the primary unit should enter a "shutdown mode" when parasitic loads are present, to avoid heating them.

Various approaches to solve these two problems have been proposed in the prior art.

Solutions to the first problem, of not wasting power when no secondary device requires charge, include:

- In EP0533247 and US 6118249 the secondary device modulates its inductive load during charging, causing a corresponding variation in the power taken from the primary unit. This indicates to the primary unit that it should stay out of the standby state.
- In EP1022840 the primary unit varies the frequency of its drive, and thus the coupling factor to a tuned secondary unit. If the secondary unit is not taking

power, there is no difference in the power taken as the frequency is swept and thus the primary unit goes into a standby state.

- In US5536979 the primary unit simply measures the power flowing in the primary coil, and enters a pulsing standby state if this is below a threshold.
- In US5896278 the primary unit contains detecting coils which have power coupled back into them according to the position of the secondary device. If the device is not present the primary unit enters a standby mode.
- In US5952814 the secondary device has a mechanical protrusion which fits a slot in the primary unit, activating it.
- In US6028413 the primary unit drives two coils, and there are a corresponding two power receiving secondary coils in the secondary unit. The primary unit measures the power delivered from each primary coil and enters standby mode if it is below a threshold.

Solutions to the second problem, of parasitic loads, include:

- As mentioned above, in EP1022840 the primary unit varies the frequency of its drive. In this system, the secondary device is tuned, so this frequency variation will result in a variation of the power taken from the primary unit. If the load is instead a piece of metal, then varying the frequency will not have as much effect and the primary unit will enter a shutdown state.
- As mentioned above, in US5952814 a key in the secondary device activates the primary unit. The assumption is that if a secondary device is present then this will physically exclude any foreign objects.
- As mentioned above, in US6028413 the primary unit supplies power to the secondary device by driving two primary coils. If the amount of power supplied by the two coils is different, the primary unit assumes that the load is not a valid secondary device and enters shutdown mode.

These approaches all assume a 1:1 relationship between the primary unit and the secondary device. Therefore they are not sufficient for systems such as those described in GB-A-2388716 where more than one secondary device at a time may be present. For

example, they would not work when there are two secondary devices present, one requiring charge and the other not.

Some of these approaches also assume that the physical or electrical presence of a valid secondary device implies that all foreign objects are physically excluded by the secondary device. This is not necessarily the case, particularly when the secondary devices may be positioned arbitrarily in respect of the primary unit, as in those described in GB-A-2388716.

According to a first aspect of the present invention, there is provided an inductive power transfer system comprising a primary unit, having a primary coil and electrical drive means connected to the primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field, and the system also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, wherein the primary unit further comprises: control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over a course of said period; and decay measurement means operable to take one or more measures of such energy decay during said period; said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

Such a system is advantageous because it can address either or both the standby problem and the parasitic load detection problem listed above, in a robust and cost-effective manner, and is particularly advantageous in systems which may have multiple secondary devices present in different charge states, and/or whose open magnetic nature makes it easy for parasitic objects to couple to the primary coil.

In the present application, the term "ring-down" will be used to mean causing the circuit ("resonant tank") including the primary coil to operate in this undriven resonating condition.

During a ring-down, no energy is being supplied to the primary coil, and so the decay of energy in the resonant tank is a measure of how much energy is being removed from it. The principal causes of energy loss are:

- Energy coupled into the secondary coil of any secondary device present. This energy may be stored in a storage unit of the secondary device (if provided) and/or delivered to a load connected to the secondary device.
- Losses to any parasitic loads (foreign objects other than valid secondary devices) present.
- Other losses in the primary unit or any secondary devices/host objects present. These other losses include inefficiencies in the primary coil itself and any other components of the resonant tank (e.g. I^2R losses in the copper of the coil or effective series resistance of any resonating capacitor). They also include any magnetic losses in the primary and secondary units, for example magnetic hysteretic loop losses in any cores associated with the primary unit and/or secondary device.

In a preferred embodiment the or one energy decay measure is a measure of a rate of such energy decay. In this case, the rate of energy decay is a measure of the rate at which energy is being removed from the resonant tank.

The control means may employ the energy decay measures to detect when a substantial parasitic load is present in proximity to said primary unit, and restrict or stop inductive power transfer from the primary unit following the detection of such a substantial parasitic load. For example, the energy decay rate may be compared with a shutdown threshold, and if the rate exceeds the threshold the power transfer is shut down.

Alternatively, or in addition, the control means may employ the energy decay measures to detect when there is no secondary device present in proximity to the primary unit, and restrict or stop inductive power transfer from the primary unit when no such secondary device is detected.

When carrying out such detection the control means may employ first compensation information relating to a load imposed on the primary unit by losses in the primary unit itself so as to compensate for said losses of said primary unit. This prevents the detection from being affected by the inefficiencies in the primary coil itself and any other components of the resonant tank, as mentioned above.

The primary unit may further comprise calibration means for deriving part or all of the first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation.

As noted above, depending on its construction, the secondary device, and/or any host object which carries it, may suffer magnetic losses intrinsic to its construction, for example in magnetic core material, and other metal used in its construction. These so-called "friendly parasitics" will be accounted for by the primary unit as a further parasitic loss, and if they sum to more than the threshold, the control means will shut the primary unit down. This may be avoided by providing a method of communicating the friendly parasitics of a device to the primary unit so that they may be accounted for and added to the shutdown threshold.

Accordingly, when carrying out such detection said control means may employ second compensation information relating to a parasitic load imposed on the primary unit by the secondary device so as to compensate for the parasitic load of the secondary device.

In this case, preferably the or each secondary device is operable to communicate its second compensation information directly to the primary unit or to communicate to the

primary unit other information from which the primary unit can derive the second compensation information.

The secondary device may modulate a dummy load to communicate this other information, and the primary unit may derive the second compensation information by measuring the dummy load modulation.

This way of communicating the second compensation information also still works if multiple secondary devices are present. For example, assuming the secondary devices apply their dummy loads at the same time, the primary unit will see a total dummy load equal to the sum of the individual dummy loads of the secondary devices. This is all that the primary unit needs to know for compensating for the parasitic loads of the secondary devices.

One way of doing this is to have a feedback resistor, whose value is proportional to the value of the friendly parasitics of the secondary device, which can be switched across the secondary coil, creating a dummy parasitic load. If this feedback resistor is always applied during certain ring-downs (for example during the third ring-down of a set), the primary unit can then measure the sum of the incremental loads resulting from the feedback resistors in each secondary device present (whether its load is drawing power or not) and adjust its threshold accordingly. As described below, the same feedback resistor may be used as a binary on/off signalling means to control standby mode.

Part or all of the first compensation information and/or part or all of the second compensation information may be information stored in the primary unit during manufacture and/or testing of the primary unit.

The system may have information varying means for varying one or both of the first and second compensation information when one or more operating conditions (for example, temperature) of the primary unit vary.

The decay measurement means may take one or more first such energy decay measures in a first such measurement period and take one or more second such energy decay measures in a second measurement period. In this case the secondary device may comprise decay varying means which cause the secondary device to consume more energy in the first measurement period than in the second measurement period. The control means in said primary unit can then employ the first and second energy decay measures to detect when a secondary device of the system is present in proximity to the primary unit. For example, if the control means detects a substantial difference between the first energy measures and the second energy measures, it may conclude that a secondary device must be present.

The decay varying means may cause the secondary device to impose a first dummy load on the primary unit in the first measurement period and to impose a second dummy load, different from the first dummy load, on said primary unit in the second measurement period. One of the first and second dummy loads may be zero.

In this way, the secondary device may apply an additional dummy (or "feedback") load only during some ring-downs and not during others, or only during some part of the ring-down but not others. This may be done for example by switching the feedback resistor mentioned above across the secondary coil, creating a dummy parasitic load, as measured by the primary unit, which varies with time. In contrast, true parasitic loads (for example a piece of steel) will appear to be a constant parasitic load. If the primary unit control means takes similar load measurements between different ring-downs, or different parts of the same ring-down, it may put the drive means into a power-saving "standby" mode. This mode will be entered when no valid secondary device is present.

The decay varying means may be disabled when an actual load of the secondary device requires no power. If the secondary device only presents a time-varying load during ring-down when it requires power, then the primary unit will enter a standby mode even when there are secondary devices present, if they don't require power.

A difference between the first dummy load and the second dummy load may be set in dependence upon said parasitic load imposed on said primary unit by said secondary device. This is a convenient way to communicate the second compensation information to the primary unit.

The secondary device may be adapted to supply the power it receives inductively from the primary unit to an actual load external to the secondary device. The load may be physically separable from the rest of the secondary device, for example it may be connected by a removable plug and socket arrangement. Of course, the secondary device will generally include its own circuitry which will need some of the received power too. In some cases the load could be internal to the secondary device.

The secondary device preferably comprises a storage means for storing energy received from the primary unit. The storage means, where provided, supplies stored energy to the actual load and/or circuitry of the secondary device when the circuit is operating in the undriven resonating condition. This is not essential in all embodiments. Any load which can cope with short power reductions or interruptions will not require the storage means.

The secondary device may comprise load isolation means operable during the measurement period to prevent the supply to an actual load of the secondary device of any of the power being received inductively by the secondary device from the primary unit. Ideally during a ring-down the storage means of the secondary device is of sufficient capacity, and sufficiently well-charged before the ring-down commences, that the decay of energy in the storage means happens more slowly than the decay of energy in the primary coil. If this cannot be guaranteed to be the case under all conditions, for example if the load is separable and with unknown characteristics, then the load isolation means can be included in the secondary device to disconnect the secondary device's storage means, and load, during the ring down, to ensure that its electrical load is not measured by the primary unit.

When the inductive power transfer from the primary unit has been set to such a restricted or stopped state, for example because the parasitic load became too high, the control means may cause the circuit to operate in the undriven resonating condition during a series of intermittent probing periods. In this case the decay measurement means takes one or more such energy decay measures during each said probing period. The control means employ the energy decay measures taken during the probing periods to determine when to end the restricted or stopped state. For example, the control means may periodically allow the drive to run for a short while in order to conduct a ring-down to measure the parasitic load and, if it is now below a threshold, resume the drive.

Alternatively, when the inductive power transfer from the primary unit has been set into such a restricted or stopped state, the control means may maintain that state until the primary unit is reset by a user of the primary unit.

It may be advantageous to provide a clear means of synchronising the behaviour of the secondary device with that of the primary unit. For example, if the secondary device must isolate the load during ring-down, it may need a clear signal that such a ring-down is about to happen, since opening it once a ring-down is in process may be too late. There are many possible means of such synchronisation using a variety of communications means, but one convenient and reliable method is to use the power transfer channel between primary unit and secondary device by putting onto the primary coil a signal which does not occur during normal operation. For example, the primary unit may change the amplitude, frequency or phase of its drive.

The primary unit may comprise synchronising means operable to transmit a predetermined synchronising signal to the secondary device to synchronise operation of the secondary device with that of the primary unit.

The synchronising means may send the predetermined synchronising signal prior to causing the circuit to operate in said undriven resonating condition.

The primary unit may further comprise snubber means. In this case, the synchronising means may switch the snubber means into the circuit after suspending the application of electrical drive signals to said primary coil, so as to send the synchronising signal to the secondary device. In this way the primary coil is stopped very quickly by switching in the snubber, which provides a very easily detectable synchronising signal.

The storage means (e.g. capacitor) of the secondary device may be of significant size and cost if it is to provide sufficient capacity to supply the load during a ring-down. Therefore it is advantageous for the ring-down to occur as quickly as possible. Measuring fewer cycles of the primary coil is one way to achieve this. This will reduce the accuracy of the system but this may be compensated for by averaging the results of several ring-downs.

The primary unit may further comprise resonant frequency increasing means for temporarily increasing a resonant frequency of the circuit during operation thereof in the undriven resonating condition. This is another way to shorten the ring-down time, because by increasing the resonant frequency of the primary coil during a ring-down, more cycles occur in less time.

The control means preferably cause the electrical drive means to resume application of the drive signals to the primary coil in phase with any residual resonating energy within the circuit. After a ring-down is complete, the primary unit must resume normal operation as quickly as possible to prevent the secondary device storage means from discharging to the point where the supply to the load becomes inadequate. Restarting the drive to the primary coil in-phase with any residual resonating energy within the primary coil can ensure that the coil returns to nominal operating conditions as quickly as possible.

The control means may cause the electrical drive means to temporarily boost the electrical drive signals prior to causing the circuit to operate in the undriven resonating condition. This can enhance the hold-up of the secondary device storage means, for any given such means, keeping the size and cost of such means to a minimum. Before a ring-

down, the control means may cause a boost in the current in the primary coil for one or more cycles, thus temporarily raising the voltage in the secondary device storage means. This stores more energy in that means, enabling it to power the load for longer during ring-down.

The control means may measure a natural resonant frequency of the circuit during the measurement period and employ the measured frequency to compensate for an influence of changes in the natural resonant frequency on the energy decay measures. Because the resonant tank is not being actively driven during ring-down, the primary coil resonates at the natural resonant frequency of the system. Measuring the natural resonant frequency during ring-down allows a calculation of the inductance to be made, leading to a direct calculation of total power loss. The inductance may change due to the presence of secondary devices and/or parasitic loads.

The control means may cause the circuit to operate in the undriven resonating condition during a series of different such measurement periods. In this case, the decay measurement means may take one or more such energy decay measures in each said measurement period. The control means can then employ the energy decay measures taken in two or more different measurement periods to control said electrical drive means. For example, the control means can employ an average of the energy decay measures taken in different measurement periods.

Two or more successive measurement periods may be part of the same ring-down. This can give fast results. Alternatively, there may be just one measurement period in each ring-down. This gives slower results but it is possible to resume application of drive signals to the primary coil between measurement periods, making the power interruption to the secondary devices shorter. Also, the circuit conditions can be replicated at the start of each measurement period. The duration of each ring-down is preferably short compared to an interval between successive ring-downs.

In some systems, the primary coil may not driven continuously. It may, for example, be driven in pulses, for example in a pulse-width-modulated manner. In such systems, a partial "ring-down" is effectively happening whenever the primary coil is not being actively driven, perhaps once or more per cycle. Measurement of the natural resonant frequency and decay of the primary coil during these un-driven periods can provide the same functionality as that from the multiple-cycle ring-downs described above.

The secondary device may have a timing means capable of changing the behaviour of the secondary device over time. For example, the timing means may detect when a second ring-down has happened shortly after a first ring-down, and, for example, switch in a conditional dummy (feedback) load only on such a shortly-following second ring-down. This may be useful for example in making interactions between the primary unit and secondary device more deterministic. For example such a means could be used to make the standby detection scheme described above more reliable. For example, if the primary unit always conducts ring-downs in pairs a few milliseconds apart but repeated once every second, and the secondary device applies the feedback load only on the second of the two ring-downs of a pair, the primary unit may average several "first ring downs", and separately average several "second ring-downs", to improve the accuracy of measurement.

The invention can operate even in systems which have more than one primary coil. An example is systems which allow complete freedom of position or orientation of the secondary device by having two orthogonal coils, driven in quadrature, as in GB-A-2388716. In such systems there will be some coupling between the two primary coils, which may make it awkward to analyse a "ring-down" occurring simultaneously on both coils. In this case, the coils can be tested alternately. At the start of a test, both coils are halted, but then only the first coil is allowed to ring-down while the second coil is held in a halted state to prevent it from affecting the measurements on the first coil. During the next test the first coil is held halted while the second coil is allowed to ring-down.

Accordingly, in a preferred embodiment the primary unit may have first and second such primary coils. A first such electrical drive means is connected to the first primary coil for applying electrical drive signals thereto so as to generate a first electromagnetic field, and a second such electrical drive means is connected to the second primary coil for applying electrical drive signals thereto so as to generate a second electromagnetic field. The control means causes the second electrical drive means to suspend application of electrical drive signals to the second primary coil whilst a first such circuit including the first primary coil is in the undriven resonating condition and the decay measurement means are taking one or more such measures of energy decay in the first circuit. Similarly the control means causes the first electrical drive means to suspend application of electrical drive signals to the first primary coil whilst a second such circuit including said second primary coil is in the undriven resonating condition and the decay measurement means are taking one or more such measures of energy decay in the second circuit.

The operating conditions of the primary unit after the ring-down is complete are likely to be identical to those before the ring-down started. If the primary unit contains any control loops (for example to maintain the strength of the magnetic flux), these control loops may be frozen during the ring-down, so that they do not respond to the ring-down and can resume normal operation immediately.

At least one secondary device may be carried in or by an object requiring power. The secondary device can receive power inductively from the primary unit when the object carrying the secondary device is placed on or in proximity to the primary unit. The object may be a portable electrical or electronic device, for example a mobile communication device.

The system may have an "open" construction with a power transfer surface, the field generated by said primary unit being distributed over a power transfer area of the surface such that, when such a secondary device is placed on or in proximity to the power transfer area, the device can receive power inductively from the primary unit.

The power transfer area may be large enough that two or more such secondary devices can be placed on or in proximity to the power transfer area to receive power simultaneously from the primary unit.

According to a second aspect of the present invention there is provided a primary unit, for use in an inductive power transfer system, the primary unit comprising: a primary coil; electrical drive means connected to said primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field; control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and decay measurement means operable to take one or more measures of such energy decay during said period; said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

According to a third aspect of the present invention there is provided a secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising: a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and communication means operable to communicate to the primary unit information relating to a parasitic load imposed on the primary unit by the secondary device.

The communication means may communicate the information by imposing a dummy load on said primary unit.

The communication means may impose a first dummy load on the primary unit at a first time and a second dummy load, different from the first dummy load, at a second time, a difference between the first and second dummy loads being set in dependence upon the parasitic load. One of the first and second dummy loads may be zero.

This way of communicating the information still works if multiple secondary devices are present. For example, assuming the secondary devices apply their dummy loads at the same time, the primary unit will see a total load equal to the sum of the individual dummy loads of the secondary devices. In this way, the total parasitic load from multiple secondary devices can be communicated very efficiently and reliably.

Alternatively, the communication means may set a time period in which a dummy load is imposed on the primary unit in dependence upon the parasitic load imposed on the primary unit by the secondary device. The primary unit can then measure the duration of the period to obtain information relating to the parasitic load.

According to a fourth aspect of the present invention there is provided a portable electrical or electronic device comprising: a load which at least at times requires power from said primary unit; and a secondary device embodying the aforesaid third aspect of the present invention, said load connection means of said secondary device being connected to said load for supplying such inductively-received power to the load at said times.

According to a fifth aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit, having a primary coil to which electrical drive signals are applied to generate an electromagnetic field, and also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said

field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, which method comprises: causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil is suspended so that energy stored in the circuit decays over the course of said period; taking one or more measures of such energy decay during said period; and restricting or stopping inductive power transfer from the primary unit in dependence upon said one or more energy decay measures.

Reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a block diagram showing parts of an inductive power transfer system embodying the present invention;

Figures 2(A) and (B) show example waveforms generated in the Figure 1 system;

Figure 3 is a graph illustrating how energy decays in different parts of the system of Figure 1;

Figure 4 is a block diagram showing parts of an inductive power transfer system according to a preferred embodiment of the present invention;

Figure 5 shows different operating states of a circuit in the Figure 4 system when the circuit is in an undriven resonating condition;

Figure 6 is a graph illustrating a variation over time of current flowing through a primary coil in each of the Figure 5 states;

Figure 7 is a diagram illustrating waveforms generated in operation of the Figure 4 system;

Figure 8 is a diagram for illustrating different modes of operation in the Figure 4 system; and

Figures 9(A) to (E) illustrate the conditions under which the modes of Figure 8 are selected in the Figure 4 system.

Figure 1 illustrates parts of an inductive power transfer system embodying the present invention. The system 1 comprises a primary unit 10 and at least one secondary device 30. The primary unit 10 has a primary coil 12 and an electrical drive unit 14 connected to the primary coil 12 for applying electrical drive signals thereto so as to generate an electromagnetic field.

The primary unit may have any suitable form but one preferred form is a flat platform having a power transfer surface on or in proximity to which each secondary device can be placed. In this case, the field may be distributed over a power transfer area of the surface, as described in GB-A-2388716.

The secondary device 30 is separable from the primary unit 10 and has a secondary coil 32 which couples with the electromagnetic field generated by the primary unit when the secondary device is in proximity to the primary unit. In this way, power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween.

The primary and secondary coils can have any suitable forms, but may for example be copper wire wound around a high-permeability former such as ferrite or amorphous metal.

The secondary device is usually connected to an external load (not shown) and supplies the inductively-received power to the external load. The secondary device may be carried in or by an object requiring power such as a portable electrical or electronic device or a rechargeable battery or cell. Further information regarding designs of secondary device and the objects which can be powered using the secondary devices can be found in GB-A-2388716.

The primary unit 10 in the Figure 1 system also comprises a control unit 16 and a decay measurement unit 18. The control unit causes a circuit (referred to hereinafter as a "resonant tank") including the primary coil to operate in an undriven resonating condition

during a measurement period. In this undriven resonating condition ("ring-down") the application of electrical drive signals to the primary coil by the electrical drive unit 14 is suspended so that energy stored in the resonant tank decays over the course of the measurement period.

Typically a resonant tank is formed by a circuit comprising at least an inductor and a capacitor. The resonant tank stores electrical energy. When brought into the undriven resonating condition, the stored electrical energy flows or oscillates within the tank at a natural resonant frequency of the tank.

The resonant tank includes not only the electrical circuit within the primary unit of which the primary coil is a part, but also the electrical circuit(s) within the at least one secondary units, which is or are coupled to the primary coil via the magnetic circuit formed by the primary and secondary coil(s).

The primary coil may be made resonant with a capacitor in series or parallel, or both series and parallel, and/or may be resonant due to its self-capacitance. It may or may not be driven at its resonant frequency in normal operation, but once a ring-down occurs will naturally oscillate at its resonant frequency.

During a ring-down, no energy is being supplied to the primary coil, and so the rate of decay of energy in the resonant tank is a measure of the rate at which energy is being removed from it. The principal causes of energy loss are:

- Energy coupled into the secondary coil of any secondary device present. This energy may be stored in a storage unit of the secondary device and/or delivered to a load connected to the secondary device.
- Losses to any parasitic loads (foreign objects) present.
- Other losses in the primary unit or any secondary devices/host objects present. These other losses include inefficiencies in the primary coil itself and any other components of the resonant tank (e.g. I^2R losses in the copper of the coil or effective series resistance of any resonating capacitor). They also include any

magnetic losses in the primary and secondary units, for example magnetic hysteretic loop losses in any cores associated with the primary unit and/or secondary device.

Figures 2(A) and 2(B) show two possible examples of energy decay during a ring-down. If the losses are small (Fig. 2(A)) then during a ring-down the energy in the resonant tank will decay slowly. Conversely if the losses are large (Fig. 2(B)) then during a ring-down the energy in the resonant tank will decay rapidly.

The decay measurement unit 18 takes one or more measures of the energy decay in the resonant tank during the measurement period.

The decay measurement unit 18 may take the energy decay measures in any suitable way, for example by measuring the voltage across, or current through, the primary coil or by measuring some other quantity associated with the primary coil, for example the magnetic flux generated thereby. The measurement may be taken over part of a cycle, or over one or more cycles. The measure may be, for example, the ratio of one peak to a subsequent peak. Alternatively, the measure may be derived by curve-fitting several data points. The measure is a rate of energy decay in the resonant tank in one preferred embodiment.

The control unit 16 controls the electrical drive unit 14 so as to restrict or stop inductive power transfer from the primary unit in dependence upon the energy decay measures produced by the decay measurement unit 18.

The energy decay measures may be used by the control unit to restrict or stop inductive power transfer from the primary unit following the detection of certain conditions.

One such condition is the presence of a substantial parasitic load in the vicinity of the primary unit. In this case, the control unit 16 may enter a shutdown mode in which the drive to the primary coil is reduced or stopped, preventing heating of the parasitic load.

Another such condition is when no secondary device of the system is present in the vicinity of the primary unit. Another such condition is when there is at least one secondary device present but none of the devices has a load currently requiring power. A load does not require power, for example, when turned off or when, in the case of a rechargeable battery or cell, the battery or cell is fully charged. Under both these conditions the control unit 16 may enter a standby mode in which the drive to the primary coil is reduced or stopped, preventing unnecessary power consumption in the primary unit.

Compared to other possible methods of measuring the power delivered to the primary coil - for example by measuring the supply power to the primary unit drive electronics - the method used in the present invention is quick and accurate. This accuracy is due at least to the following aspects:

- The drive electronics may be inactive and largely out of circuit during the ring-down, therefore their noise and tolerances do not affect the measurement accuracy.
- Since the method directly measures power taken, it is very hard to "trick" – it works reliably regardless of how power is being taken out, in contrast to other indirect techniques such as measuring inductance shift which make assumptions between the quality they measure and the parasitic load, which may not always be true.

Figure 4 shows parts of an inductive power transfer system according to a preferred embodiment of the present invention. The system 1 has a primary unit 10 and a secondary device 30. Figure 4 also shows a parasitic load 500 on the primary unit, caused for example by a foreign object placed in the vicinity of the primary unit. The secondary device 30 in this case is assumed to be carried in or by a host object such as a portable electrical or electronic device. As explained hereinbefore the secondary device and/or host object also inevitably impose a "friendly" parasitic load 501 on the primary unit.

As described earlier with reference to Figure 1, the primary unit 10 comprises a primary coil 12, an electrical drive unit 14, a control unit 16 and a decay measurement unit 18.

The electrical drive unit 14 in this embodiment has a conventional half bridge configuration in which a first switch 20 is connected between a first power supply line of the primary unit and an output node of the electrical drive unit, and a second switch 21 is connected between the output node and a second power supply line of the primary unit. The first and second switches 20 and 21 may, for example, be field-effect transistors (FETs). The electrical drive unit 14 also comprises a drive controller 19 which applies control signals to the switches 21 and 22 to turn them on and off. The drive controller 19 has a control input connected to an output of the control unit 16

The output node of the electrical drive unit 14 is connected via a capacitor 17 to one side of the primary coil 12.

The control unit 16 is a microprocessor in this embodiment. Alternatively, an ASIC could be used to implement the control unit 16, as well as some or all of the other circuit elements of the primary unit.

The decay measurement unit 18 in this embodiment comprises a resistor 25 which has a first node connected to one side of a switch 28 and a second node connected to the second power supply line. The resistor 25 is a low-value resistor. The decay measurement unit 18 further comprises an operational amplifier 26 having an input connected to the first node of the resistor 25. The decay measurement unit 18 also comprises an analog-to-digital converter (ADC) 27 connected to an output of the operational amplifier 26. An output of the ADC 27 is connected to a measurement input of the control unit 16.

The other side of the switch 28 is connected to the other side of the primary coil 12. A snubber unit 22 is connected in parallel with the switch 28. The snubber unit 22 comprises a capacitor 23 and a resistor 24 connected in series with one another.

The primary unit 10 further comprises a calibration unit 29 in this embodiment. The calibration unit 29 stores first compensation information about the losses in the primary unit (e.g. electrical or magnetic losses). By design, at manufacture, and/or periodically thereafter, the losses in the primary unit may be calibrated and stored within the calibration unit 29. The calibration unit supplies the stored information to the control unit 16 to enable the control unit 16 to subtract the losses from the total measurement, thus calculating a number for the loss due to parasitic loads alone. This calibration unit 29 may vary the first compensation information to cope with variable losses in the primary unit, for example losses which vary with temperature.

The secondary device 30 comprises a secondary coil 32, a rectifier 34, a secondary control unit 36, a dummy load switch 38, a dummy load 40, a load switch 42, a storage unit 44 and an actual load 46. The dummy load switch 38 and the load switch 42 may each be an FET, for example. The dummy load 40 is, for example, a resistor. The storage unit 44 is a capacitor in this embodiment but an inductor could be used instead. The actual load 46 is external to the secondary device in this embodiment and is part of the host object. It could be a battery charge controller for a Lithium-ion cell.

Operation of the system of Figure 4 will now be described.

In an "operating mode" of the system, the host object incorporating the secondary device 30 is placed on or in proximity to the primary unit 10. The drive controller 19 applies control signals to the switches 20 and 21 alternately, so that electrical drive signals are applied to the primary coil 12 via the capacitor 17. The switch 28 is closed. The primary coil 12, capacitor 17, switch 28 and resistor 25 and parts of the secondary device 30 together form a resonant tank. The resonant tank is preferably driven by the electrical drive unit 14 at or near resonance so as to maximise power transfer to the secondary device, but this is not essential in the present invention. In its driven condition, the resonant tank could be driven at some frequency other than its resonant frequency.

In the operating mode, the primary coil 12 generates an electromagnetic field in the vicinity of the primary unit. The secondary coil 32 couples with this field and an alternating current is induced in the coil by the field. The dummy load switch 38 is open and the load switch 42 is closed. The alternating current induced in the secondary coil 32 is rectified by the rectifier 34 and the rectified current is supplied via the load switch 42 to the storage unit 44 and the actual load 46. In this way, power is transferred inductively from the primary unit to the secondary device 30 and from there to the load. The storage unit 44 stores energy in the operating mode.

Whilst in the operating mode, from time to time the control unit 16 in the primary unit initiates a series of three ring-downs in quick succession. Such a series of three ring-downs is shown in Figure 7. The interval between successive series of ring-downs may be, for example, one second. The duration of each ring-down is, for example, one millisecond. Each ring-down of a series has a sequence of three states as shown in Figure 5.

Initially, the system has a normal state in which the control unit 16 causes the electrical drive unit 14 to apply drive signals to the primary coil 12 to cause it to oscillate. It will be appreciated that in the operating mode as described above, the system is in this state for almost all the time.

The next state is a "snub" state. The application of drive signals to the primary coil 12 by the electrical drive unit 14 is suspended under the control of the control unit 16. The drive controller 19 closes the switch 21. The control unit 16 also opens the switch 28 at a time when most of the energy in the resonant tank resides in the capacitor 17. The opening of the switch 28 brings the snubber unit 22 in series with the resonant tank. The snubber unit 22 quickly dissipates any energy which remains in the primary coil 12, stopping it from resonating within one cycle or so. Most of the energy stored in the resonant tank is left in the capacitor 17.

The sudden cessation of cycles is detected by the secondary control unit 36 in the secondary device 30. The secondary control unit 36 opens the load switch 42. The system then enters the decay state from the snub state.

The control unit 16 closes the switch 28, removing the snubber unit 22 from the resonant tank, and thus allowing the energy in capacitor 17 to flow again within the resonant tank. In the decay state, the resonant tank operates in an undriven resonating condition. Energy stored in the resonant tank decays over the course of time in the decay state. In this embodiment, the decay measurement unit 18 measures the energy decay in the resonant tank by measuring the current flowing through the primary coil 12. The same current flows through the resistor 25 and generates a voltage at the first node of that resistor. This voltage is buffered by the operational amplifier 26 and converted into a digital signal by the ADC 27. The resulting digital signal is applied to the measurement input of the control unit 16.

The secondary device uses the storage unit 44 to store energy from the primary unit during normal operation. During the decay state, the energy stored in the storage unit 44 of the secondary device gradually decays as energy is delivered to the load. Provided that the storage unit has sufficient capacity, and is sufficiently well-charged before ring-down commences, the storage unit can deliver continuous power to the secondary device load throughout the ring-down, so the actual load 46 is not interrupted. In Figure 3 a solid line 411 shows the decay of energy in the primary coil 12 and a dotted line 410 represents the decay of energy in the storage unit 44 of the secondary device during the decay state.

The secondary device load will not take any power from the primary coil, and will thus be "invisible" to the primary unit, during the decay state. This is possible in this embodiment because the rectifier 34 between the secondary coil and the storage unit allows current to flow only from the former to the latter. It can be arranged in other ways that the secondary device load will not take any power from the primary coil during the ring-down.

As long as this is the case, the decay measurement will not include losses due to power supplied to the secondary load, i.e. will only measure losses in the primary unit and losses due to parasitic loads.

Figure 6 shows how the current flowing through the primary coil 12 varies in the normal, snub and decay states which occur during a ring-down. In this embodiment, the digital signals representing the current flowing in the primary coil within a measurement period are received and processed within the control unit 16 to calculate a measure of the rate of energy decay in the resonant tank.

An equation describing the energy stored in the resonant tank, at resonance, is:

$$E = \frac{1}{2} L\hat{I}^2 = \frac{1}{2} C\hat{V}^2$$

where E is the energy, L the inductance, $\hat{I}$ is the peak current, C is the capacitance and $\hat{V}$ is the peak voltage.

Therefore the energy stored in the resonant tank of the primary at any given moment can be calculated if the inductance and peak current are known, or if the capacitance and peak voltage are known, or combinations thereof. Typically the capacitance is known by design, the peak current and voltage can be measured by suitable circuitry, and the inductance can be deduced by observing the natural resonant frequency during ring-down and applying the formula:

$$L = \frac{1}{4\pi^2 f^2 C}$$

The rate of decay of energy (and thus the loss) from the resonant tank can be calculated by measuring E_1 at time T_1 and E_2 at another time T_2, and calculating

$$\frac{E_2 - E_1}{T_2 - T_1}$$

Since at resonance the voltage and current in the resonant tank will be 90 degrees out of phase with one another, a convenient method of reading the peak voltage of one is to trigger the measurement on the zero-crossing of the other.

The control unit 16 employs the first compensation information stored in the calibration unit 29 when processing the digital signals to measure the energy decay rate. In this way, the control unit 16 compensates for the losses arising in the primary unit itself.

The behaviour of the primary unit and the secondary device is slightly different in each of the three ring-downs of a series.

During the first ring-down, the secondary control unit 36 has the dummy load switch 38 open so that the dummy load 40 is not connected to the secondary coil 32. As a result, the energy decay measure produced during the first ring-down is a measure of the energy decay due to any parasitic loads 500 from foreign objects in the vicinity of the primary unit and any parasitic load 501 imposed by losses in the secondary device and/or its host object .

During the second ring-down, the secondary control unit 36 selectively closes the dummy load switch 38. The secondary control unit 36 decides whether to have the dummy load switch 38 open or closed during the second ring-down based on the power requirement of the actual load 46. If the load 46 does not require any power at the present time, for example, because it has a rechargeable battery which is presently fully charged, then the dummy load switch 38 is kept open during the second ring-down. If, on the other hand, the load 46 does require power at the present time, then the dummy load switch 38 is closed so that the dummy load 40 is connected to the primary coil 32.

The control unit 16 produces another measure of the energy decay rate during a measurement period within the second ring-down. If the energy decay rate during the second ring-down is substantially different from the energy decay rate during the first ring-down, the control unit 16 detects that a secondary device requiring power may be present in the vicinity of the primary unit.

During the third ring-down, the secondary control unit 36 always closes the dummy load switch 38 so that the dummy load 40 is connected to the secondary coil 32. Another measure of the energy decay rate is taken by the control unit 16 in the primary unit. In this case, the energy decay rate is a measure of the sum of the parasitic loads 500, the parasitic load 501 of the secondary device and/or host object, and the dummy load 40. Based on the difference between the energy decay rates in the first and third ring-downs, the control unit calculates the value of the total of the dummy loads 40 in all of the secondary devices present in the vicinity of the primary unit.

Each dummy load 40 in a secondary device 30 in the system of this embodiment is set to a particular value (at manufacture or during calibration or testing) so that the value represents the parasitic load 501 imposed by the secondary device concerned and/or by its host object.

Thus, the total dummy load for all secondary devices present, as calculated by the control unit 16, can be used by the control unit 16 as second compensation information to compensate for the parasitic loads 501 of the secondary devices present. For example, if the control unit 16 detects that a substantial parasitic load 500 is present in the vicinity of the primary unit when the energy decay rate exceeds some threshold, the threshold may be increased by an amount dependent on the total parasitic load 501 of all the secondary devices present, so that the detection of parasitic loads 500 from foreign objects is not influenced by the number of secondary devices present.

A system embodying the present invention is capable of measuring loads imposed on the primary unit sensitively, for example to within 50mW or so. With this degree of

sensitivity, it is possible to ensure that very little power is coupled into parasitic loads 500 such as foreign objects.

Figure 8 is a diagram illustrating the different modes of operation in the Figure 4 system and the conditions for switching between these different modes. The three modes of operation are an operating mode, a shutdown mode and a standby mode.

In the operating mode, the primary unit is in the normal state (driven condition) most of the time, but periodically does a series of three ring-downs as described above. If the result of the ring-downs is that no secondary device requires power, the primary unit goes into a standby mode. If the result of the ring-downs is that a significant parasitic load 500 is present, the primary unit goes into a shutdown mode.

In the standby mode, the electrical drive unit 14 is stopped for most of the time, thus consuming little power. Periodically the primary unit enters the normal state then does a series of ring-downs in respective probing periods, to check whether it should enter either the operating mode or the shutdown mode. Otherwise it remains in the standby mode.

The shutdown mode is functionally identical to standby mode. However, the two modes may be distinguished by some user-interface feature such as an LED to prompt the user to remove any substantial parasitic load 500.

Figures 9(A) to 9(E) illustrate the conditions under which the modes of Figure 8 are selected in the Figure 4 system. In Figure 9(A) there is no secondary device present in the vicinity of the primary unit. In this case, the primary unit is in the standby mode. In Figure 9(B) no secondary device is present but a substantial parasitic load is present in the vicinity of the primary unit. In this case, the primary unit is in the shutdown mode. In Figure 9(C) a secondary device and a substantial parasitic load are both present at the same time in the vicinity of the primary unit. In this case, the primary unit is in the shutdown mode. In Figure 9(D) a secondary device is present in the vicinity of the primary unit, but the load connected to the secondary device does not need any power at

the current time. In this case, the primary unit is in the standby mode. Finally, in Figure 9(E) a secondary device is present and its load needs power to charge or operate. Thus, the primary unit is in the operating mode.

CLAIMS:

1. An inductive power transfer system comprising a primary unit, having a primary coil and electrical drive means connected to the primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field, and the system also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, wherein the primary unit further comprises:

control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and

decay measurement means operable to take one or more measures of such energy decay during said period; and

said control means are further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

2. A system as claimed in claim 1, wherein the or one said energy decay measure is a measure of a rate of such energy decay.

3. A system as claimed in claim 1 or 2, wherein said control means are operable to employ said one or more energy decay measures to detect when a substantial parasitic load is present in proximity to said primary unit, and are operable to restrict or stop inductive power transfer from the primary unit following the detection of such a substantial parasitic load.

4. A system as claimed in any preceding claim, wherein said control means are operable to employ said one or more energy decay measures to detect when there is no said secondary device present in proximity to said primary unit, and are operable to restrict or stop inductive power transfer from the primary unit when no such secondary device is detected.

5. A system as claimed in claim 3 or 4, wherein when carrying out such detection the control means are also operable to employ first compensation information relating to losses in the primary unit itself so as to compensate for said losses.

6. A system as claimed in claim 5, wherein the primary unit further comprises calibration means for deriving part or all of said first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation.

7. A system as claimed in any one of claims 3 to 6, wherein when carrying out such detection said control means are also operable to employ second compensation information relating to a parasitic load imposed on the primary unit by the secondary device so as to compensate for said parasitic load of said secondary device.

8. A system as claimed in claim 7, wherein the or each said secondary device is operable to communicate its said second compensation information directly to said primary unit or to communicate to said primary unit other information from which the primary unit can derive said second compensation information.

9. A system as claimed in claim 8, wherein said secondary device is operable to modulate a dummy load to communicate said other information, and the primary unit is operable to derive said second compensation information by measuring the dummy load modulation.

10. A system as claimed in any one of claims 5 to 9, wherein part or all of said first compensation information and/or part or all of said second compensation information is information stored in the primary unit during manufacture and/or testing of the primary unit.

11. A system as claimed in any one of claims 3 to 10, further comprising information varying means for varying one or both of said first and second compensation information when one or more operating conditions of the primary unit varies.

12. A system as claimed in any preceding claim, wherein:

said decay measurement means are operable to take one or more first such energy decay measures in a first such measurement period and to take one or more second such energy decay measures in a second measurement period;

the secondary device comprises decay varying means operable to cause the secondary device to consume more energy in said first measurement period than in said second measurement period; and

the control means in said primary unit are operable to employ the first and second energy decay measures to detect when a secondary device of the system is present in proximity to said primary unit.

13. A system as claimed in claim 12, wherein said decay varying means are operable to cause the secondary device to impose a first dummy load on the primary unit in said first measurement period and to impose a second dummy load, different from said first dummy load, on said primary unit in said second measurement period.

14. A system as claimed in claim 13, wherein one of the first and second dummy loads is zero.

15. A system as claimed in claim 13 or 14, wherein said decay varying means are disabled when an actual load of the secondary device requires no power.

16. A system as claimed in claim 13, 14 or 15 when read as appended to claim 9, wherein a difference between said first dummy load and said second dummy load is set in dependence upon said parasitic load imposed on said primary unit by said secondary device.

17. A system as claimed in any preceding claim, wherein said secondary device is adapted to supply the power it receives inductively from the primary unit to an actual load external to the secondary device.

18. A system as claimed in any preceding claim, wherein said secondary device comprises a storage means for storing energy received from the primary unit, said storage means being operable to supply such stored energy to an actual load and/or circuitry of the secondary device when said circuit is operating in said undriven resonating condition.

19. A system as claimed in any preceding claim, wherein said secondary device comprises load isolation means operable during said measurement period to prevent the supply to an actual load of the secondary device of any of the power being received inductively by the secondary device from the primary unit.

20. A system as claimed in any preceding claim, wherein:

said control means are operable, following such restriction or stopping of the inductive power transfer from the primary unit, to cause said circuit to operate in said undriven resonating condition during a series of intermittent probing periods;

the decay measurement means are operable to take one or more such energy decay measures during each said probing period; and

the control means are operable to employ the energy decay measures taken during the probing periods to determine when to end the restricted or stopped state.

21. A system as claimed in any one of claims 1 to 19, wherein said control means are operable, when the inductive power transfer from the primary unit has been set into such a restricted or stopped state, to maintain that state until the primary unit is reset by a user of the primary unit.

22. A system as claimed in any preceding claim, wherein the primary unit comprises synchronising means operable to transmit a predetermined synchronising signal to the secondary device to synchronise operation of the secondary device with that of the primary unit.

23. A system as claimed in claim 22, wherein said synchronising means are operable to send said predetermined synchronising signal prior to causing said circuit to operate in said undriven resonating condition.

24. A system as claimed in claim 22 or 23, wherein said primary unit further comprises snubber means, and said synchronising means are operable to switch said snubber means into said circuit after suspending the application of said electrical drive signals to said primary coil, so as to send said synchronising signal to said secondary device.

25. A system as claimed in any preceding claim, wherein said primary unit further comprises resonant frequency increasing means for temporarily increasing a resonant frequency of said circuit during operation thereof in said undriven resonating condition.

26. A system as claimed in any preceding claim, wherein said control means are operable to cause said electrical drive means to resume application of said drive signals to said primary coil in phase with any residual resonating energy within said circuit.

27. A system as claimed in any preceding claim, wherein said control means are operable to cause said electrical drive means to temporarily boost said electrical drive signals prior to causing said circuit to operate in said undriven resonating condition.

28. A system as claimed in any preceding claim, wherein said control means are operable to measure a natural resonant frequency of said circuit during said measurement period and to employ the measured frequency to compensate for an influence of changes in the natural resonant frequency on said one or more energy decay measures.

29. A system as claimed in any preceding claim, wherein:

said control means are operable to cause said circuit to operate in said undriven resonating condition during a series of different such measurement periods;

said decay measurement means are operable to take one or more such energy decay measures in each said measurement period; and

said control means are operable to employ the energy decay measures taken in two or more different measurement periods to control said electrical drive means.

30. A system as claimed in any preceding claim, wherein:

said primary unit has first and second such primary coils, a first such electrical drive means connected to said first primary coil for applying electrical drive signals thereto so as to generate a first electromagnetic field, and a second such electrical drive means connected to said second primary coil for applying electrical drive signals thereto so as to generate a second electromagnetic field; and

said control means are operable to cause said second electrical drive means to suspend application of said electrical drive signals to said second primary coil whilst a first such circuit including said first primary coil is in said undriven resonating condition and said decay measurement means are taking one or more such measures of energy decay in said first circuit, and are also operable to cause said first electrical drive means to suspend application of said electrical drive signals to said first primary coil whilst a second such circuit including said second primary coil is in said undriven resonating condition and said decay measurement means are taking one or more such measures of energy decay in said second circuit.

31. A system as claimed in any preceding claim, wherein at least one said secondary device is carried in or by an object requiring power and can receive power inductively from the primary unit when the object carrying the secondary device is placed on or in proximity to the primary unit.

32. A system as claimed in claim 31, wherein said object is a portable electrical or electronic device.

33. A system as claimed in claim 31 or 32, wherein said object is a mobile communication device.

34. A system as claimed in any preceding claim, having a power transfer surface, said field generated by said primary unit being distributed over a power transfer area of the surface such that, when such a secondary device is placed on or in proximity to the power transfer area, the device can receive power inductively from the primary unit.

35. A system as claimed in any preceding claim, wherein said power transfer area is large enough that two or more such secondary devices can be placed on or in proximity to the power transfer area to receive power simultaneously from the primary unit.

36. A primary unit, for use in an inductive power transfer system, the primary unit comprising:

a primary coil;

electrical drive means connected to said primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field;

control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and

decay measurement means operable to take one or more measures of such energy decay during said period;

said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

37. A secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising:

a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and

communication means operable to communicate to the primary unit information relating to a parasitic load imposed on the primary unit by the secondary device.

38. A secondary device as claimed in claim 37, wherein said communication means are operable to communicate said information by imposing a dummy load on said primary unit.

39. A secondary device as claimed in claim 38, wherein said communication means are operable to impose a first dummy load on the primary unit at a first time and a second dummy load, different from said first dummy load, at a second time, a difference between said first and second dummy loads being set in dependence upon said parasitic load.

40. A secondary device as claimed in claim 39, wherein one of said first and second dummy loads is zero.

41. A portable electrical or electronic device comprising:

a load which at least at times requires power from said primary unit; and

a secondary device as claimed in any one of claims 37 to 40, said load connection means of said secondary device being connected to said load for supplying such inductively-received power to the load at said times.

42. A method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit, having a primary coil to which electrical drive signals are applied to generate an electromagnetic field, and also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to

couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, which method comprises:

causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil is suspended so that energy stored in the circuit decays over the course of said period;

taking one or more measures of such energy decay during said period; and

restricting or stopping inductive power transfer from the primary unit in dependence upon said one or more energy decay measures.

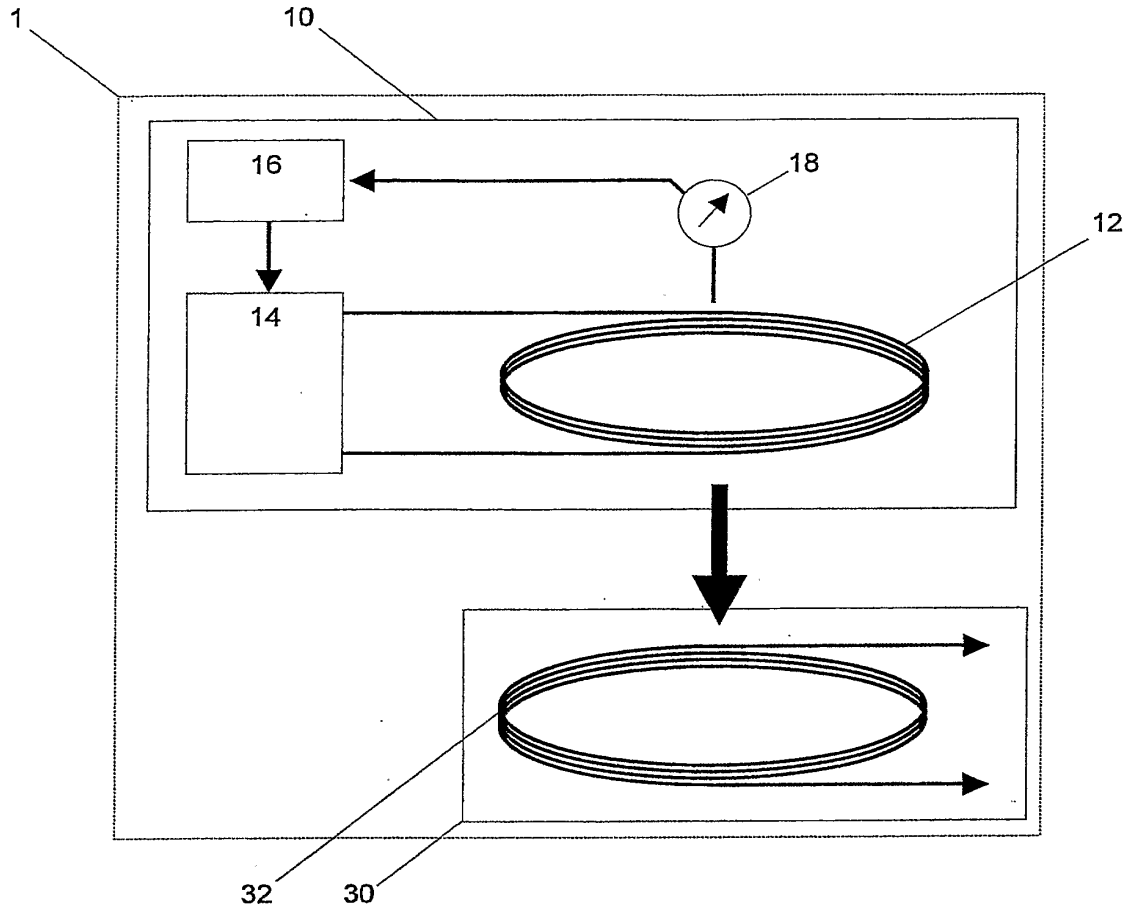


Figure 1

Figure 2(A)

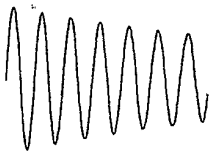
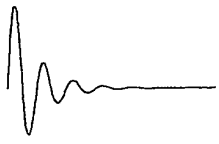


Figure 2(B)



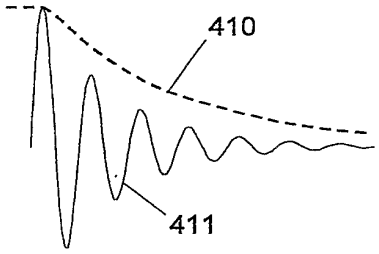


Figure 3

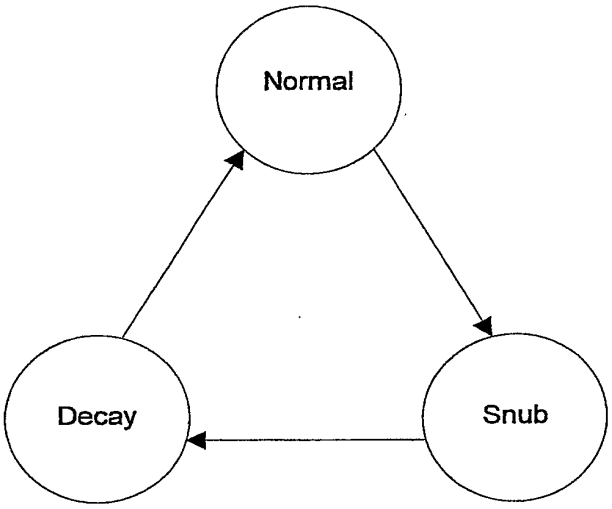


Figure 5

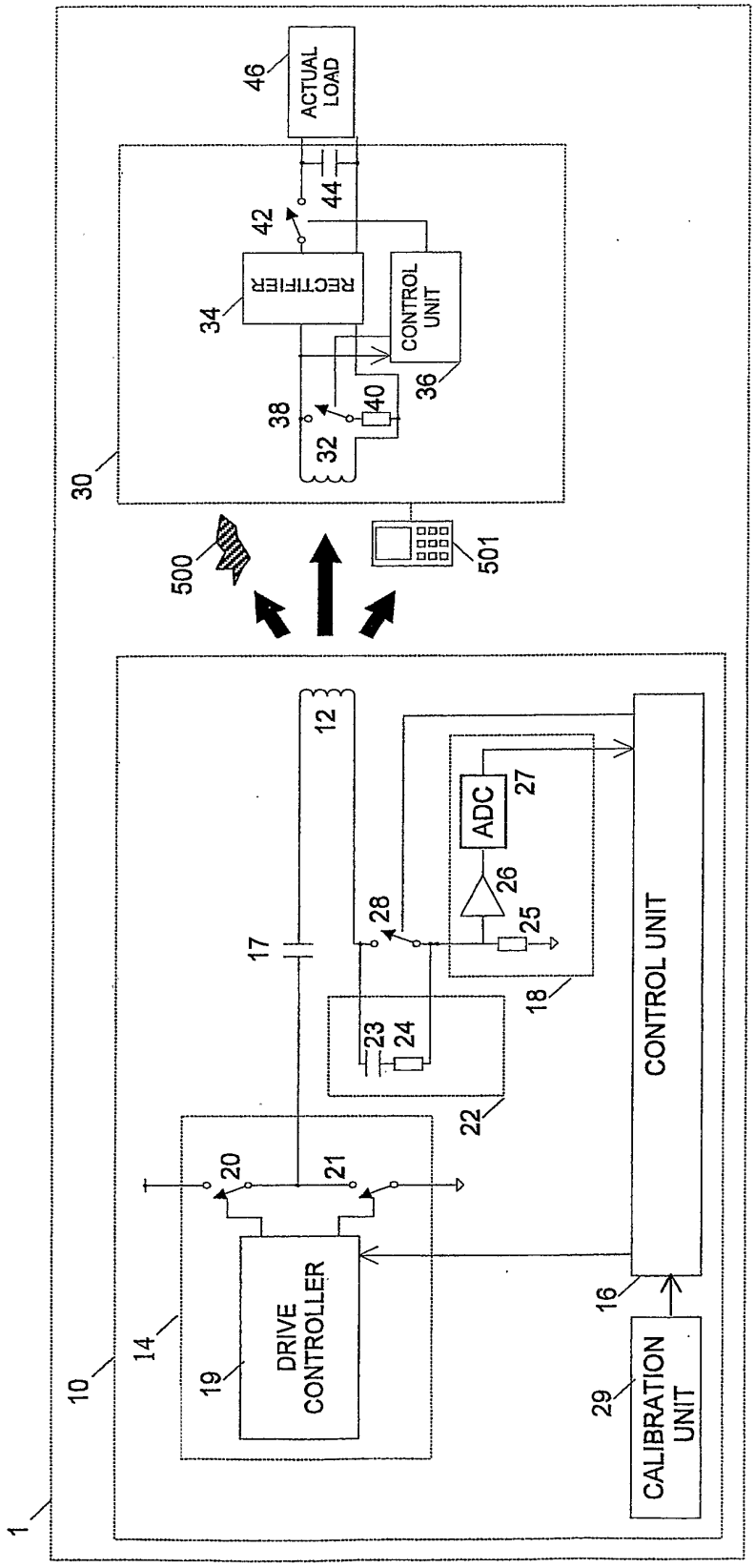

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501
ACTUAL LOAD
RECTIFIER
CONTROL UNIT
ADC
DRIVE CONTROLLER
CONTROL UNIT
CALIBRATION UNIT

Figure 4

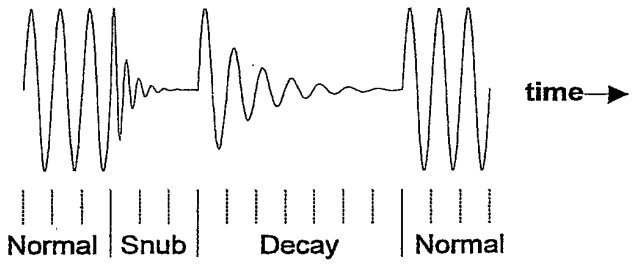


Figure 6



Figure 7

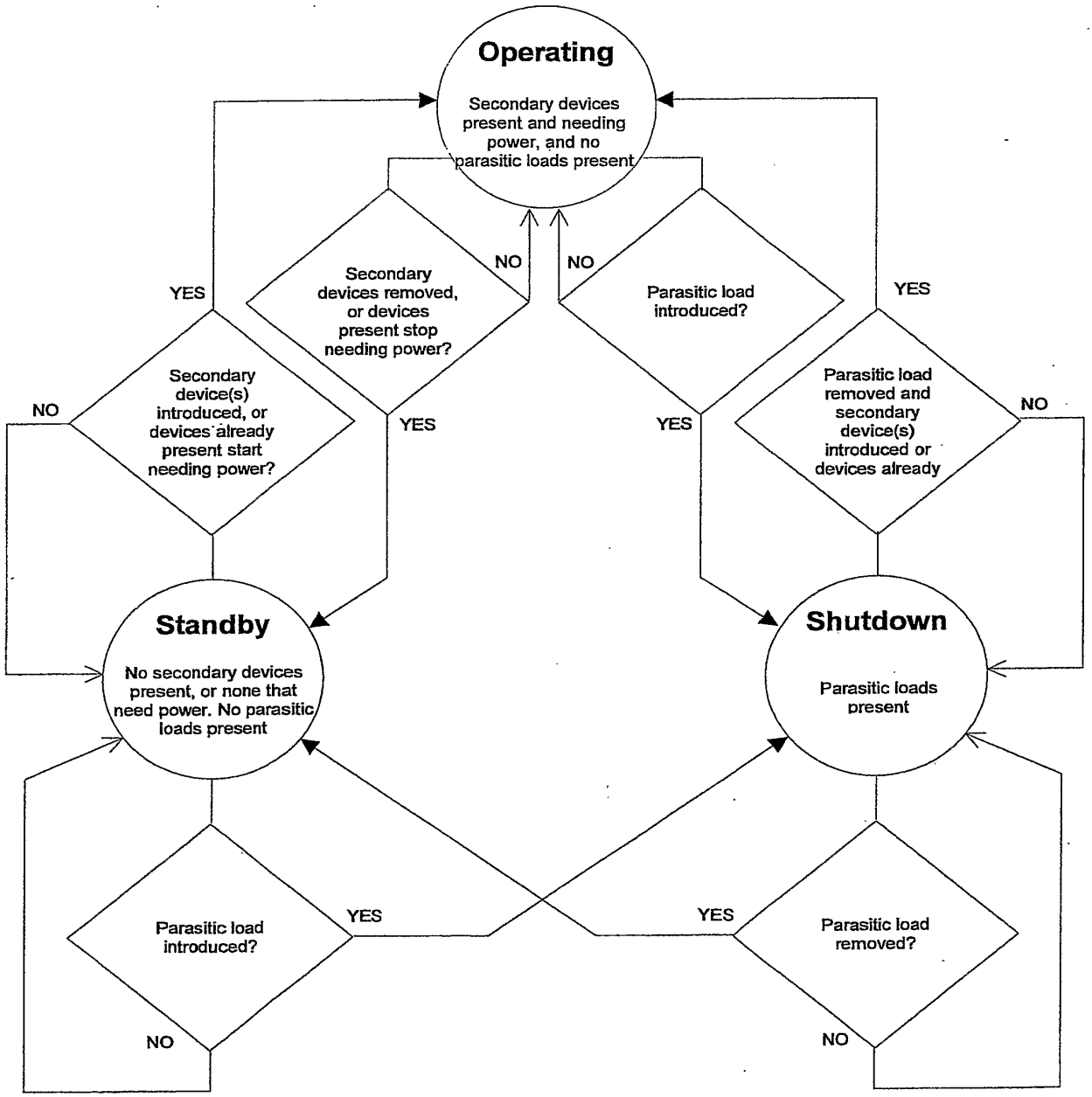

Operating
Secondary devices present and needing power, and no parasitic loads present
Secondary devices removed, or devices present stop needing power?
NO
YES
Parasitic load introduced?
NO
YES
Secondary device(s) introduced, or devices already present start needing power?
NO
YES
Parasitic load removed and secondary device(s) introduced or devices already
YES
NO
Standby
No secondary devices present, or none that need power. No parasitic loads present
Shutdown
Parasitic loads present
Parasitic load introduced?
YES
NO
Parasitic load removed?
YES
NO

Figure 8

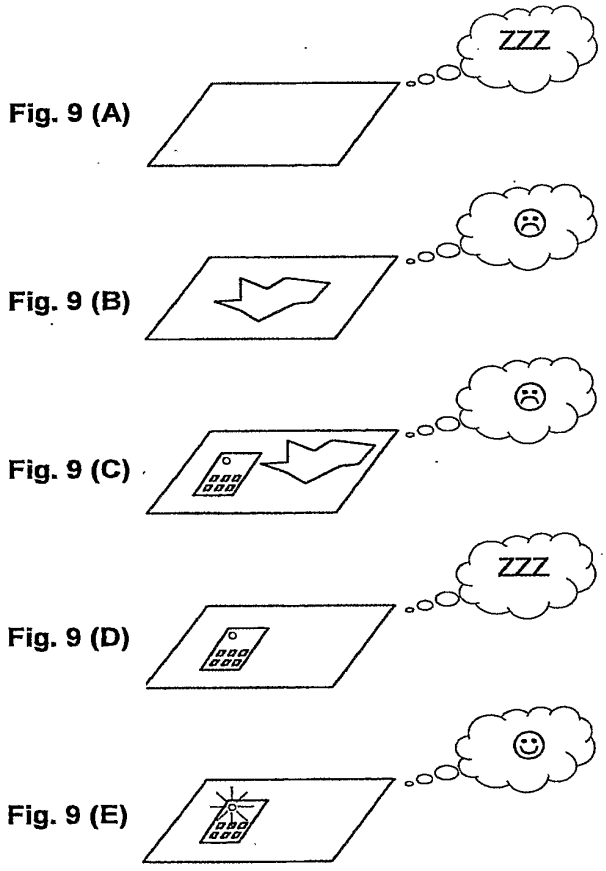


Figure 9

INTERNATIONAL SEARCH REPORT

Int Application No
PCT/GB2005/001833

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 057 668 A (CHAO ET AL) 2 May 2000 (2000-05-02) claims 1-5; figure 2	37-41
A	US 6 263 247 B1 (MUELLER JEFFREY S ET AL) 17 July 2001 (2001-07-17) column 1 - column 9; claims 1-4; figure 8	1-36,42
A	US 5 619 078 A (BOYS ET AL) 8 April 1997 (1997-04-08) column 10, line 60 - column 12, line 55; figures 9,10	1-36,42

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2005	03/08/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mapp, G

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

mation on patent family members

Inter il Application No
PCT/GB2005/001833

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6057668 A	02-05-2000	DE 29816725 U1	14-01-1999
US 6263247 B1	17-07-2001	US 6047214 A	04-04-2000
		US 6345203 B1	05-02-2002
US 5619078 A	08-04-1997	AU 4093493 A	13-12-1993
		AU 4093593 A	13-12-1993
		DE 69326762 D1	18-11-1999
		DE 69326762 T2	20-04-2000
		DE 69330516 D1	06-09-2001
		DE 69330516 T2	25-04-2002
		EP 0640254 A1	01-03-1995
		EP 0640255 A1	01-03-1995
		ES 2163409 T3	01-02-2002
		ES 2139004 T3	01-02-2000
		JP 3512798 B2	31-03-2004
		JP 8501435 T	13-02-1996
		JP 3512799 B2	31-03-2004
		JP 8501436 T	13-02-1996
		KR 154345 B1	15-12-1998
		WO 9323908 A1	25-11-1993
		WO 9323909 A1	25-11-1993
		US 5898579 A	27-04-1999

Form PCT/ISA/210 (patent family annex) (January 2004)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)
(PCT Rule 44bis.1(c))

To:

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NOV 10 2011

KENNA, Karl, F.
Fliesler Meyer LLP
650 California Street, Fourteenth Floor
San Francisco, California 94108
ETATS-UNIS D'AMERIQUE

FLIESLER MEYER LLP

Date of mailing *(day/month/year)* 10 November 2011 (10.11.2011)	
Applicant's or agent's file reference AFPA1026WO0 ✓	IMPORTANT NOTICE

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2010/032845 /	28 April 2010 (28.04.2010) ✓	28 April 2009 (28.04.2009) ✓

Applicant
MOJO MOBILITY, INC. et al ✓

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

Docket No: AFPA-01026WO4
Atty: KFK
Docketed By: mpx
Verified By: ✓
Notes

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Athina Nickitas-Etienne
Facsimile No. +41 22 338 82 70	e-mail: pt04.pct@wipo.int

Form PCT/IB/326 (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference AFPA1026WO0	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2010/032845	International filing date *(day/month/year)* 28 April 2010 (28.04.2010)	Priority date *(day/month/year)* 28 April 2009 (28.04.2009)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant MOJO MOBILITY, INC.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 01 November 2011 (01.11.2011)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Athina Nickitas-Etienne e-mail: pt04.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KENNA KARL F.

FLIESLER MEYER LLP 650 CALIFORNIA STREET,
FOURTEENTH FLOOR SAN FRANCISCO CA 94108 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**13 DECEMBER 2010 (13.12.2010)**
Applicant's or agent's file reference AFPA1026WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2010/032845	**28 APRIL 2010 (28.04.2010)**	28 APRIL 2009 (28.04.2009)

International Patent Classification (IPC) or both national classification and IPC

H02J 7/00(2006.01)i, H02J 17/00(2006.01)i, H01F 38/14(2006.01)i

Applicant

MOJO MOBILITY, INC. et al

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302 -701, Republic of Korea Facsimile No. 82-42-472-7140	10 DECEMBER 2010 (10.12.2010)	KOO, Young Hoi Telephone No.0424818376

Form PCT/ISA/237 (cover sheet) (July 2009)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/032845

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/032845

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-60	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-60	NO
Industrial applicability (IA)	Claims	1-60	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: WO 2008-137966 A1 (MOJO MOBILITY, INC. et al) 13 NOVEMBER 2008.
D2: US 2008-0258679 A1 (Manico Joseph A. et al) 23 OCTOBER 2008.

The present invention relates to systems and methods for inductive charging.

D1 discloses system and method for inductive charging of portable device.
D2 discloses a charging display system.

1. Novelty and Inventive Step

1.1 Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, includes additional functionality such as communication of data(Page 5), heat removal, reducing any potential EMI issues, and shielding the outside environment from any potential radiative fields([00308]). Claim 1 differs from D1 in that includes activation of applications. However, it is well known in that includes charging display system determining whether activation of a particular wireless charging element in D2([0056]). Claim 1 would have been obvious over D1 in view of D2. Therefore, claim 1 lacks an inventive step under PCT Article 33(3).

1.2 Claim 2

The subject matter of claim 2 relates a method claim corresponding to a system for use with a charging device for charging or powering another device of claim 1. Therefore, Claim 2 lacks an inventive step under PCT Article 33(3), because the subject matter of claim 1 is considered to lack an inventive step under PCT Article 33(3).

1.3 Independent Claim 15

D1, which is considered to be the closest prior art to the subject matter of claim 15, includes wireless or wired charger, the basic concepts for the control, verification, and data transmission implemented in a similar manner([00208]) and determining the appropriate charging/powering condition([00107]). Claim 15 differs from D1 in that includes determining the best method for charging by wireless and/or wired power transfer. However, it would be obvious to a person skilled in the art to apply the feature of determining the appropriate charging/powering condition in D1([00107]). Claim 15 would have been obvious over D1. Therefore, claim 15 lacks an inventive step under PCT Article 33(3).

1.4 Dependent Claims 3, 5, 6-14, 16-27, 29-34, 36-42, 44-60

The subject matter of claim 3 dependent on claim 1 is identical to base unit, charger or power

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Box V

supply, and a device or batteries in D1(Claims 1-2). Therefore, claim 3 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 5 dependent on claim 3 is considered to be a minor difference over data communication between a device and a charger or power supply in D1(Page 45). Therefore, claim 5 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 6 dependent on claim 3 is considered to be a minor difference over a device including cellular telephones, PDAs, notebook, radios in D1([0003]). Therefore, claim 6 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 7 dependent on claim 3 is identical to inductive power transfer in D1([00105]). Therefore, claim 7 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 8-10 dependent on claim 3 is considered to be a minor difference over the same coil or wires as antenna for data transfer in D1([00130]). Therefore, claims 8-10 lack an inventive step under PCT Article 33(3).

The subject matter of claim 11 dependent on claim 3 is considered to be a minor difference over pre-programmed manner in D1([154]). Therefore, claim 11 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 12-13 dependent on claim 3 is considered to be a minor difference over device identification and verification in D1([00182]). Therefore, claims 12-13 lack an inventive step under PCT Article 33(3).

The subject matter of claim 14 dependent on claim 1 is considered to be a minor difference over alignment magnets in D1([00341]). Therefore, claim 14 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 16-23 dependent on claim 1 is considered to be a minor difference over a base unit and/or receiver, inductive coil, magnet, metal layer, reducing eddy current, coil layer, conductive layer in D1. Therefore, claims 16-23 lack an inventive step under PCT Article 33(3).

The subject matter of claims 24-27 dependent on claim 1 is considered to be a minor difference over a base unit and/or receiver, inductive coil, several devices, rechargeable batteries, ferromagnetic layers, heat reduction, magnet, metal layer, reducing eddy current in D1. Therefore, claims 24-27 lack an inventive step under PCT Article 33(3).

The subject matter of claims 29-34 dependent on claim 1 is considered to be a minor difference over a receiver coil, connector, battery pack, some contact points, bidirectional communication, and cylindrical battery in D1. Therefore, claims 29-34 lack an inventive step under PCT Article 33(3).

The subject matter of claims 36-42 dependent on claim 1 is considered to be a minor difference over charging for laptop computer and USB outlet of a laptop in D1, speaker and monitor in D2, mouse pad in D1. Therefore, claims 36-42 lack an inventive step under PCT Article 33(3).

The subject matter of claim 44 dependent on claim 1 is considered to be a minor difference over flatness in D1 (Fig. 35) and coil shape in D1. Therefore, claim 44 lacks an inventive step under PCT Article 33(3).

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Previous Supplemental Box

The subject matter of claims 45-50 dependent on claim 1 is considered to be a minor difference over CD, DVD player, receiver coil, magnet, shield layer, battery identification, protection against reverse voltage, temperature sensor, and alignment magnets in D1. Therefore, claims 45-50 lack an inventive step under PCT Article 33(3).

The subject matter of claims 51-54 dependent on claim 1 is considered to be a minor difference over metal layer, battery, case, skin, RFID, temperature sensor, and switching circuit in D1. Therefore, claims 51-54 lack an inventive step under PCT Article 33(3).

The subject matter of claims 55-60 dependent on claim 52 is considered to be a minor difference over battery, case, skin, coil layer, reducing any potential EMI issues, wireless charging, wired power supply, RFID, termperature sensor, and alignment magnets in D1. Therefore, claims 55-60 lack an inventive step under PCT Article 33(3).

1.5 Claim 4, 28, 35, 43

The subject matter of claims 4, 28, 35, 43 relates a method claim corresponding to a system for use with a charging device for charging or powering another device of claims 3, 16, 30, 36. Therefore, Claims 4, 28, 35, 43 lack an inventive step under PCT Article 33(3), because the subject matter of claims 3, 16, 30, 36 is considered to lack an inventive step under PCT Article 33(3).

2. Industrial Applicability

Claims 1-60 are considered to be industrially applicable under PCT Article 33(4).

(19)日本国特許庁(JP)　(12)公開特許公報(A)　(11)特許出願公開番号
特開2006-246633
(P2006-246633A)
(43)公開日　平成18年9月14日(2006.9.14)

(51)Int.Cl.		F I			テーマコード（参考）
H02J 7/00	(2006.01)	H02J	7/00	301D	5G003
H02J 17/00	(2006.01)	H02J	17/00	B	

審査請求 未請求　請求項の数 10　OL　（全 24 頁）

(21)出願番号　特願2005-59747(P2005-59747)
(22)出願日　平成17年3月3日(2005.3.3)

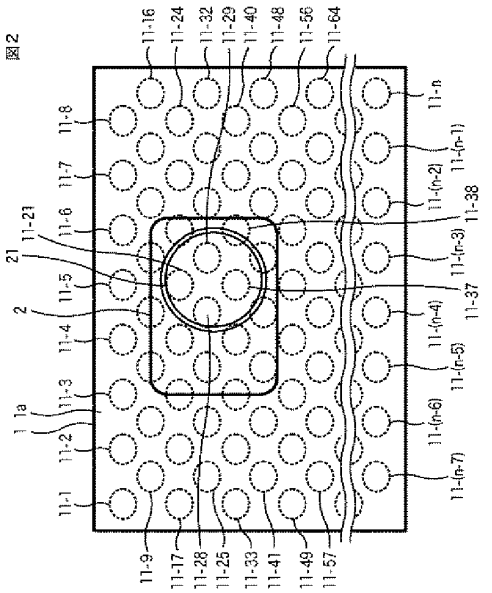
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最終頁に続く

(54)【発明の名称】電力供給システム、電力供給装置および方法、受電装置および方法、記録媒体、並びにプログラム

(57)【要約】
【課題】より迅速に、受電装置に電力を供給するようにする。
【解決手段】電磁誘導により電力を供給する電力供給部１１－１乃至１１－ｎを有する電力供給装置１において、電力供給装置１が、電力供給部１１－１乃至１１－ｎのうちから、電力供給装置１の設置面１ａに載せられた、受電装置２の受電部２１の位置に対応する電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７を選択する。その後、選択された電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７が、受電装置２の受電部２１に対して電磁誘導により電力を供給する。本発明は、携帯電話機等に電力を供給する電力供給装置に適用することができる。
【選択図】図２

図2



【特許請求の範囲】
【請求項1】
少なくとも１個の受電装置と、前記受電装置に電力を供給する電力供給装置とからなる電力供給システムにおいて、
前記電力供給装置は、
前記受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、
複数の前記電力供給手段のうちの、前記受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、
前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段と、
前記制御情報に基づいて、選択された複数の前記電力供給手段により前記受電装置へ電力を供給するように制御する制御手段と
を備え、
前記受電装置は、
選択された複数の前記電力供給手段から前記電磁誘導により電力の供給をうける１つの受電手段と、
選択された前記電力供給手段から前記電磁誘導により電力の供給をうけた場合、前記制御情報を無線で送信する送信手段と
を備える
ことを特徴とする電力供給システム。
【請求項2】
少なくとも１個の受電装置に電力を供給する電力供給装置において、
前記受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、
複数の前記電力供給手段のうちの、前記受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、
前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段と、
前記制御情報に基づいて、選択された複数の前記電力供給手段により前記受電装置へ電力を供給するように制御する制御手段と
を備えることを特徴とする電力供給装置。
【請求項3】
前記制御手段は、前記通信手段を介して情報の授受を行い、前記受電装置との認証処理を行う
ことを特徴とする請求項２に記載の電力供給装置。
【請求項4】
前記選択手段は、複数の前記電力供給手段が順に磁界を発生することに基づいて、前記通信手段が、前記受電装置から送信されてくる、電力が供給されたことを示す情報を受信した場合、そのとき前記磁界を発生している前記電力供給手段を、前記受電装置が載せられた前記位置に対応する電力供給手段として選択する
ことを特徴とする請求項２に記載の電力供給装置。
【請求項5】
前記電力供給手段が前記磁界を発生した場合に、前記電力供給手段に過電流が流れたことを検出する検出手段をさらに備え、
前記選択手段は、前記通信手段が電力が供給されたことを示す情報を受信する前に、前記検出手段により過電流が検出された場合、過電流が検出された前記電力供給手段を選択しない
ことを特徴とする請求項４に記載の電力供給装置。
【請求項6】
受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の

載せされた受電装置に前記電力供給部から電力を供給する電力供給装置の電力供給方法において、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とする電力供給方法。
【請求項7】
　受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の載せされた受電装置に前記電力供給部から電力を供給する電力供給装置の電力供給処理用のプログラムにおいて、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とするコンピュータが読み取り可能なプログラムが記録されている記録媒体。
【請求項8】
　受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の載せされた受電装置に前記電力供給部から電力を供給する電力供給装置のコンピュータに電力供給処理を行わせるプログラムにおいて、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とするプログラム。
【請求項9】
　電磁誘導により電力を供給する複数の電力供給部を備える電力供給装置から電力の供給をうける受電装置において、
　複数の前記電力供給部から前記電磁誘導により電力の供給をうける少なくとも１つの受電手段と、
　前記電力供給部から前記電磁誘導により電力の供給をうけた場合、前記電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段と
　を備えることを特徴とする受電装置。
【請求項10】
　電磁誘導により電力を供給する複数の電力供給部を備える電力供給装置から電力の供給をうける受電装置の受電方法において、
　複数の前記電力供給部から前記電磁誘導により電力の供給をうける受電ステップと、
　前記電力供給部から前記電磁誘導により電力の供給をうけた場合、前記電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップと
　を含むことを特徴とする受電方法。

【発明の詳細な説明】
【技術分野】
【0001】
　本発明は、電力供給システム、電力供給装置および方法、受電装置および方法、記録媒

体、並びにプログラムに関し、特に、受電装置への電力の供給に好適な電力供給システム、電力供給装置および方法、受電装置および方法、記録媒体、並びにプログラムに関する。

【背景技術】

【0002】

従来、PDA（Personal Digital Assistance）やデジタル携帯電話機などの電子機器は、交流電源から、ACアダプタを介し、ACアダプタから延びるプラグと接続されることで、電力が供給され、バッテリの充電を行っていた。すなわち、電源から、電力供給用の配線を介して（有線で）、電子機器に電力が供給されていた。

【0003】

これに対して、電源から電力供給用の配線を用いずに（無線で）、電子機器に電力を供給する電力供給装置が提案されている。

【0004】

例えば、特許文献１には、マスタシステムの１個の電磁誘導コイルからパワーレシーバシステムの１個の電磁誘導コイルに、電磁誘導により電力を供給することが開示されている。

【0005】

特許文献２では、複数の給電コイルを有する給電装置が、複数の給電コイルの内の１つを順次選択して通電する。給電装置の設置面に載置された受電機器においては、その１個の受電コイルおよび１個の認識タグ用コイルが、給電コイルの発生する電磁波を受け、誘電起電力を得る。認識タグ用コイルから給電装置にＩＤが送信され、給電装置は受信したＩＤを、そのとき通電していた給電コイルのインデックスとともに記憶する。以後、記憶された情報を基に、給電コイルの通電時間が制御される。

【特許文献1】特開平６－１３３４７６号公報

【特許文献2】特開２００３－２２４９３７号公報

【発明の開示】

【発明が解決しようとする課題】

【0006】

しかしながら、これら従来の装置においては、電力供給装置における給電コイルと受電装置における受電コイルとが１対１に対応していた。その結果、充電完了までに時間がかかっていた。

【0007】

本発明は、このような状況に鑑みてなされたものであり、より迅速に、受電装置に電力を供給することができるようにするものである。

【課題を解決するための手段】

【0008】

本発明の電力供給システムは、電力供給装置が、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段とを備え、受電装置が、選択された複数の電力供給手段から電磁誘導により電力の供給をうける１つの受電手段と、選択された電力供給手段から電磁誘導により電力の供給をうけた場合、制御情報を無線で送信する送信手段とを備えることを特徴とする。

【0009】

本発明の電力供給装置は、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段とを備えることを

特徴とする。

【0010】

制御手段は、通信手段を介して情報の授受を行い、受電装置との認証処理を行うようにすることができる。

【0011】

選択手段は、複数の電力供給手段が順に磁界を発生することに基づいて、通信手段が、受電装置から送信されてくる、電力が供給されたことを示す情報を受信した場合、そのとき磁界を発生している電力供給手段を、受電装置が載せられた位置に対応する電力供給手段として選択するようにすることができる。

【0012】

電力供給装置は、電力供給手段が磁界を発生した場合に、電力供給手段に過電流が流れたことを検出する検出手段をさらに備え、選択手段は、通信手段が電力が供給されたことを示す情報を受信する前に、検出手段により過電流が検出された場合、過電流が検出された電力供給手段を選択しないようにすることができる。

【0013】

本発明の電力供給方法は、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとを含むことを特徴とする。

【0014】

本発明の記録媒体のプログラムは、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとを含むことを特徴とする。

【0015】

本発明のプログラムは、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとをコンピュータに実行させることを特徴とする。

【0016】

本発明の受電装置は、複数の電力供給部から電磁誘導により電力の供給をうける少なくとも１つの受電手段と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段とを備えることを特徴とする。

【0017】

本発明の受電方法は、複数の電力供給部から電磁誘導により電力の供給をうける受電ステップと、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップとを含むことを特徴とする。

【0018】

本発明の電力供給システムにおいては、電力供給装置において、複数の電力供給手段により受電装置に対して電磁誘導により電力が供給され、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段が選択され、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報が受信され、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力が供給されるように制御され、受電装置において、１つの受電手段に、選択された複数の電力供給手段から電磁誘導により電力が供給され、選択された電力供給手段から電磁誘導により電力が供給された場合、制御情報が無線で送信される。

【0019】
本発明の電力供給装置、電力供給方法、記録媒体のプログラム、およびプログラムにおいては、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部が選択され、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報が受信され、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力が供給されるように制御される。
【0020】
本発明の受電装置および受電方法においては、複数の電力供給部から電磁誘導により電力が供給され、電力供給部から電磁誘導により電力が供給された場合、電力供給装置に、電力の供給を制御する制御情報が無線で送信される。
【発明の効果】
【0021】
本発明によれば、受電装置に電力を供給することができる。また、本発明によれば、より迅速に、受電装置に電力を供給することができる。
【発明を実施するための最良の形態】
【0022】
以下に本発明の実施の形態を説明するが、請求項に記載の構成要件と、発明の実施の形態における具体例との対応関係を例示すると、次のようになる。この記載は、請求項に記載されている発明をサポートする具体例が、発明の実施の形態に記載されていることを確認するためのものである。従って、発明の実施の形態中には記載されているが、構成要件に対応するものとして、ここには記載されていない具体例があったとしても、そのことは、その具体例が、その構成要件に対応するものではないことを意味するものではない。逆に、具体例が構成要件に対応するものとしてここに記載されていたとしても、そのことは、その具体例が、その構成要件以外の構成要件には対応しないものであることを意味するものでもない。
【0023】
さらに、この記載は、発明の実施の形態に記載されている具体例に対応する発明が、請求項に全て記載されていることを意味するものではない。換言すれば、この記載は、発明の実施の形態に記載されている具体例に対応する発明であって、この出願の請求項には記載されていない発明の存在、すなわち、将来、分割出願されたり、補正により追加される発明の存在を否定するものではない。
【0024】
請求項１に記載の電力供給システムは、少なくとも１個の受電装置と、受電装置に電力を供給する電力供給装置とからなる電力供給システムであって、電力供給装置（例えば、図１の電力供給装置１）は、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段（例えば、図３の電力供給部１１）と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段（例えば、図３のセレクタ７２）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段（例えば、図３の通信部７３）と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段（例えば、図３の電力供給制御部７１）とを備え、受電装置（例えば、図１の受電装置２）は、選択された電力供給手段から電磁誘導により電力の供給をうける受電手段（例えば、図４の受電部２１）と、選択された電力供給手段から電磁誘導により電力の供給をうけた場合、制御情報を無線で送信する送信手段（例えば、図４の通信部１０７）とを備えることを特徴とする。
【0025】
請求項２に記載の電力供給装置は、少なくとも１個の受電装置に電力を供給する電力供給装置（例えば、図１の電力供給装置１）であって、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段（例えば、図３の電力供給部１１）と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択

手段（例えば、図３のセレクタ７２）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段（例えば、図３の通信部７３）と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段（例えば、図３の電力供給制御部７１）とを備えることを特徴とする。

【0026】

請求項５に記載の電力供給装置は、電力供給手段が、磁界を発生した場合に、電力供給手段に過電流が流れたことを検出する検出手段（例えば、図３の電流検出器５３）をさらに備え、選択手段は、通信手段が電力が供給されたことを示す情報を受信する前に、検出手段により過電流が検出された場合、過電流が検出された電力供給手段を選択しない（例えば、図５のステップＳ４９の処理）ようにすることができる。

【0027】

請求項６に記載の電力供給装置は、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）の電力供給方法において、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを含むことを特徴とする。

【0028】

請求項７に記載の記録媒体のプログラムは、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）の電力供給処理用のプログラムであって、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを含むことを特徴とする。

【0029】

請求項８に記載のプログラムは、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）のコンピュータに、電力供給処理を行わせるプログラムにおいて、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを実行させる。

【0030】

請求項９に記載の受電装置は、電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備える電力供給装置（例えば、図１の電力供給装置１）から電力の供給をうける受電装置（例えば、図１の受電装置２）であって、複数の電力供給部から電磁誘導により電力の供給をうけるすくなくとも１つの受電手段（例えば、図４の受電部２１）と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段（例えば、図４の通信部１０７）とを備えることを特徴とする。

【0031】
請求項１０に記載の受電方法は、電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備える電力供給装置（例えば、図１の電力供給装置１）から電力の供給をうける受電装置（例えば、図１の受電装置２）の受電方法であって、複数の電力供給部から電磁誘導により電力の供給をうける受電ステップ（例えば、図１０のステップＳ１５１の処理）と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップ（例えば、図１０のステップＳ１５５）とを含むことを特徴とする。
【0032】
以下に、本発明の実施の形態について図面を参照して説明する。
【0033】
図１は、本発明の一実施の形態に係る電力供給システムの構成の例を示す斜視図である。
【0034】
このシステムは、電力供給装置１と受電装置２とで構成される。電力供給装置１の表面には、電磁波を透過させる材質のシートで形成される設置面１ａが設けられている。電力供給装置１は、この設置面１ａに、受電装置２が載せられた場合、受電装置２に無線で、必要な電力を供給する。すなわち、電力供給装置１は、電力供給用の配線無しで、受電装置２に電力を供給する。
【0035】
受電装置２は、例えば、ノート型パーソナルコンピュータ、PDA、携帯電話機、もしくはPHS（Personal Handyphone System）などの機器、または各種機器から取り外すことが可能なバッテリである。
【0036】
図２は、電力供給装置１の設置面１ａ上に受電装置２が載せられた状態を上方向から見た透過図である。
【0037】
電力供給装置１には、電磁誘導により受電装置２に電力を供給するｎ個の電力供給部１１－１乃至１１－ｎが設けられている。電力供給部１１－１乃至１１－ｎは、設置面１ａの下部（図２の紙面と垂直な下方向）に、例えば、市松状に設けられている。
【0038】
以下、電力供給部１１－１乃至１１－ｎを個々に区別する必要のないとき、単に、電力供給部１１と称する。
【0039】
受電装置２には、その下面側（設置面１ａと接触している面側）に、１個の受電部２１が設けられている。１個の受電部２１は、複数の電力供給部１１が発生する磁界による電磁誘導により電力の供給をうける。
【0040】
すなわち、図２に示されるように、１個の受電部２１（より詳細には後述する図４の受電アンテナ１０１）は、その大きさ（面積）が１個の電力供給部１１の大きさ（面積）より、大きくなるように形成されている。図２の例では、受電装置２の１個の受電部２１は、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個の電力供給部１１を含む大きさになされている。
【0041】
図３は、電力供給装置１の構成の例を示すブロック図である。電力供給装置１は、ｎ個の電力供給部１１（図３には１個のみが示されている）、制御部４１、メモリ４２、リアルタイムクロック４３、および電源回路４４により構成されている。
【0042】
電力供給部１１は、スイッチ５１、電力供給アンテナ５２、および電流検出器５３により構成される。

【0043】
スイッチ５１は、制御部４１のセレクタ７２から供給される制御信号に基づいて、オンまたはオフされる。スイッチ５１がオンの場合、電力供給アンテナ５２には、電源回路４４から交流電流が流れる。このとき、電力供給アンテナ５２は、電流が流れることで磁界を発生する。すなわち、電力供給アンテナ５２は、電流が流れることで磁界を発生するコイルである。
【0044】
電流検出器５３はグランドに接続されており、スイッチ５１がオンである場合、電力供給アンテナ５２に流れる電流の大きさを検出する。また、電流検出器５３は検出した電流の大きさに対応する電流検出信号を、制御部４１のセレクタ７２に供給する。
【0045】
制御部４１は、電力供給制御部７１、セレクタ７２、通信部７３、および温度センサ７４により構成される。
【0046】
電力供給制御部７１は、汎用のCPU（Central Processing Unit）やMPU（Micro Processing Unit）などにより構成される。電力供給制御部７１は、必要に応じて、フラッシュメモリなどで構成されるメモリ４２にデータを記憶したり、メモリ４２に記憶してあるデータまたはプログラム、もしくはクロックパルスを発生するリアルタイムクロック４３から供給されるクロックパルスを基に、充電動作を制御する。
【0047】
セレクタ７２は、電力供給制御部７１の制御の基に、スイッチ５１のオンまたはオフを指示する制御信号を電力供給部１１に供給する。また、セレクタ７２には、電流検出器５３から、電力供給アンテナ５２に流れている電流値を示す電流検出信号が供給される。セレクタ７２は、その電流検出信号を電力供給制御部７１に供給する。
【0048】
アンテナなどより構成される通信部７３は、電力供給制御部７１の制御に基づいて、電波や赤外線を用いることにより、受電装置２と情報の授受を行う。
【0049】
温度センサ７４は、電力供給部１１－１乃至１１－ｎのそれぞれ、または設置面１ａの一部（例えば、電力供給部１１－１乃至１１－３２が配置されている部分、電力供給部１１－３３乃至１１－６４が配置されている部分、電力供給部１１－６５乃至１１－ｎが配置されている部分の３つの部分）の温度を測定し、その測定結果を電力供給制御部７１に供給する。これにより、電力供給制御部７１は、電力供給部１１における回路異常や漏電などを認識し、必要に応じて全てのスイッチ５１をオフにすることができる。
【0050】
電源回路４４は、電源ケーブルを介して供給される交流電流をそのまま、あるいは所定の周波数の交流電流を生成して、電力供給部１１に供給する。
【0051】
電力供給制御部７１には、必要に応じて、ドライブ８１が接続され、磁気ディスク、光ディスク、光磁気ディスク、或いは半導体メモリなどのリムーバブルメディア８２が適宜装着され、それらから読み出されたコンピュータプログラムが、必要に応じてメモリ４２にインストールされる。
【0052】
図４は、受電装置２の構成の例を示すブロック図である。受電装置２は、受電部２１、メモリ１２１、リアルタイムクロック１２２、およびバッテリ１２３により構成される。
【0053】
受電部２１は、受電アンテナ１０１、整流器１０２、受電制御部１０３、端子１０４、端子１０５、スイッチ１０６、および通信部１０７から構成される。
【0054】
受電アンテナ１０１には、上述した電力供給部１１の電力供給アンテナ５２に電流が流

れることにより発生した磁界によって、交流電流が流れる。すなわち、受電アンテナ１０１は、電力供給アンテナ５２が発生した磁界による電磁誘導により電流が流れるコイルである。

【0055】

受電アンテナ１０１の大きさは電力供給アンテナ５２の大きさより大きく形成されている。

【0056】

受電アンテナ１０１に流れる電流は整流器１０２に供給される。整流器１０２は、受電アンテナ１０１から流れる交流電流を整流し、直流電流を生成する。整流器１０２は、生成した直流電流を受電制御部１０３に動作電源として供給する。また、整流器１０２は、端子１０４、端子１０５、およびスイッチ１０６を介して、バッテリ１２３に電流を流し、バッテリ１２３を充電させる。

【0057】

受電制御部１０３は、汎用のCPUやMPUなどにより構成される。すなわち、例えば、受電部２１およびバッテリ１２３は、スマートバッテリの規格に準ずるインテリジェントバッテリである。

【0058】

受電制御部１０３は、整流器１０２から電流が供給されることで起動する。受電制御部１０３は、起動後、通信部１０７を介し、電力供給装置１と情報の通信を行う。また、受電制御部１０３は、スイッチ１０６をオンにし、バッテリ１２３に充電電力を供給する。

【0059】

受電制御部１０３は、必要に応じて、フラッシュメモリなどで構成されるメモリ１２１にデータを記憶したり、メモリ１２１に記憶してある受電装置２を識別する識別情報を取得したり、またはメモリ１２１に記憶されているプログラムを基づいて、充電動作を制御する。

【0060】

また、受電制御部１０３は、バッテリ１２３の充電が完了した場合、すなわち、端子１０４および端子１０５にかかる電圧が、バッテリ１２３の充電の完了を示す電圧に達した場合、スイッチ１０６をオフにする。

【0061】

従って、バッテリ１２３の充電が完了した場合、整流器１０２、端子１０４、バッテリ１２３、端子１０５、およびスイッチ１０６の経路での充電電流が流れなくなる。

【0062】

次に、図５のフローチャートを参照して、受電装置２が載せられた設置面１ａ上の位置、すなわち、設置面１ａにおける受電部２１の位置に対応する電力供給部１１の選択の処理について説明する。この処理は、電力供給装置１の電源がオンされたとき、あるいは受電装置２に対する充電が完了したとき再び開始される。

【0063】

ステップＳ４１において、電力供給制御部７１は、変数Ｎに１を設定する。

【0064】

ステップＳ４２において、セレクタ７２は、電力供給制御部７１の制御の基に、Ｎ番目の電力供給部１１に微弱な磁界を発生させる。すなわち、セレクタ７２は、Ｎ番目の電力供給部１１のスイッチ５１に対しオンの制御信号を供給し、電力供給アンテナ５２に電流を流し、弱い磁界を発生させる。

【0065】

ここで、Ｎ番目の電力供給部１１とは、図２で示される電力供給部１１－１乃至１１－ｎのいずれか１つを意味する。例えば、１（＝Ｎ）番目の電力供給部１１は、電力供給部１１－１を意味し、２（＝Ｎ）番目の電力供給部１１は、電力供給部１１－２を意味し、ｎ（＝Ｎ）番目の電力供給部１１は、電力供給部１１－ｎを意味する。

【0066】

ステップＳ４３において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0067】

ステップＳ４４において、電流検出器５３は、Ｎ番目の電力供給部１１における、電力供給アンテナ５２に流れている電流の値を検出する。

【0068】

ステップＳ４５において、電力供給制御部７１は、ステップＳ４４の処理により検出された電流の値が、閾値THａ以上であるか否かを判定する。すなわち、電力供給制御部７１は、電流検出器５３から供給される電流検出信号が示す電流の値が、閾値THａ以上であるかを判定する。

【0069】

ここで、ステップＳ４５において、電力供給アンテナ５２に流れる電流の値が閾値THa以上であるか否かを判定する理由を説明する。

【0070】

図６は、設置面１ａに異物２０１が載せられている状態を示す図である。図６で示される例では、異物２０１は、電力供給装置１において、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７に対応する位置に載せられている。

【0071】

異物２０１が金属である場合、例えば、Ｎ番目の電力供給部１１が電力供給部１１－２１であるとき、異物２０１には、電力供給部１１－２１が発生している磁界によって、異物２０１には渦電流が発生する。この異物２０１は金属であるため抵抗が少ない。これにより、この渦電流によって、電力供給部１１－２１の電力供給アンテナ５２には、過剰な電流（過電流）が流れてしまう。また、異物２０１も渦電流によって発熱してしまう恐れがある。

【0072】

以上のように、ステップＳ４５の処理は、電力供給アンテナ５２に、許容量以上の大きな電流が流れてしまうことを防ぐための処理である（後述するステップＳ４９の処理参照）。

【0073】

ステップＳ４５において、ステップＳ４４の処理により検出された電流の値が、閾値THa以上ではないと判定された場合、ステップＳ４６において、電力供給制御部７１は、通信部７３を介し、後述する図１０のステップＳ１５１の処理により、受電装置２から送信されてくる、電流情報および識別情報を受信したか否かを判定する。

【0074】

ここで、電流情報とは、Ｎ番目の電力供給アンテナ５２に発生した磁界による電磁誘導により、受電アンテナ１０１に流れた電流の値や電圧を示す情報である。また、識別情報とは、受電装置２を識別（特定）するための情報である。

【0075】

ステップＳ４６において、受電装置２から電流情報および識別情報を受信していないと判定された場合、ステップＳ４７において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、ステップＳ４３の処理により計測が開始した時間が、予め設定してある一定の時間、例えば、１秒が経過したか否かを判定する。

【0076】

ステップＳ４７において、所定の時間が経過していないと判定された場合、処理は、ステップＳ４６に戻り、上述した処理が繰り返される。

【0077】

ステップＳ４７において、所定の時間が経過したと判定された場合、受電装置２から電流情報が送信されていないことになる。すなわち、電力供給装置１に受電装置２が載せら

れていないことになるので、ステップＳ４８において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が無いことを示すフラグを設定する。すなわち、例えば、電力供給制御部７１はメモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が無いことを示すフラグとして、“０１”を記憶させる。

【0078】

ステップＳ４８の処理の後、処理は、ステップＳ５２に進む。

【0079】

ステップＳ４５において、電流の値が、閾値THa以上であると判定された場合、上述したように、Ｎ番目の電力供給部１１の電力供給アンテナ５２に過電流が流れているので、ステップＳ４９において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、異物２０１が在ることを示すフラグを設定する。すなわち、例えば、メモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、異物２０１が在ることを示すフラグ、“１０”が記憶される。

【0080】

ステップＳ４９の処理の後、処理は、ステップＳ５２に進む。

【0081】

ステップＳ４６において、受電装置２から電流情報および識別情報を受信したと判定された場合、ステップＳ５０において、電力供給制御部７１は、電流情報における電流値が閾値THb以上であるかを判定する。

【0082】

ステップＳ５０において、電流情報における電流値が閾値THb以上であると判定された場合、受電装置２の受電部２１（受電アンテナ１０１）の範囲にある電力供給部１１から電力が供給されているので、ステップＳ５１において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が在ることを示すフラグと識別情報を設定する。すなわち、メモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、受電部２１が在ることを示すフラグ、例えば、“１１”が記憶されるとともに、その受電部２１（受電装置２）の識別情報が記憶される。

【0083】

ステップＳ５２において、電力供給制御部７１は、ステップＳ４２の処理により発生させた、Ｎ番目の電力供給部１１における微弱な磁界の発生を停止させる。すなわち、電力供給制御部７１はセレクタ７２を介して、制御信号を供給し、スイッチ５１をオフさせる。

【0084】

ステップＳ５３において、電力供給制御部７１は、変数Ｎに設定されている数値を１だけインクリメントする。例えば、電力供給制御部７１は、変数Ｎに“１”が設定されている場合、変数Ｎを“２”に設定する。

【0085】

ステップＳ５４において、電力供給制御部７１は、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下であるかを判定する。すなわち、電力供給制御部７１は、変数Ｎに設定されている値が、全ての電力供給部１１の数以下であるか否か（ｎ≦Ｎであるか否か）を判定する。

【0086】

ステップＳ５４において、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下であると判定された場合、すなわち、ｎ≦Ｎである場合、処理は、ステップＳ４２に戻り、同様の処理が次の電力供給部１１に対して実行される。

【0087】

ステップＳ５４において、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下ではないと判定された場合、すなわち、ｎ＞Ｎである場合、処理は終了する。

【0088】

ステップＳ５０において、電流情報における電流値が閾値Thb以上ではないと判定された場合、受電装置２の受電部２１に少量の電力が供給されている。すなわち、例えば、図２に示されるように、受電部２１にその一部のみがかかるように配置されている電力供給部１１－３８による磁界によって、受電部２１の受電アンテナ１０１に少量の電流が流れていることが想定される。そこでこの場合、ステップ４８において、上述した処理が実行される。

【0089】

ステップＳ５０の処理により、例えば、図２で示されるように、受電装置２の受電部２１は、受電部２１（受電アンテナ１０１）の範囲内にその大半が含まれる電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７のみから電力の供給をうける。すなわち、受電部２１（受電アンテナ１０１）の範囲内にその大半が含まれる電力供給部１１のみから電力の供給をうけることで、無駄な磁界の発生を防ぎ、効率的に電力を供給することができる。

【0090】

以上の処理により、例えば、図２で示される受電装置２に対して、電力を供給する電力供給部１１として、電力供給部１１－２１，１１－２８，１１－２９、および１１－３７が選択されることになる。

【0091】

図７は、複数の受電装置や異物が同時に載せられた電力供給装置１を説明する図である。例えば、図７に示されるように、今、電力供給装置１には、受電装置２、受電装置２２０、および異物２３１が同時に載せられているとする。

【0092】

ここで、受電装置２２０および受電部２２１のそれぞれは、受電装置２および受電部２１のそれぞれと同様の構成であるため、その説明は省略する。また、異物２３１は、例えば金属板である。

【0093】

図７の例の場合、図５のフローチャートを参照して上述した電力供給部１１の選択の処理において、受電装置２に電力を供給する電力供給部１１としては、電力供給部１１－２１，１１－２８，１１－２９、および１１－３７が選択される。また、受電装置２２０に電力を供給する電力供給部１１としては、電力供給部１１－４０，１１－４７，１１－４８、および１１－５６が選択され、金属である異物２３１に対しては、電力供給部１１が選択されないことになる。

【0094】

次に、図８のフローチャートを参照して、受電装置との認証の処理について説明する。この処理は、図５のフローチャートを参照して上述した電力供給部１１の選択の処理において、電力供給部１１が選択され、メモリ４２に受電装置の受電部が在ることを示すフラグが記憶された場合に開始される。

【0095】

また、この受電装置との認証の処理は、例えば、図２に示されるように、電力供給装置１に１個の受電装置２のみが載せられている場合、電力供給装置１においては、受電装置２と以下に説明する認証処理が実行される。

【0096】

また、例えば、図７に示されるように、電力供給装置１に受電装置２および受電装置２２０が載せられている場合、電力供給装置１においては、受電装置２と以下に説明する認証処理が実行され、その後、受電装置２２０と以下に説明する認証処理が実行されるようにしてもよいし、受電装置２との認証処理と受電装置２２０との認証処理が同時に実行されるようにしてもよい。

【0097】

電力供給装置１において、複数の受電装置との認証処理が実行される場合、図５のステップＳ５１において受電装置の識別情報をメモリ４２に記憶しているため、以下に説明す

るように、受電装置が電力供給装置１にデータを送信する際に、受電装置の識別情報も送信するようにすることで、電力供給装置１は、どの受電装置と通信を行っているのかを認識することができる。

【0098】

ステップＳ８１において、電力供給制御部７１は、通信部７３に、受電装置に対し、受電装置を認証するための情報としてのID（IDentification）を要求する信号を送信する。このIDの要求先としての受電装置は識別番号を付することで指定される。

【0099】

受電装置のIDは識別情報と、同じ情報であってもよいし、異なるものであってもよい。受電装置のIDと識別情報とが同じである場合、ステップＳ８１乃至Ｓ８４の処理は省略することができる。両者が異なる場合、ステップＳ８１乃至Ｓ８４の処理が実行される。

【0100】

ステップＳ８２において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0101】

ステップＳ８３において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１５３の処理により、識別番号で指定された受電装置から送信されてくる、受電装置のIDおよび識別情報を受信したかを判定する。

【0102】

ステップＳ８３において、受電装置のIDおよび識別情報を受信していないと判定された場合、ステップＳ８４において、電力供給制御部７１は、ステップＳ８２の処理により計測を開始した所定の時間（例えば、１秒）が経過したかを判定する。

【0103】

ステップＳ８４において、所定の時間が経過していないと判定された場合、処理はステップＳ８３に戻り、上述した処理が繰り返される。

【0104】

ステップＳ８３において、受電装置のIDおよび識別情報を受信したと判定された場合、ステップＳ８５において、電力供給制御部７１は、受信した受電装置のIDが、電力供給装置１と対応しているIDであるかを判定する。すなわち、電力供給制御部７１は、メモリ４２に記憶されているIDを参照し、受電装置のIDが予め登録されている装置（規格上充電が許容される装置）のものであるか否かを判定する。

【0105】

ステップＳ８５において、受信した受電装置のIDが、電力供給装置１と対応しているIDであると判定された場合、ステップＳ８６において、電力供給制御部７１は、受電装置に、受電装置の電力情報を要求する信号を送信する。この場合にも信号の送信先が識別番号で指定される。ここで、電力情報とは、受電装置に電力を供給するのに必要な情報、すなわち、受電部２１おいて許容される電圧の大きさや受電部２１に流れる電流の値、現在、受電部２１において端子１０４および端子１０５における電圧を意味する。

【0106】

ステップＳ８７において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0107】

ステップＳ８８において、電力供給制御部７１は、ステップＳ８７の処理により測定を開始した所定の時間（例えば、１秒）が経過したかを判定する。

【0108】

ステップＳ８８において、所定の時間がまだ経過していないと判定された場合、ステップＳ８９において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１５５の処理により、受電装置から送信されてくる、電力情報および識別情報を受信したかを判定する。

【0109】

ステップＳ８９において、受電装置から電力情報および識別情報を受信していないと判定された場合、処理は、ステップＳ８８に戻り、上述した処理が繰り返される。

【0110】

ステップＳ８９において、受電装置から電力情報および識別情報を受信したと判定された場合、ステップＳ９０において、電力供給制御部７１は、受信した電力情報に示されている電力は、供給可能であるかを判定する。すなわち、電力供給制御部７１は、メモリ４２に記憶されている情報を基に、その受電装置へ指定された電力を供給することが規格上許容されているか否かを判定する。

【0111】

ステップＳ９０において、受信した電力情報における電力が、受電装置に供給可能であると判定された場合、ステップＳ９１において、電力供給制御部７１は、受電装置が電力供給装置１に対応している機器であることを示すフラグを設定する。すなわち、電力供給制御部７１は、メモリ４２に、その識別番号の受電装置が電力供給装置１に対応している機器であることを示すフラグ、例えば、“００１”を記憶させる。

【0112】

ステップＳ８４において、所定の時間が経過したと判定された場合（受電装置が電力供給装置１の設置面１aから取り除かれたことが推測される場合）、ステップＳ８５において、受電装置のIDが電力供給装置１と対応しているIDではないと判定された場合、ステップＳ８８において、所定の時間が経過したと判定された場合（受電装置が電力供給装置１の設置面１aから取り除かれたことが推測される場合）、並びにステップＳ９０において、受信した電力情報における電力が、受電装置に供給可能ではないと判定された場合、ステップＳ９２において、電力供給制御部７１は、受電装置が電力供給装置１に対応している機器ではないことを示すフラグを設定する。すなわち、電力供給制御部７１は、メモリ４２に、その識別番号の受電装置が電力供給装置１に対応している機器ではないことを示すフラグ、例えば、“０１１”を記憶させる。

【0113】

ステップＳ９１またはステップＳ９２の処理の後、処理は終了する。

【0114】

以上のように、受電装置のIDおよび電力情報が電力供給装置１と対応しているか否かを判定することにより、受電装置２との認証の精度をより向上させることができる。

【0115】

図９のフローチャートを参照して、受電装置への電力の供給の処理について説明する。この処理は、図８のフローチャートを参照して上述した受電装置との認証の処理において、ステップＳ９１の処理により、受電装置が電力供給装置１に対応していることを示すフラグが設定された場合に開始される。

【0116】

また、この受電装置への電力の供給の処理は、例えば、図２に示されるように、電力供給装置１に受電装置２のみが載せられている場合、電力供給装置１において、受電装置２のみに対し、以下に説明する電力の供給の処理が実行される。

【0117】

さらに、図７に示されるように、電力供給装置１に受電装置２および受電装置２２０が載せられている場合、電力供給装置１において、受電装置２への電力の供給の処理が実行され、その後、受電装置２２０への電力の供給の処理が実行されるようにしてもよいし、電力供給装置１において、受電装置２および受電装置２２０への電力の供給の処理が同時に実行されてもよい。

【0118】

電力供給装置１において、複数の受電装置に対して、電力の供給の処理が実行される場合、図５のステップＳ５１において受電装置の識別情報をメモリ４２に記憶しているため、以下に説明するように、受電装置が電力供給装置１に所定のデータを送信する際に、受電装置の識別情報も送信するようにすることで、電力供給装置１は、どの受電装置と通信

を行っているのか認識することができる。

【0119】

ステップＳ１１１において、電力供給制御部７１は、図８のステップＳ８９の処理により受信した受電装置の電力情報を基に、電力供給部１１に対し、受電装置への電力の供給のための磁界を発生させる。すなわち、電力供給制御部７１は、セレクタ７２を介し、その識別情報に対応して選択されている電力供給部１１のスイッチ５１にオンの制御信号を供給する。これにより、電力供給部１１の電力供給アンテナ５２に、電源回路４４から交流電流が供給される。このとき、電力供給アンテナ５２においては、電流が流れることで、磁界が発生する。

【0120】

ステップＳ１１１の処理において、磁界を発生させる電力供給部１１は、図５のステップＳ５１の処理により、同じ識別情報が記憶されている電力供給部１１の全てである。すなわち、例えば、図２で示される電力供給装置１においては、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個である。

【0121】

ステップＳ１１２において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0122】

ステップＳ１１３において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１６０の処理により受電装置から送信されてくる、充電中を示す信号および識別情報を受信したかを判定する。

【0123】

ステップＳ１１３において、受電装置から、充電中を示す信号および識別情報を受信していないと判定された場合、ステップＳ１１４において、電力供給制御部７１は、後述する図１０のステップＳ１６２の処理により受電装置から送信されてくる、充電の完了を示す信号および識別情報を受信したか否かを判定する。

【0124】

ステップＳ１１４において、受電装置から、充電の完了を示す信号および識別情報を受信していないと判定された場合、ステップＳ１１５において、電力供給制御部７１は、ステップＳ１１２の処理において時間の計測を開始してから、所定の時間が経過したかを判定する。すなわち、例えば、電力供給制御部７１は、ステップＳ１１２の処理により時間の計測を開始してから１分３０秒が経過したか否かを判定する。

【0125】

ステップＳ１１５において、所定の時間がまだ経過していないと判定された場合、処理はステップＳ１１３に戻り、それ以降の処理が繰り返される。

【0126】

ステップＳ１１３において、受電装置から充電中を示す信号および識別情報を受信したと判定された場合、ステップＳ１１６において、電力供給制御部７１は、ステップＳ１１２において計測を開始した時間をリセットする。すなわち、電力供給制御部７１は、計測中の時間を０秒にする。

【0127】

ステップＳ１１６の処理の後、処理は、ステップＳ１１２に戻り、受電装置から送信されてくる充電の完了を示す信号を受信するまで、ステップＳ１１２，Ｓ１１３，Ｓ１１６の処理が繰り返し実行される。

【0128】

ステップＳ１１４において、受電装置から、充電の完了を示す信号および識別情報を受信したと判定された場合、ステップＳ１１５の処理は、スキップされ、ステップＳ１１７において、電力供給制御部７１は、ステップＳ１１１の処理により発生させた、受電装置の識別情報に対応づけられている、電力供給部１１における磁界の発生を停止させる。

【0129】
すなわち、電力供給制御部７１は、セレクタ７２を介し、電力供給部１１のスイッチ５１にオフの制御信号を供給する。これにより、電力供給部１１の電力供給アンテナ５２に、電源回路４４から電流が流れなくなり、電力供給アンテナ５２において発生していた磁界が消えることになる。
【0130】
ステップＳ１１４の処理において、磁界の発生を停止させる電力供給部１１は、ステップＳ１１１の処理により、磁界を発生させた電力供給部１１の全てである。すなわち、図５のステップＳ５１の処理により、同じ識別情報が記憶されている電力供給部１１の全てである。例えば、図２で示される電力供給装置１においては、ステップＳ１１７の処理により、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個の磁界の発生が停止する。
【0131】
ステップＳ１１５において、ステップＳ１１２の処理において時間の計測が開始されてから、所定の時間が経過したと判定された場合、例えば、１分３０秒が経過した場合、電力供給装置１の設置面１aから受電装置が取り除かれたことが推測されるため、ステップＳ１１７において、上述した処理が実行される。すなわち、電力を供給する受電装置がないので、ステップＳ１１７の処理により、電力供給部１１が発生した磁界を消す必要がある。
【0132】
図１０のフローチャートを参照して、受電装置の受電の処理について説明する。この処理は、電力供給装置１が、図５のステップＳ４２において、微弱な磁界を発生させることにより、電力供給部１１に対応する位置にある受電部２１の受電アンテナ１０１に、電磁誘導によって電流が流れ、その電流が整流器１０２を介し、受電制御部１０３に供給されることで、受電制御部１０３が起動したとき開始される。
【0133】
ステップＳ１５１において、受電制御部１０３は、通信部１０７に、電力供給装置１に対しメモリ１２１に記憶されている電流情報および識別情報を送信させる。ステップＳ１５２において、受電制御部１０３は、通信部１０７が、受電装置のIDを要求する信号を受信したかを判定する。
【0134】
ステップＳ１５２において、通信部１０７が、受電装置のIDを要求する信号を受信していないと判定された場合、処理はステップＳ１５１に戻り、判定された場合、ステップＳ１５３において、受電制御部１０３は、受電装置のIDおよび識別情報をメモリ１２１から読み出し、電力供給装置１に送信する。
【0135】
ステップＳ１５４において、受電制御部１０３は、通信部１０７が電力情報を要求する信号を受信したかを判定する。ステップＳ１５４において、通信部１０７が、受電装置２のIDを要求する信号を受信していないと判定された場合、受電装置の電力情報を要求する信号を受信するまで待機する。
【0136】
ステップＳ１５４において、通信部１０７が受電装置の電力情報を要求する信号を受信したと判定された場合、ステップＳ１５５において、受電制御部１０３は、電力情報および識別情報を通信部１０７に送信させる。
【0137】
ステップＳ１５６において、受電制御部１０３は、バッテリ１２３の充電を開始させる。すなわち、受電制御部１０３は、スイッチ１０６をオンにすることにより、受電アンテナ１０１から整流器１０２に交流電流が流れ、整流器１０２が整流した直流電流が、端子１０４、バッテリ１２３、端子１０５、およびスイッチ１０６の経路で流れ、バッテリ１２３が充電される。

【0138】
ステップＳ１５７において、受電制御部１０３は、リアルタイムクロック１２２から供給されるクロックパルスを計数することで、時間の計測を開始する。
【0139】
ステップＳ１５８において、受電制御部１０３は、ステップＳ１５７の処理により計測を開始した時間（例えば、１分）が経過したかを判定する。
【0140】
ステップＳ１５８において、時間が、例えば、１分が経過していないと判定された場合、ステップＳ１５９において、受電制御部１０３は、バッテリ１２３の充電が完了したかを判定する。すなわち、受電制御部１０３は、端子１０４および端子１０５にかかる電圧が、バッテリ１２３の充電の完了を示す基準電圧に達したか否かを判定する。
【0141】
ステップＳ１５９において、充電が完了していないと判定された場合、処理はステップＳ１５８に戻り、上述した処理が実行される。
【0142】
ステップＳ１５８において、１分が経過したと判定された場合、ステップＳ１６０において、受電制御部１０３は、通信部１０７に、電力供給装置１に対して、充電中を示す信号および識別情報を送信させる。
【0143】
ステップＳ１６１において、受電制御部１０３は、ステップＳ１５７において計測を開始した時間をリセットする。すなわち、受電制御部１０３は、計測中の時間を０秒にする。
【0144】
ステップＳ１６１の処理の後、処理は、ステップＳ１５７に戻る。
【0145】
ステップＳ１５９において、バッテリ１２３の充電が完了したと判定された場合、ステップＳ１６２において、受電制御部１０３は、通信部１０７に、電力供給装置１に対し、充電の完了を示す信号および識別情報を送信させる。
【0146】
ステップＳ１６３において、受電制御部１０３は、バッテリ１２３の充電を終了させる。すなわち、受電制御部１０３は、スイッチ１０６をオフにする。
【0147】
以上のように、１個の受電部２１に対して、受電部２１の位置に対応する複数の電力供給部１１により電力が供給されるので、迅速に、受電部２１への電力の供給を完了することができる。
【0148】
また、電力供給装置１において、金属である、例えば、異物２０１を検出することにより、異物２０１の発熱や電力供給部１１の電力供給アンテナ５２に流れる過電流を防ぐことができる。これにより、より安全に、受電装置に電力を供給することができる。
【0149】
また、コネクタを使用せず、無線で、受電装置２に電力が供給されるので、電圧や電流などの規格による制限が緩和され、規格の異なる複数の受電装置にも電力を供給することができる。
【0150】
なお、受電装置２が受電部２１（受電アンテナ１０１）の大きさを電力供給装置１に送信することで、図５の電力供給部１１の選択の処理において、全ての電力供給部１１を順に、走査することで、受電部２１の位置に対応する電力供給部１１を検出する必要がなくなる。
【0151】
すなわち、受電部２１の大きさを基に、最初に検出された電力供給部１１の周りの電力

供給部１１のみに微弱な磁界を発生させ、電力供給部１１が受電部２１の位置に対応しているか否かを判定するだけで、電力供給部１１を検出することが可能となる。従って、受電部２１の位置に対応する電力供給部１１をより迅速に検出することができる。

【0152】

図１１は、受電装置２の受電部の他の構成の例を示す図である。受電装置２において、受電部３２１－１および受電部３２１－２は、受電部２１と同様の構成をしている。すなわち、受電部３２１－１および受電部３２１－２は、両方とも受電部２１におけるバッテリ１２３に接続されており、受電部３２１－１および受電部３２１－２の両方から、バッテリ１２３は電力が供給される。

【0153】

また、図１１で示されるように、受電部３２１－１および受電部３２１－２のそれぞれは、１個の電力供給部１１だけを含む大きさに形成されている。

【0154】

受電装置２は、受電部３２１－１および受電部３２１－２のそれぞれが、電力供給部１１－２１および電力供給部１１－３６のそれぞれの位置に対応するように電力供給装置１の設置面１ａに載せられている。従って、受電部３２１－１および受電部３２１－２のそれぞれは、電力供給部１１－２１および電力供給部１１－３６のそれぞれから電力の供給をうけることになる。

【0155】

以下、受電部３２１－１および受電部３２１－２を個々に区別する必要のない場合、単に、受電部３２１と称する。

【0156】

以上のように、複数の受電部３２１を受電装置２に設けることにより、複数の電力供給部１１から電力の供給をうけることができる。従って、図２で示される受電装置２と同様に、より迅速に、図１１で示される受電装置２は、電力の供給を完了することができる。

【0157】

なお、図１１で示される受電装置２が、受電部３２１の数および受電部３２１同士の距離、すなわち、例えば、受電部３２１－１の中心から受電部３２１－２の中心までの距離を電力供給装置１に送信することで、図５の電力供給部１１の選択の処理において、全ての電力供給部１１を順に、走査することで、受電部３２１の位置に対応する電力供給部１１を検出する必要がなくなる。

【0158】

すなわち、例えば、最初に検出された電力供給部１１から、受電部３２１の数および受電部３２１同士の距離を基に、各受電部３２１に電力を供給することが推測される位置にある電力供給部１１を検出し、検出された電力供給部１１に微弱な磁界を発生させ、電力供給部１１が受電部３２１の位置に対応しているか否かを判定するだけで、受電部２３１に電力を供給する電力供給部１１を検出することが可能となる。従って、複数の受電部３２１の位置に対応する電力供給部１１をより迅速に検出することができる。

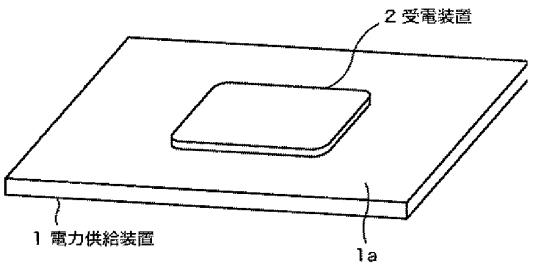
【0159】

このように、電力供給装置において、無線で電力を供給することができるようにした場合、配線を必要としないため、電圧や電流の規格による規制が緩和され、容易に受電装置に電力を供給することができる。電力供給装置において、複数の電力供給手段が受電装置に対して電磁誘導により電力を供給し、選択手段が、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する電力供給手段を選択し、受信手段が、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信し、制御手段が、制御情報に基づいて、選択された電力供給手段による電力の受電装置への供給を制御し、受電装置において、受電手段が、選択された電力供給手段による電磁誘導により電力の供給をうけ、送信手段が、選択された電力供給手段による電磁誘導により電力の供給をうけた場合、制御情報を無線で送信するようにした場合、より容易に受電装置に電力を供給することができる。

【0160】
上述した一連の処理は、ハードウェアにより実行させることもできるが、ソフトウェアにより実行させることもできる。一連の処理をソフトウェアにより実行させる場合には、そのソフトウェアを構成するプログラムが、専用のハードウェアに組み込まれているコンピュータ、または各種のプログラムをインストールすることで、各種の機能を実行することが可能な、例えば汎用のパーソナルコンピュータなどに、記録媒体からインストールされる。
【0161】
この記録媒体は、図３で示されるリムーバブルメディア８２のように、コンピュータとは別に、ユーザにプログラムを提供するために配布される、プログラムが記録されている磁気ディスク（フレキシブルディスクを含む）、光ディスク（CD-ROM（Compact Disk Read-Only Memory），DVDを含む）、光磁気ディスク（MD（Mini Disc）（商標）を含む）、若しくは半導体メモリなどよりなるパッケージメディアにより構成されるだけでなく、コンピュータに予め組み込まれた状態でユーザに提供される、プログラムが記録されているメモリ４２もしくはハードディスクなどで構成される。
【0162】
なお、上述した一連の処理を実行させるプログラムは、必要に応じてルータ、モデムなどのインターフェースを介して、ローカルエリアネットワーク、インターネット、デジタル衛星放送といった、有線または無線の通信媒体を介してコンピュータにインストールされるようにしてもよい。
【0163】
また、本明細書において、記録媒体に格納されるプログラムを記述するステップは、記載された順序に沿って時系列的に行われる処理はもちろん、必ずしも時系列的に処理されなくても、並列的あるいは個別に実行される処理を含むものである。
【0164】
さらに、本明細書において、システムとは、複数の装置により構成される装置全体を表すものである。
【図面の簡単な説明】
【0165】
【図1】本発明の一実施の形態に係る電力供給システムの構成の例を示す斜視図である。
【図2】図１の電力供給装置の設置面上に受電装置が載せられた状態を上方向から見た透過図である。
【図3】図１の電力供給装置の構成の例を示すブロック図である。
【図4】図１の受電装置の構成の例を示すブロック図である。
【図5】電力供給部の選択の処理を説明するフローチャートである。
【図6】設置面に異物が載せられている状態を示す図である。
【図7】複数の受電装置や異物が同時に載せられた電力供給装置を説明する図である。
【図8】受電装置との認証の処理を説明するフローチャートである。
【図9】受電装置への電力の供給の処理を説明するフローチャートである。
【図10】受電装置の受電の処理を説明するフローチャートである。
【図11】受電装置の受電部の他の例を説明する図である。
【符号の説明】
【0166】
１　電力供給装置，　１１、および１１－１乃至１１－ｎ　電力供給部，　２　受電装置，　２１　受電部，　４１　制御部，　５２　電力供給アンテナ，　５３　電流検出器，　７１　電力供給制御部，　７２　セレクタ，　７３　通信部，　８２　リムーバブルメディア，　１０１　受電アンテナ，　１０３　受電制御部，　１２３　バッテリ，　３２１、並びに３２１－１および３２１－２　受電部

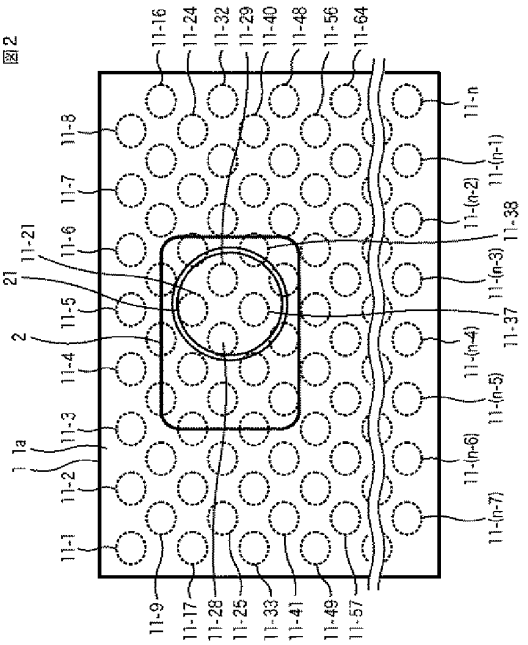
【図1】

図1



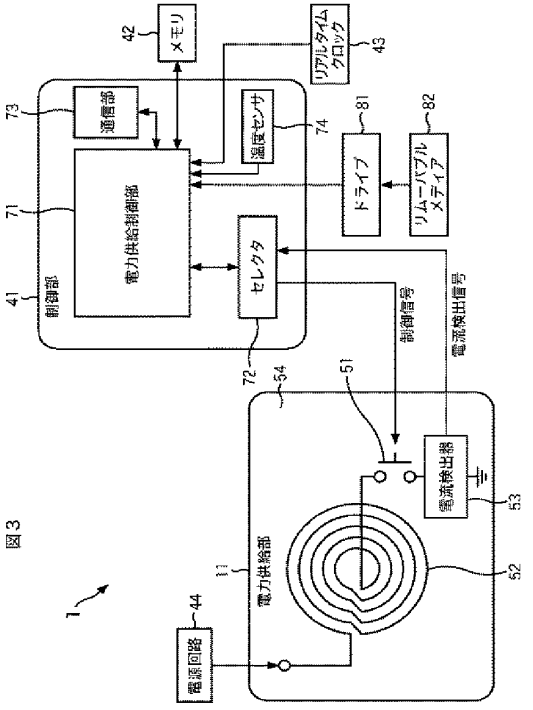
【図2】

図2



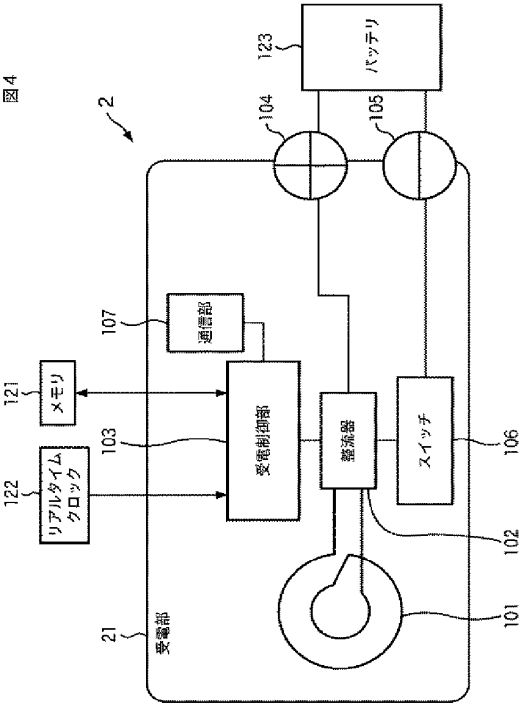
【図3】

図3

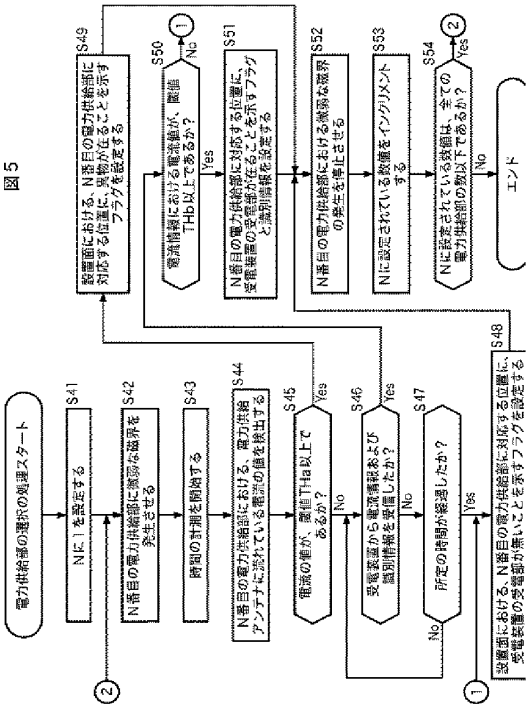


【図4】

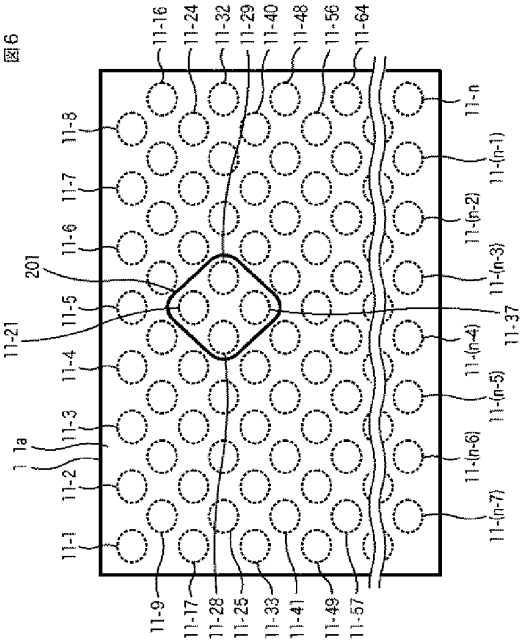
図4



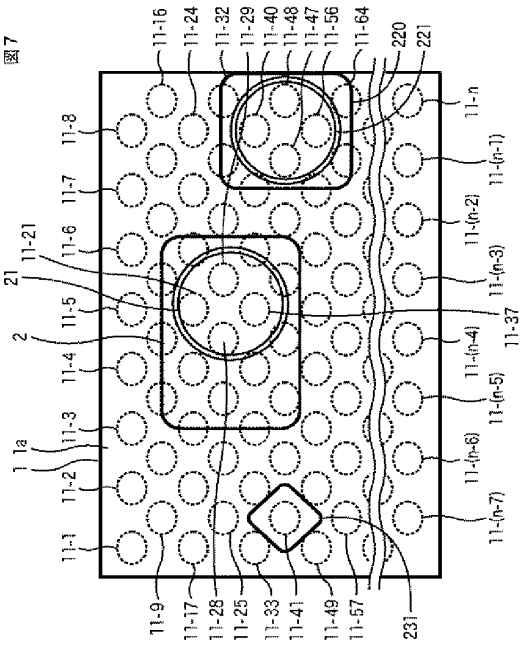
【図5】


図5
電力供給部の運転の処理スタート
N=1 を設定する
N番目の電力供給部に微弱な磁界を発生させる
時間の計測を開始する
N番目の電力供給部における、電力供給アンテナに流れている電流の値を検出する
電流の値が、閾値T1a以上であるか？
受電装置から識別情報および識別情報を受信したか？
所定の時間が経過したか？
設置面における、N番目の電力供給部に対応する位置に、受電装置の受電部が無いことを示すフラグを設定する
N番目の電力供給部に対応する位置に、受電装置の受電部が在ることを示すフラグと識別情報を設定する
電流情報における電流値が、閾値T1b以上であるか？
N番目の電力供給部における微弱な磁界の発生を停止させる
N=N+1
N=設定されている数値は、全ての電力供給部の数以下であるか？
エンド
Yes
No

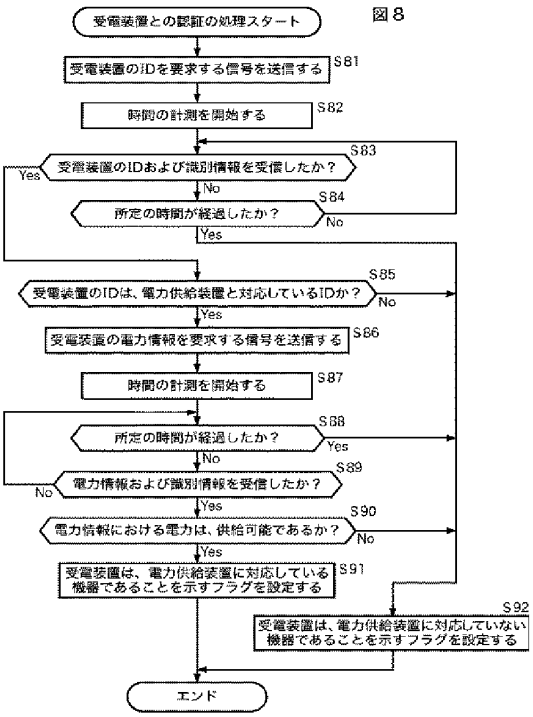
【図6】


図6
11-16
11-24
11-32
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11-40
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11-56
11-64
11-n
11-8
11-7
11-6
201
11-5
11-21
11-4
11-3
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11-2
11-1
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11-49
11-57

【図7】

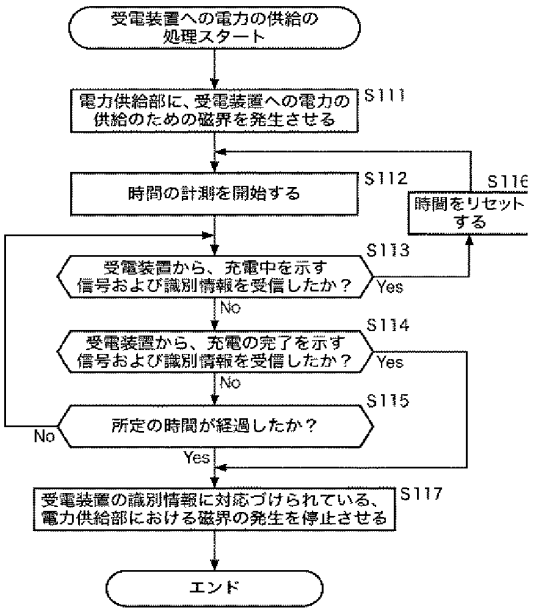

図7
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11-48
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11-56
11-64
220
221
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11-8
11-7
11-6
21
11-21
11-5
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11-(n-6)
11-(n-7)
11-9
11-17
11-28
11-25
11-33
11-41
11-49
11-57
231

【図8】


図8
受電装置との認証の処理スタート
受電装置のIDを要求する信号を送信する
S81
時間の計測を開始する
S82
受電装置のIDおよび識別情報を受信したか？
S83
所定の時間が経過したか？
S84
受電装置のIDは、電力供給装置と対応しているIDか？
S85
受電装置の電力情報を要求する信号を送信する
S86
時間の計測を開始する
S87
所定の時間が経過したか？
S88
電力情報および識別情報を受信したか？
S89
電力情報における電力は、供給可能であるか？
S90
受電装置は、電力供給装置に対応している機器であることを示すフラグを設定する
S91
受電装置は、電力供給装置に対応していない機器であることを示すフラグを設定する
S92
エンド
Yes
No

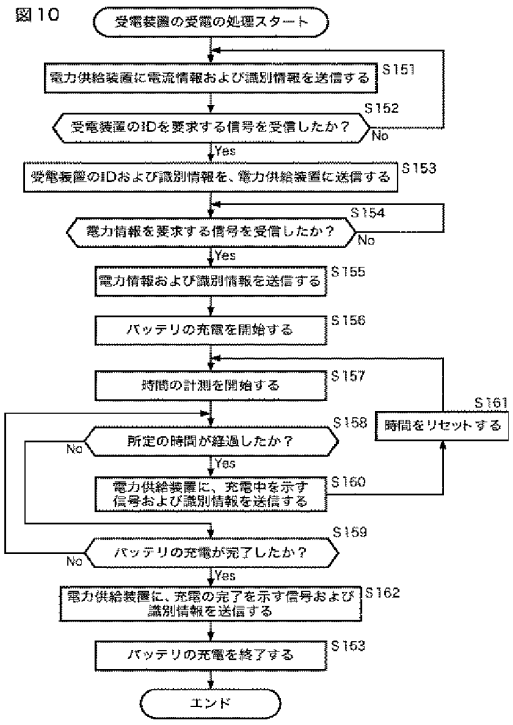
【図9】

図９



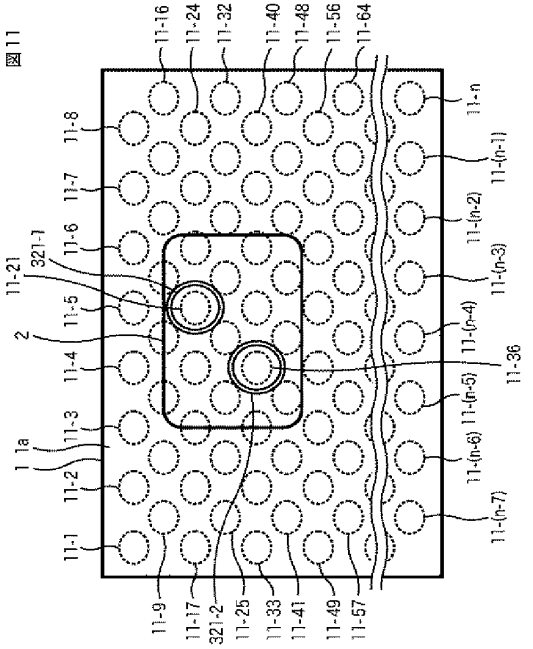
【図10】

図１０



【図11】

図１１



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(54) **Title**: SYSTEM FOR WIRELESS POWER TRANSFER THAT SUPPORTS INTEROPERABILITY, AND MULTI-POLE MAGNETS FOR USE THEREWITH

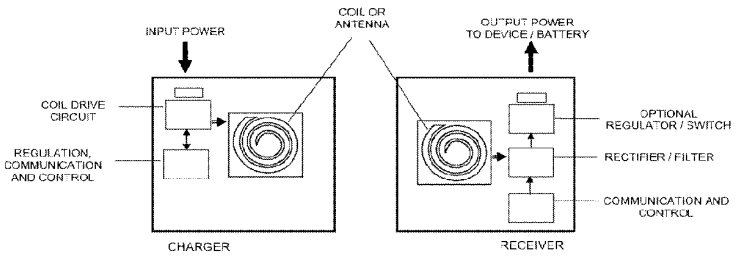


FIGURE 1

(57) **Abstract**: In the field of wireless power, to enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and receiver) can communicate in a manner that allows operation. With the proliferation of different communication schemes, a multi-protocol system that can adapt and interoperate with different communication protocols allows maximum interoperability. Described herein are systems and methods for providing such multi-protocol operation and maximum interoperability. Also described herein are methods for use of magnets in or around magnetically sensitive devices such that the operation of such a device is not impaired. Applications in various devices and systems are described. In particular, applications for fastening mobile devices to their cases or other surfaces, and also alignment or attachment for power transfer or charging are described. Also described herein are systems and methods for the use of multi-pole and other magnets, in electronic and other articles, devices, components, or parts thereof.

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SYSTEM FOR WIRELESS POWER TRANSFER THAT SUPPORTS INTEROPERABILITY, AND MULTI-POLE MAGNETS FOR USE THEREWITH

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Claim of Priority:

[0001] This application claims the benefit of priority to U.S. Provisional Patent Applications "IMPROVED MAGNETS FOR USE IN PROXIMITY TO MAGNETICALLY SENSITIVE PARTS OR DEVICES", Application No. 61/354,114, filed June 11, 2010; "SYSTEM AND METHOD FOR PROVIDING A UNIVERSAL-COMPATIBLE WIRELESS POWER SYSTEM", Application No. 61/387,895, filed September 29, 2010; and "SYSTEM AND METHOD FOR PROVIDING A UNIVERSAL-COMPATIBLE WIRELESS POWER SYSTEM", Application No. 61/478,015, filed April 21, 2011, each of which applications are hereby incorporated by reference herein.

Field of Invention:

[0002] The invention is generally related to inductive charging, including applications for use in mobile or other devices and vehicles, and improved compatibility and transfer of wireless power; and is also related to the use of magnets in electronic devices, and in particular to devices or parts having proximity to magnetic sensors.

Cross-Reference to Related Applications:

[0003] This application is related to U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by

reference herein.

Background:

[0004] Wireless technologies for powering and charging mobile and other electronic devices and vehicles have been developed. These systems generally use a wireless charger or transmitter system and a wireless receiver in combination to provide a means for transfer of power across a distance. For safe and efficient operation the two parts of the system often communicate with each other to verify the presence of receivers and/or initiate charging and continued power transfer. To enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and the receiver) can communicate in a manner that allows such operation.

[0005] Additionally, many mobile, industrial, automotive, medical devices, etc. contain compasses or other components that are sensitive to magnetic field. At the same time, it is often desired to use magnets for fastening or attachment, or alignment purposes near such devices without affecting the operation of such sensitive material. One application may be fastening of a mobile device or phone to a surface in a car or other vehicle to avoid movement during transport.

[0006] These are the general areas that embodiments of the invention are intended to address.

Summary:

[0007] As described above, to enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and receiver) can communicate in a manner that allows operation. With the proliferation of different communication schemes, a multi-protocol system that can adapt and interoperate with different communication protocols allows maximum interoperability. Described herein are systems and methods for providing such multi-protocol operation and maximum interoperability. Also described herein are methods for use of magnets in or around magnetically sensitive devices such that the operation of such a device is not impaired. Applications in various devices and systems are described. In particular, applications for fastening mobile devices to their cases or other surfaces, and also alignment or attachment for power transfer or charging are described. Also described herein are systems and methods for the use of multi-pole and other magnets, in electronic and other articles, devices, components, or parts thereof.

Brief Description of the Figures:

[0008] **Figure 1** illustrates an example of a wireless charger or power system that comprises a charger or transmitter part, and a receiver part, in accordance with an embodiment.

[0009] **Figure 2** shows a more detailed view of the wireless charger system with a resonant

converter geometry, in accordance with an embodiment.

[0010] **Figure 3** illustrates a system wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes, in accordance with an embodiment.

[0011] **Figure 4** illustrates the use a center-tapped receiver wherein during each cycle current passes only through one part of the coil and one diode in the receiver and therefore halves the rectification losses, in accordance with an embodiment.

[0012] **Figure 5** illustrates that the charger and receiver coils can be represented by their respective inductances by themselves and the mutual inductance between, in accordance with an embodiment.

[0013] **Figure 6** shows a wirelessly powered battery pack and receiver, in accordance with an embodiment.

[0014] **Figure 7** illustrates the use of a battery cell connected through a protection circuit comprising a battery protection IC that protects a battery from over-current and under or over voltage, in accordance with an embodiment.

[0015] **Figure 8** illustrates a typical charge cycle for a Lithium Ion battery, in accordance with an embodiment.

[0016] **Figure 9** illustrates how the charger periodically activates the charger coil driver and powers the charger coil with a drive signal of appropriate frequency, in accordance with an embodiment.

[0017] **Figure 10** illustrates an example of the communication process and regulation of power and/or other functions, in accordance with an embodiment.

[0018] **Figure 11** shows a Notebook-style portfolio case and a mobile phone or camera pouch, where magnets are used to secure a closing clasp or flap, in accordance with an embodiment.

[0019] **Figure 12** illustrates several commercially available mounts for devices, in accordance with an embodiment.

[0020] **Figure 13** shows an example of a power plug for an electronic device, in accordance with an embodiment.

[0021] **Figure 14** shows an inductive wireless charger and/or power supply with multiple charging stations, in accordance with an embodiment.

[0022] **Figure 15** illustrates several different placements and shapes for magnets, in accordance with an embodiment.

[0023] **Figure 16** shows a measured z-component along the axial direction of magnetization of a magnet, in accordance with an embodiment.

[0024] **Figure 17** illustrates the performance of a 50 x 50 x 1 mm^3 magnet with one of 10 x

10 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part, in accordance with an embodiment.

[0025] **Figure 18** illustrates how the same shape part can be periodically poled in a multi-pole pattern, in accordance with an embodiment.

[0026] **Figure 19** shows the drop off of maximum flux density value for a 10 x 10 x 1 mm^3 magnet magnetized periodically with a periodicity of 1 and 2 mm, in accordance with an embodiment.

[0027] **Figure 20** shows several magnet types that are magnetized perpendicular to the magnet surface (axially), in accordance with various embodiments.

[0028] **Figure 21** shows an example of various ring or arc multi-pole magnets, as may be used to with a coil to provide alignment, in accordance with an embodiment.

[0029] **Figure 22** illustrates a ring magnet that includes a discontinuity, in accordance with an embodiment.

[0030] **Figure 23** illustrates a multi-pole ring magnet with radially magnetized sections, in accordance with an embodiment.

Detailed Description:

[0031] With the proliferation of electrical and electronic devices and vehicles (which are considered devices herein), simple and universal methods of providing power and or charging of these devices is becoming increasingly important. To enable a user to easily charge or power these devices, a simple non-contact method such as wireless power transfer is increasingly important.

[0032] Many of these devices contain internal batteries, and the device may or may not be operating during receipt of power. Depending on the degree of charge status of the battery or its presence and the system design, the applied power may provide power to the device, charge its battery or a combination of the above. The terms charging and/or power are used interchangeably herein to indicate that the received power can be used for either of these cases or a combination thereof. Unless specifically described, these terms are therefore used interchangeably.

[0033] As shown in **Figure 1**, a wireless charger or power system comprises a charger or transmitter part, and a receiver part. The charger or transmitter can generate a repetitive power signal pattern (such as a sinusoid or square wave from 10's of Hz to several MHz or even higher but typically in the 100 kHz to several MHz range) with its coil drive circuit and a coil or antenna for transmission of the power. The charger or transmitter typically also includes a communication and regulation / control system that detects a receiver and/or turns the applied power on or off and/or modify the amount of applied power by mechanisms such as changing the amplitude, frequency or duty cycle, etc. or a combination thereof of the applied power signal

to the coil or antenna.

[0034] The second part of the system is a receiver that includes a coil or antenna to receive power, a method for change of the received AC voltage to DC voltage such as rectification and smoothing with one or more rectifiers or a bridge or synchronous rectifier, etc. and one or more capacitors and optionally, a method for the receiver to communicate with the charger.

[0035] In accordance with an embodiment, the method of communication between the charger and receiver can be through the same coils as for transfer of power, through a separate coil, through an RF or optical link or combination thereof. In case of communication through the power transfer coil, one method for the communication is to modulate the load in the receiver to affect the voltage in the receiver coil and therefore create a modulation in the charger coil parameters that can be detected through monitoring of its voltage or current. Other methods can include frequency modulation by combining the received frequency with a local oscillator signal or inductive, capacitive, or resistive modulation of the output of the receiver coil.

[0036] In accordance with an embodiment, the communicated information can be the output voltage, current, device or battery status, validation ID for receiver, end of charge or various charge status information, receiver battery, device, or coil temperature, or user data.

[0037] In accordance with an embodiment, the data communicated can be any of the information detailed herein, or the difference between these values and the desired value or simple commands to increase or decrease power or simply one or more signals that would confirm presence of a receiver or a combination of the above. In addition, the receiver can include other elements such as a dc to dc converter or regulator such as a switching, buck, boost, buck / boost, or linear regulator. The receiver may also include a switch between the DC output of the receiver coil and its output to a device or battery or a device case or skin and in cases where the receiver is used to charge a battery, the receiver may also include a battery charger IC or circuitry and/or battery protection circuit and associated transistors, etc. The receiver and/or charger and/or their coils can also include elements such as thermistors, magnetic shields or magnetic cores, magnetic sensors, and input voltage filters, etc. for safety and/or emission compliance reasons. In addition, the charger and or receiver can include means to provide more precise alignment between the charger and receiver coils or antennas. These may include visual, physical, or magnetic means to assist the user in alignment of parts. To implement more positioning freedom of the receiver on the charger, the size of the coils can also be mismatched. For example, the charger can comprise a larger coil size and the receiver a smaller one or vice versa, so that the coils do not have to be precisely aligned for power transfer.

[0038] In accordance with an embodiment, the power section (coil drive circuit and receiver power section) can be a resonant, zero switching, flyback, or any other appropriate topology. **Figure 2** shows a more detailed view of the wireless charger system with a resonant converter

geometry where a pair of transistors Q1 and Q2 (such as FETs) are driven by a half-bridge driver IC and the voltage is applied to the coil L1 through one or more capacitors shown as C1. The receiver includes a coil and an optional capacitor (for added efficiency) shown as C2 that may be in series or in parallel with the receiver coil L2. The charger and/or receiver coils may also include magnetic material layers behind them to increase their inductance or to shield the magnetic field leakage to surrounding area.

[0039] In accordance with an embodiment, the charger also includes a circuit that measures the current through and/or voltage across the charger coil (in this case a current sensor is shown in the figure as an example). Various demodulation methods for detection of the communication signal on the charger current or voltage are available. This demodulation mechanism can be an AM or FM receiver (depending on whether amplitude or frequency modulation is employed in the receiver modulator) similar to a radio receiver tuned to the frequency of the communication or a heterodyne detector, etc.

[0040] In accordance with an embodiment, the microcontroller unit (MCU) in the charger (MCU2) is responsible for understanding the communication signal from the detection / demodulation circuit and, depending on the algorithm used, making appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output. In addition, MCU1 is responsible for processes such as periodic start of the charger to seek a receiver at the start of charge, keeping the charger on when a receiver is found and accepted as a valid receiver, continuing to apply power and making necessary adjustments, and/or monitoring temperature or other environmental factors, providing audio or visual indications to the user on the status of charging or power process, etc. or terminating charging or application of power due to end of charge or customer preference or over temperature, over current, over voltage, or some other fault condition or to launch or start another program or process. For example, the charger can be built into a car and once a valid receiver integrated into or on a mobile device, its case or skin, or battery is found, the charger may activate some other functions such as Bluetooth connectivity to the device, displaying the device identity on a display, etc. Other similar actions can be done in other environments. It may be useful in addition to the communication signal to detect the dc value of the current through the charger coil. For example, faults may be caused by insertion or presence of foreign objects such as metallic materials between the charger and receiver. These materials may be heated by the application of the power and can be detected through detection of the charger current or temperature or comparison of input voltage, current, or power to the charger and output voltage, current, or power from the receiver and concluding that the ratio is out of normal range and extra power loss due to unknown reasons is occurring. In these conditions or other situations such as abnormal charger and/or receiver heating, the charger may be programmed to declare a fault condition and shut down and/or alert the user or take other actions.

[0041] Once the charger MCU has received a signal and decoded this signal, it can take action to provide more or less power to the charger coil. This can be accomplished through known methods of adjusting the frequency, duty cycle or input voltage to the charger coil or a combination of these approaches. Depending on the system and the circuit used, the MCU can directly adjust the bridge driver or an additional circuit such as a frequency oscillator may be necessary to drive the bridge driver or the FETs.

[0042] A typical circuit for the receiver in accordance with an embodiment, is also shown in Figure 2. In accordance with an embodiment, the receiver circuit can include a capacitor C2 in parallel or series with the receiver coil to produce a tuned receiver circuit. This circuit is known to increase the efficiency of a wireless power system. The rectified and smoothed (through a bridge rectifier and capacitors) output of the receiver coil and optional capacitor is either directly or through a switch or regulator applied to the output. A microcontroller is used to measure various values such as output voltage, current, temperature, state of charge, battery full status, end of charge, etc. and to report back to the charger to provide a closed loop system with the charger as described above. In the circuit shown in Figure 2, the receiver MCU communicates back to the charger by modulating the receiver load by rapidly closing and opening a switch in series with a modulation load at a pre-determined speed and coding pattern. This rapid load modulation technique at a frequency distinct from the power transfer frequency can be easily detected by the charger. A capacitor and/or inductor can also be placed in parallel or in series with this load.

[0043] For example, one may assumes that the maximum current output of the receiver is 1000 mA and the output voltage is 5 V for a maximum output of 5W. In this case, the minimum load resistance is 5 ohms. A modulation load resistor of several ohms (20, or 10 ohms or smaller) would be able to provide a large modulation depth signal on the receiver coil voltage. Choosing a 5 ohm resistor would modulate the output between a maximum current of 1 Amp or larger and a smaller value defined by the device load at the output. Such a large modulation can be easily detected at the charger coil current or voltage as described above.

[0044] The receiver in Figure 2 also shows an optional dc regulator that is used to provide constant stable voltage to the receiver MCU. This voltage supply may be necessary to avoid drop out of the receiver MCU during startup conditions where the power is varying largely or during changes in output current and also to enable the MCU to have a stable voltage reference source so it can measure the output voltage accurately.

[0045] In the above description, a uni-directional communication (from the receiver to the charger) is described. However, this communication can also be bi-directional and data can be transferred from the charger to the receiver through modulation of the voltage or current in the charger coil and read back by the microcontroller in the receiver detecting a change in the voltage or current, etc.

[0046] In accordance with an embodiment, in other geometries where position independence on placement of the receiver on the charger surface is achieved by having multiple charger coils in an array or pattern, similar drive and communication circuits in the charger and receiver can be implemented. However, to detect the appropriate coil to activate in the charger, the coils can be activated in a raster or zigzag fashion or other geometry and current drawn from a charger coil, strength of voltage, current, power or signal from the receiver or other methods can be used to determine the closest match between position of one or more of the charger coils and a receiver coil and the appropriate charger coil or coils can be activated and modulated to provide optimum power transfer to the receiver.

[0047] While a system for communication between the charger and receiver through the power transfer coil or antenna is described above, the communication can also be implemented through a separate coil, a radio frequency link (am or fm or other communication method), an optical communication system or a combination of the above. The communication in any of these methods can also be bi-directional rather than uni-directional as described above. As an example, **Figure 3** shows a system in accordance with an embodiment, wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes. This system is similar to the system shown in Figure 2, except rather than load modulation being the method of communication, the MCU in the receiver transmits the necessary information over an RF communication path. A similar system with LED or laser transceivers or detectors and light sources can be implemented. Advantages of such system may be that the power received is not modulated and therefore not wasted during communication and/or that no noise due to the modulation is added to the system.

[0048] One of the disadvantages of the circuit shown in Figure 2 is that in the receiver circuit shown therein, the current path passes through 2 diodes and suffers 2 voltage drops resulting in large power dissipation and loss. For example, for Schottky diodes with forward voltage drop of 0.4 V, at a current output of 1 A, each diode would lose 0.4 W of power for a combined power loss of 0.8 W for the two in a bridge rectifier configuration. For a 5 V, 1 A output power (5W), this 0.8 W of power loss presents a significant amount of loss (16%) just due to the rectification system. In accordance with an embodiment, an alternative is to use a center-tapped receiver as shown in **Figure 4** wherein during each cycle current passes only through one part of the coil and one diode in the receiver and therefore halves the rectification losses. Such a center tapped coil can be implemented in a wound wire geometry with 2 sections of a wound wire or a printed circuit board coil or with a double or multi-sided sided PCB coil or a combination or even a stamped, etched or otherwise manufactured coil or winding.

[0049] In any of the systems described above, as shown in **Figure 5**, the charger and receiver coils can be represented by their respective inductances by themselves (L1 and L2) and

the mutual inductance between them M which is dependent on the material between the 2 coils and their position with respect to each other in x, y, and z dimensions. The coupling coefficient between the coils k is given by:

$$k = M / (L1 * L2)^{1/2}$$

[0050] The coupling coefficient is a measure of how closely the 2 coils are coupled and may range from 0 (no coupling) to 1 (very tight coupling). In coils with small overlap, large gap between coils or dissimilar coils (in size, number of turns, coil winding or pattern overlap, etc.), this value can be smaller than 1.

[0051] **Figure 6** shows a wirelessly powered battery pack and receiver in accordance with an embodiment. The components of a typical common battery pack (battery cell and protection circuit, etc.) used in a battery device used in applications such as mobile phone, etc. are shown inside the dashed lines. The components outside the dashed lines are additional components necessary to enable safe wireless and wired charging of a battery pack. A battery pack may have four or more external connector points that interface with a mobile device pins in a battery housing or with an external typical wired charger. In accordance with an embodiment, the battery cell is connected as shown in **Figure 7** to two of these connectors (shown in the figure as Batt+ and Batt-) through a protection circuit comprising a battery protection IC that protects a battery from over-current and under or over voltage. A typical IC may be Seiko 8241 IC that uses 2 external FETs as shown in Figure 7 to prevent current going from or to the battery cell (on the left) from the external battery pack connectors if a fault condition based on over current, or battery cell over or under voltage is detected. This provides safety during charging or discharging of the battery. In addition, a battery pack may include a PTC conductive polymer passive fuse. These devices can sense and shut off current by heating a layer inside the PTC if the amount of current passing exceeds a threshold. The PTC device is reset once this current falls and the device cools.

[0052] In addition, in accordance with an embodiment, the battery pack can contain a thermistor that the mobile device checks through one other connector on the battery pack to monitor the health of the pack, and in some embodiments an ID chip or microcontroller that the mobile device interrogates through another connector to confirm an original battery manufacturer or other information about the battery. Other connectors and functions can be included in a battery pack to provide accurate battery status and/or charging information to a device being powered by a battery pack or a charger charging the battery pack.

[0053] In addition to the components described above, In accordance with an embodiment, the receiver circuit comprises a receiver coil that could be a wound wire or PCB coil as described above, optional electromagnetic shielding between the coil and the metal body of the battery,

optional alignment assisting parts such as magnets, etc., a receiver communication circuit (such as the resistor and FET for load modulation shown in Figures 2 and 4), a wireless power receiver (such as rectifiers and capacitors as discussed above), and an optional Battery charger IC that has a pre-programmed battery charging algorithm. Each type of battery and chemistry requires a pre-determined optimized profile for charging of a battery. A typical charge cycle for a Lithium Ion (Li-Ion) is shown in **Figure 8**. Such a battery may be charged up to a value of 4.2 V at full capacity. The battery should be charged according to the guidelines of the manufacturer. For a battery of capacity C, the cell can typically be charged at the rate 1C. In Stage 1, the maximum available current is applied and the cell voltage increases until the cell voltage reaches the final value (4.2 V). In that case, the charger IC switches to Stage 2 where the charger IC switches to Constant Voltage charging where the cell voltage does not change but current is drawn from the source to further fill up the battery. This second Stage may take 1 or more hours and is necessary to fully charge the battery. Eventually, the battery will draw little (below a threshold) or no current. At this stage, the battery is full and the charger may discontinue charging. The charger IC can periodically seek the condition of the battery and top it off further if the battery has drained due to stand-by, etc.

[0054] Such multiple stages of battery charging may be implemented in firmware with the wireless power charger and receiver microcontrollers monitoring the battery cell voltage, current, etc. and working in tandem and to provide appropriate voltage, current, etc. for safe charging for any type of battery. In another approach as shown in Figure 6, a battery charger IC chip that has specialized battery charging circuitry and algorithm for a particular type of battery can be employed. These charger ICs (with or without fuel gauge capability to accurately measure battery status, etc.) are available for different battery chemistries and are included in most mobile devices with mobile batteries such as mobile phones. They can include such safety features as a temperature sensor, open circuit shut off, etc. and can provide other circuits or microcontrollers such useful information as end of charge signal, signaling for being in constant current or voltage (stage 1 or 2 above, etc.). In addition, some of these ICs allow the user to program and set the maximum output current to the battery cell with an external resistor across 2 pins of the IC.

[0055] In accordance with an embodiment, the wirelessly charged battery pack in addition includes a micro-controller that coordinates and monitors various points and may also include thermal sensors on the wireless power coil, battery cell and/or other points in the battery pack. The microcontroller also may communicate to the charger and can also monitor communication from the charger (in case of bi-directional communication). Typical communication through load modulation is described above.

[0056] Another aspect of a wirelessly charged battery pack is the optional external / internal switch. A battery pack may receive power and be charged wirelessly or through the connectors

of a battery pack. For example when such a battery pack is used in a mobile phone, the user may wish to place the phone on a wireless charger or plug the device in to a wired charger for charging or charge the device as well as synchronize or upload and/or download information. In the second case, it may be important for the battery pack to recognize current incoming to the battery pack and to take some sort of action. This action may include notifying the user, shutting off the wired charger by a switch or simply shutting down the charger IC and sending a signal back through the microcontroller and modulating the current back to the charger that a wired charger is present (in case priority is to be given to the wired charger) or conversely to provide priority to the wireless charger and shut off wired charger access to battery when the wireless charger is charging the battery. At either case, a protocol for dealing with presence of two chargers simultaneously should be pre-established and implemented in hardware and firmware.

[0057] As shown in Figure 6, the wireless charging of battery occurs with current flowing into the battery through the battery contacts from the mobile device. Typically, such current is provided by an external DC supply to the mobile device (such as an AC/DC adaptor for a mobile phone) and the actual charging is handled by a charger IC chip or power management IC inside the mobile device that in addition to charging the battery, measures the battery's state of charge, health, verifies battery authenticity, and displays charge status through LEDs, display, etc. to a user. It may be therefore be advantageous to include a current sense circuit at one of the battery pack contacts to measure and sense the direction of current flow into or out of the battery. In case the current is flowing in (i.e. battery being externally charged through wired charging through a mobile device), the micro-controller may take the actions described above and shut off wireless charging or conversely, provide priority to wireless charging and if it is present, not allow wired charging to occur as preferred by design.

[0058] In accordance with an embodiment, the firmware in the receiver micro-controller is a key element in the operation of this battery pack. The micro-controller can measure voltages and currents, flags, and temperatures at appropriate locations for proper operation. In accordance with one embodiment, by way of example, the micro-controller can measure the value of Vout from the rectifier circuit and attempt to keep this constant throughout the charging cycle thereby providing a stable regulated DC supply to the charger IC chip. The microcontroller can send back the value of this voltage or error from a desired voltage (for example 5V) or simply a code for more or less power back to the charger in a binary or multi-level coding scheme through a load modulation or other scheme (for example RF communication as described earlier) back to the charger. The charger can then take action through adjustment of input voltage to the charger coil, adjustment of the frequency or duty cycle of the ac voltage applied to the charger coil to bring the Vout to within required voltage range. The micro-controller throughout the charging process, in addition, monitors the end of charge and/or other signals from charger and/or protection circuit and the current sense circuit (used to sense battery

pack current direction and value) to take appropriate action. Li-ion batteries for example need to be charged below a certain temperature for safety reasons. It is therefore essential to monitor the cell, wireless power receiver coil or other temperature and take appropriate action such as terminate charging or lower charging current, etc. if a certain maximum temperature is exceeded.

[0059] It is important to realize that during charging, as shown in Figure 8, the battery cell voltage increases from 3 V or lower, to 4.2 V, as it is charged. The V_{out} of the wireless power receiver is input to a charger IC and if this V_{out} is kept constant (for example 5V), a large voltage drop (up to 2 V or more) can occur across this chip especially during Stage 1 where maximum current is applied. With charging currents of up to 1 A, this may translate to up to 2 Watts of wasted power / heat across this IC that may contribute to battery heating. It may be therefore preferable to implement a strategy whereby the V_{out} into the charger IC tracks the battery voltage thereby creating a smaller voltage drop and therefore loss across the charger IC. This can provide a significant improvement in performance since thermal performance of the battery pack is very important.

[0060] The communication between the receiver and charger needs to follow a pre-determined protocol, baud rate, modulation depth, etc. and a pre-determined method for hand-shake, establishment of communication, and signaling, etc. as well as optionally methods for providing closed loop control and regulation of power, voltage, etc. in the receiver.

[0061] In accordance with an embodiment, a typical wireless power system operation can be as follows: As shown in **Figure 9**, the charger periodically activates the charger coil driver and powers the charger coil with a drive signal of appropriate frequency. During this 'ping' process, if a receiver coil is placed on top or close to the charger coil, power is received through the receiver coil and the receiver circuit is energized. The receiver microcontroller is activated by the received power and begins to perform an initiation process whereby the receiver ID, its presence, power or voltage requirements, receiver or battery temperature or state of charge and/or other information is sent back to the charger. If this information is verified and found to be valid, then the charger proceeds to provide continuous power to the receiver. The receiver may alternately send an end of charge, over-temperature, battery full, or other messages that will be handled appropriately by the charger and actions performed. The length of the ping process should be planned to be of sufficient length for the receiver to power up its microcontroller and to respond back and for the response to be received and understood. The length of time between the pings is determined by the designer. If ping process is performed often, the stand-by power use of the charger is higher. Alternately, if the ping is done infrequently, the system will have a delay before the charger discovers a receiver nearby.

[0062] Alternately, the ping operation can be initiated upon discovery of a nearby receiver by other means. This provides a very low stand-by power use by the charger and may be

performed by including a magnet in the receiver and a magnet sensor in the charger or through optical, capacitive, weight or other methods for detection. Alternatively, the system can be designed to be always ON (i.e. the charger coil is powered at an appropriate drive frequency) and presence of the receiver coil brings the coil to resonance with the receiver coil and power transfer occurs. The receiver in this case may not even contain a microcontroller and act autonomously and simply have a regulator to provide regulated output power to a device, its kin or case, or battery.

[0063] In accordance with an embodiment, the protocol for communication can be any of, e.g. common RZ, NRZ, Manchester code, etc. used for communication. An example of the communication process and regulation of power and/or other functions is shown in **Figure 10**. As discussed above, the charger may periodically start and apply a ping voltage of pre-determined frequency and length to the charger coil (bottom figure in Figure 10). The receiver is then activated and may begin to send back communication signals as shown in top of Figure 10. The communication signal can include an optional preamble that is used to synchronize the detection circuit in the charger and prepare it for detection of communication. A communication containing a data packet may then follow, optionally followed by checksum and parity bits, etc. These processes are quite standard in communication systems and similar techniques can be followed. The actual data packet can include information such as an ID code for the receiver, received voltage, power, or current values, status of the battery, amount of power in the battery, battery or circuit temperature, end of charge or battery full signals, presence of external wired charger, or a number of the above. Also this packet may include the actual voltage, power, current, etc. value or the difference between the actual value and the desired value or some encoded value that will be useful for the charger to determine how best to regulate the output.

[0064] Alternatively, the communication signal can be a pre-determined pattern that is repetitive and simply lets the charger know that a receiver is present and/or that the receiver is a valid device within the power range of the charger, etc. Any combination of systems can be designed to provide the required performance.

[0065] In response to the receiver providing information regarding output power or voltage, etc. the charger may modify voltage, frequency, duty cycle of the charger coil signal or a combination of the above. The charger can also use other techniques to modify the power out of the charger coil and to adjust the received power. Alternatively the charger can simply continue to provide power to the receiver if an approved receiver is detected and continues to be present. The charger may also monitor the current into the charger coil and/or its temperature to ensure that no extra-ordinary fault conditions exist. One example of this type of fault may be if instead of a receiver, a metal object is placed on the charger.

[0066] The charger can adjust a parameter to increase or decrease the power or voltage in the receiver and then wait for the receiver to provide further information before changing a

parameter again or it can use more sophisticated Proportional Integral Derivative (PID) or other control mechanisms for closing the loop with the receiver and achieving output power control. Alternatively, as described above, the charger can provide a constant output power, and the receiver can regulate the power through a regulator or a charger IC or a combination of these to provide the required power to a device or battery.

[0067] Various manufacturers may use different coding and also bit rates and protocol. The control process used by different manufacturers may also differ, further causing interoperability problems between various chargers and receivers. A source of interoperability differences may be the size, shape, and number of turns used for the power transfer coils. Furthermore, depending on the input voltage used, the design of a wireless power system may step up or down the voltage in the receiver depending on the voltage required by a device by having appropriate number of turns in the charger and receiver coils. However, a receiver from one manufacturer may then not be able to operate on another manufacturer charger due to these differences in designs employed. It is therefore extremely beneficial to provide a system that can operate with different receivers or chargers and can be universal.

[0068] In accordance with an embodiment, to be able to detect and power / charge various receivers, the charger can be designed such that the initial Ping signal is at such a frequency range to initially be able to power and activate the receiver circuitry in any receiver during the ping process. After this initial power up of the receiver, the charger communication circuit should be able to detect and understand the communication signal from the receiver. Many microcontrollers are able to communicate in multiple formats and may have different input pins that can be configured differently to simultaneously receive the communication signal and synchronize and understand the communication at different baud rates and protocols. The charger firmware can then decide on what type of receiver is present and proceed to regulate or implement what is required (end of charge, shut-off, fault condition, etc.). Depending on the message received, then the charger can decide to change the charger driver voltage amplitude, frequency, or duty cycle or a combination of these to provide the appropriate regulated output.

[0069] In accordance with an embodiment, the charger's behavior can also take into account the difference in the coil geometry, turns ratio, etc. For example, a charger and receiver pair from one or more manufacturers may require operation of the charger drive voltage at 150 kHz. However, if the same receiver is placed on a charger from another manufacturer or driven with different coil / input voltage combination, to achieve the same output power, the charger frequency may need to be 200 kHz. The charger program may detect the type of receiver placed on it and shift the frequency appropriately to achieve a baseline output power and continue regulating from there.

[0070] As shown in Figure 10, after the receiver sends back a communication signal back to the charger, in response to it, the charger adjusts its frequency and then awaits further

information from the receiver. The receiver acknowledges the change and as shown in the second data packet in the receiver signal, has modified its state and communicates back to the charger. This closed loop continues during the charging process.

[0071] For receivers that contain an onboard regulator for the output power, the input voltage to the regulator is not as critical since the regulator performs a smoothing function and keeps the output voltage at the desired level with any load changes. It is however, important not to exceed the maximum rated input voltage of the regulator or to drop below a level required so that the output voltage could no longer be maintained at the required value. However, in general, inclusion of a regulator and/or a charger IC chip (for batteries) reduces the power / voltage regulation requirements at the expense of the additional size and cost of this component.

[0072] While the system above describes a system where the communication is primarily through the coil, as described earlier, communication may be implemented through a separate coil, RF, optical system or a combination of the above. In such circumstances, a multi-protocol system can also be used to interoperate between systems with different communication and/or control protocols or even means of communication.

[0073] Alternately, the receiver may be designed to accommodate different types of chargers. For example, once a receiver is awakened by a charger, it may try to detect the ping frequency used by the charger. This may be done by any number of phase locking or other techniques. Alternately, the receiver may send back a variety of trial communication signals during ping process to establish which type of device is performing the ping. Once the type of the charger is established, the receiver can proceed and communicate with the appropriate communication protocol and frequency with the charger.

[0074] The multi-protocol approach described above is important for development of a universal system that can operate amongst multiple systems and provide user convenience.

[0075] The description for the systems above may use discreet electronics components or some or all of the functions described above may be integrated into an Application Specific Integrated Circuit (ASIC) to achieve smaller footprint, better performance / noise, etc. and/or cost advantages. Such integration is common in the Electronics industry and can provide additional advantages here.

Magnets for use with Magnetically Sensitive Devices and Materials

[0076] Magnetically sensitive devices, materials, or components are used in a variety of applications in industrial, consumer, credit, debit, Identification, or loyalty cards, computer, MP3 players, cameras, medical, satellite, marine, mining, transport, and military applications. Examples of magnetically sensitive components or sensors include traditional or electronic compasses, Hall sensors, magnetometers, disk drives, speakers, rotational or linear encoders, pneumatic sensors, electric motor position sensors, etc. These sensors monitor and/or measure

slight amounts of magnetic field. For example, a traditional or electronic compass (consisting of magnetometer or Hall Effect sensors) responds to the small magnetic field of the earth to provide directional information to the user. Use of a magnet near such a device would alter its performance and reliability. However, there are instances where such a use would be beneficial. As an example, recently, there is interest in incorporation of electronic compasses in mobile devices such as phones, GPS, cameras, electronic tablets, and electronic compasses to provide the user a portable navigation capability. Simultaneously, these devices have often used magnets to secure the device in a holder, case, or holster or to attach the device to a surface such as a holder in a car. One example of use of magnets in mobile phones is in certain phones, such as Blackberry-type phones, where the presence of a device in its holster containing a small magnet is detected by a magnetic sensor in a phone and activates certain actions that may be selectable by the user on the phone. These actions can for example consist of turning the ringer on the phone off or switching to a vibrate mode.

[0077] In cases such as the phone described above, if a magnetic compass is implemented in the phone, the presence of a magnet in a case can interfere with the operation of the compass and/or navigation capabilities of the device. Another example is the often used magnetic discs or clasps in cases or holders for phones or cameras to close a protective cover on a mobile device, phone, computer, GPS device, etc. In these and many other cases, it is desired to have an easy method of fastening two parts together magnetically while not affecting the operation of the device or system.

[0078] **Figure 11** shows a Notebook-style portfolio case (left) and a mobile phone or camera pouch (right), where magnets are used to secure a closing clasp or flap. Magnets have also been used to secure cases or portfolios to Notebook computers or the back of their screens. These devices often incorporate components such as disk drives or magnetically sensitive components such as compasses, etc. that may be affected by use of such magnets. In addition, the existing magnetic sensors in the device (as in the blackberry phone case discussed above) may be affected by such magnets.

[0079] In addition, in many instances, it is desirable to hold or mount various devices securely by use of magnets. These can include having a convenient method for mounting of mobile phones, MP3 players, cameras, radar detectors, GPS units, compass, video screens, TVs, etc. in cars, boats, ships, trains, planes, helicopters, or other transport vehicles or work or home areas. Several commercially available mounts for such devices are shown in **Figure 12**. In these instances, a magnetic or ferromagnetic base unit is coupled with a magnetic or ferromagnetic matching thin sticker or small sheet that can be attached or inserted inside a mobile device or its battery compartment or incorporated into a skin or case for the device such that the device will be attracted to the base and be held firmly during use or for storage. One or the other or both the holder or the mount and the other part incorporated into or on a device can

be magnetic, to provide the necessary attractive force for this operation. Similarly, if the device is sensitive to magnetic fields, such a magnet can interfere with its operation.

[0080] Another area of use of magnets is in design of handbags, bags, backpacks, wallets, money clasps, etc. where magnets are used as a convenient method of closing or fastening parts to close or shut parts together. Use of magnets in such instances where the user may place a magnetically sensitive device, phone, camera, MP3 player with disk drive, GPS unit, compass, or credit cards, etc. may cause problems. In particular, erasure of data in credit cards due to use of magnets in wallets or handbags can be a concern.

[0081] More recently, magnets have been used to provide easy and safe connectivity between power or data cables and mobile devices or Notebook computers. As shown in **Figure 13** and described, for example in U.S. Patent Nos. 7,311,526 and 7,645,143 , a power plug for an electronic device or Notebook computer or deep fryer using a magnetic method for fastening and attachment of the power cable and its plug to the matching connector in the Notebook and a deep fryer. The magnet or ferromagnet material in the part of the plug surrounding the 5 connectors shown is attracted to the matching part in the Notebook and automatically aligns and connects the connectors in the 2 parts. The magnetic element on one or both of the plug and the device connector or receptacle can be a magnet to provide the necessary attractive force. The advantages of this type of connector is that in case a user accidentally trips over such a cable, it would easily pull the cable out of the Notebook computer or deep fryer without damage to either side and pulling the product off to the floor causing damage or injury. This is a considerable advantage over other types of connectors that are mated by force and insertion of one part into another and liable to break in case of such accidents or cause unnecessary damage or injury. However, similar to the situations described above, use of such types of magnets near devices that are sensitive to the magnetic field such as mobile phones with compasses or devices with magnetic sensors or hard drives near the connector is problematic and therefore similar connectors are not used in many devices that can take advantage of this technology.

[0082] Another area of use of magnets is in the area of wireless power. With the proliferation of mobile devices in recent years, the area of powering and charging these devices has attracted more attention. The vast majority of the electronic devices in use today are powered and/or charged through conduction of electricity through wires from a power supply or charger to the device. While this method has proven to be efficient for most stationary devices, recently, there has been an interest in providing wireless methods for powering or charging several mobile devices, batteries, or electronics devices. The advantages include the ability to eliminate a power / charger cord and the possibility of implementing a universal charger / power supply that is able to charge / power multiple devices one at a time or simultaneously. In addition, in many situations, eliminating the connectors for charging and/or power would improve

device and/or battery reliability. The so called "wireless power" methods can also be generally divided into conductive and inductive methods. While the conductive methods use flow of current from a charger into the mobile devices and/or battery to provide power and therefore are not strictly speaking wireless, they offer geometries where a user can place a device on a pad or similar object and receive power through matching contacts on the back of a device and the pad without 'plugging in' the device. The inductive methods utilize coils or wires near the surface of a charger to create a magnetic field in the vicinity of the surface. A coil or wire in a receiver embedded into a device or battery that is in the vicinity of the surface can sense the magnetic field. Power from the charger can be transferred to the receiver without any wired connection through air or other media in between. The inductive method has several advantages over the conductive approach, such as:

- Connectors that are a major failure point in electronics are eliminated.
- Environmentally hermetic devices can be developed that are immune to moisture or liquids.
- The receiver can be built directly on the battery so the battery can be charged through the outside shell of the device by induction. This enables changing the battery of any existing product after-market with a similar sized and shaped battery to enable inductive charging.
- With a properly designed charger pad, the charging is independent of position and does not require placement of device in any particular location or orientation.

[0083] Methods based on an array of connectors (e.g. U.S. Patent No. 6,913,477 B2) or strips of power (e.g. www.pureenergy.com) in a pad that can power mobile devices conductively have been proposed. Sakamoto (H.Sakamoto and K.Harada in PESC'93 Record, pp168-174, Spain, (1992)) has also shown the possibility of recharging a device through a transformer coil with a core where the sections of the transformer can be separated. S. Hui, et al., in Electronics Letters, 34, pp. 1052-1054, (1998) and S. Tang, et al., Electronics Letters, 36, pp 943-944 (2000), describe the use of coreless printed circuit board transformers. Fernandez, et al., in Proc. APECOZ, 2002, pp. 339-345, have described the process of optimization of PCB coils for power transfer. The use of a resonance circuit is described in U.S. Publication No. 2009/0015075 and U.S. Publication No. 2009/0033564.

[0084] As described herein, powering or charging of a mobile or electronic device or battery can be used interchangeably. Many mobile devices incorporate rechargeable batteries and require external DC power to charge these batteries for operation. However, in case of some devices such as a notebook, computer, etc., while the device is connected to DC power to charge its internal battery, the device can also be using the DC power to operate simultaneously. The ratio of power used for charging the internal rechargeable battery to operating the device

depends on the degree to which the battery is discharged, the power necessary to operate the device, and what the device is doing at any given time. In the extreme, a laptop with its battery removed can only use the DC power to operate. In this case no charging occurs and 100% of the provided DC power is used to operate the device.

[0085] In some of the applications described above, magnets can be used to provide alignment or a secure connection for an electrical contact. For example, in some implementations of the inductive charging technology, it may be desirable to provide alignment between the charger and receiver coils by aligning them through use of disk, ring, or other magnets attached to the two coils. When a receiver embedded in a device, battery, battery door, skin, or case is brought close to a charger surface, the corresponding magnets can attract and bring the coils to the necessary alignment for optimum power transfer. Several embodiments for implementing this, for example to provide higher insensitivity to placement of the receiver, better mechanical and smaller volume requirements, minimal impact on power transfer, etc., are described in U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein.

[0086] **Figure 14** shows an Inductive wireless charger and/or power supply with multiple charging stations in accordance with an embodiment. The inductive receiver can be incorporated into a mobile device, its battery door, case or skin, a battery, etc. To align the coil in the charger and the coil in the receiver, magnets that attract the coils into alignment can be incorporated or on around the coils. Many types of magnets such as round discs, square, ring, oval, rectangular, arc, etc. can be used for alignment of coils. In Figure 14, round disc (top) and ring (bottom) magnets are used for this alignment. One or many magnets can be used. Several different placements and shapes for magnets are shown in **Figure 15** by way of example. For example, a single disc or square, or other shaped magnet at the center of each coil can be used. In other implementations, 4 disc or square magnets placed in the corners of a square pattern can be used or other patterns. The patterns shown herein are shown by way of example. In accordance with other embodiments, other numbers and/or shapes of magnets or magnetization direction or strength can be used to achieve the desired alignment. It is possible to incorporate

magnets with attracting magnetic orientation in the two parts to be aligned or alternatively, only one or one set of magnets and a ferromagnetic or magnetically attractable material used in the other part to achieve similar alignment results.

[0087] The advantage of use of a single disc magnet in the center of a charger and one in the center of a receiver is that the receiver can rotate with respect to the charger and still maintain optimum alignment. With 4 magnets placed as shown in Figure 15, the coils can be rotated 90, 180, or 270 degrees with respect to each other and still maintain alignment. Other shapes or number of magnets can be used and patterns in Figure15 are shown only as a way of example. The magnets can be magnetized with the magnet direction perpendicular to the face of the disk or magnet and by using magnet poles in the charger and receiver such that the pole is In the same direction in both, for example as south pole out of the page. When the two devices are close to each other, the magnets attract and align the coils. U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein, each of which applications are hereby incorporated by reference herein, previously described improvements on the design of alignment magnets. For example, in Figure 15 or Figure 16, disc, square, rectangular, or ring magnets are used in the charger and the receiver with the magnets magnetized in the direction perpendicular to the flat surface. A gap in the ring magnet is incorporated to reduce potential eddy currents due to changing magnetic field of the wireless charger / power supply. Ring magnets have better performance for these applications due to the larger diameter of the magnet that can be used in this case (thereby providing a larger alignment target for the user), the ability to rotate one coil with respect to the other one at any angle and maintain alignment, and the ability to reduce or eliminate any potential eddy currents through a cut in the ring as described above. In accordance with other embodiments, other shapes or combinations of shapes, such as square, rectangle, circle, oval, or triangle, etc. rins or other narrow wall, or others or combination of the above can be used depending on the particular needs of the intended application.

[0088] In some situations, the charger / and or power supply is incorporated into a mobile device or part that includes a magnetically sensitive portion. For example, the charger can be

incorporated into a notebook or laptop or computer with a disk drive, compass, or other magnetically sensitive parts. In these instances, incorporation of the magnet or magnets in the charger as well as the receiver can pose problems for the device incorporating the charger as well as for the device or part incorporating the receiver.

[0089] In accordance with various embodiments, the coils described here can be manufactured with wires, Litz wire, Printed circuit board (PCB), stamped, formed, shaped, etc. metal or magnetic material. The spiral patterns shown here are for example only and the coils can be any shape or size or pattern that could generate a magnetic field.

[0090] Similarly, the alignment can be achieved between a magnet or magnets incorporated into or around one of the coils and a part constructed of ferromagnetic or other magnetic material that can be attracted to the magnet for alignment. The magnet or the magnetically attracted part can be made from Nickel, Iron, Cobalt, gadolinium and dysprosium, steel, etc. or an alloy of these materials or ceramic, Alnico, Ticonal, Rare Earth magnets, flexible or injection molded or nano-crystalline magnets so that the magnets on the receiver attract and attach to the magnetic or ferromagnetic material on the other part. Examples of metal or magnetic material or ferromagnetic material that could form the opposite side are Nickel, Steel, cobalt, gadolinium and dysprosium, steel, etc. or an alloy of these material or ceramic, Alnico, Ticonal, Rare Earth magnetic material, flexible or injection molded or nano-crystalline materials or any other material that can be attracted to a magnet or an alloy containing such. Of course, either the receiver or charger can incorporate a magnet and the other part a material that is attracted to a magnet or vice versa or both can contain magnets with poles arranged such that they attract each other for alignment. The type of materials discussed above or combination thereof can be used in any of these cases. The magnets can be permanent magnets or electromagnets activated by application of an electrical current.

[0091] Similarly, in conductive types of wireless or wire free charging or power, the connectors on a receiver in or on a device or skin, etc. are often magnetized to attract strips of metal or additional magnets on a pad to make a strong connection. For example, some companies produce a conductive type of so called "wireless" or "wire-free" charger. In some instances, connectors on the back of a mobile device incorporated into the device, its skin, or battery door, or an additional part attached to the back of the device contain a number of metallic contacts which make contact with metal strips on a pad. The metal strips are connected to a power supply rail with an applied voltage and upon contact with the receiver connectors and verification of the receiver, provide necessary voltage and/or current to the receiver. To enable a strong connection between the receiver and the pad metal strips or to enable the receiver and the device it is attached or incorporated in, to be placed at an angle or vertically, etc., the metal strips are made of a magnetic or ferromagnetic material such as Nickel, Iron, Cobalt, gadolinium and dysprosium, steel, etc. or an alloy so that the magnets on the receiver contact attract and

attach to the strips. Enabling such an attractive contact is especially important when it is desired that the device not move during the charging process such as when the charger pad is used or incorporated into a car, airplane, ship, boat, etc. where motion is present. However, in instances where the mobile device contains a compass such as an electronic compass in certain phones, use of magnets in the receiver connectors interferes with such an operation. Therefore the manufacturer has generally not incorporated magnetic connectors for such instances, which eliminates the benefits of the magnetic attachment.

[0092] In these and many other applications, it may be desirable to benefit from the seemingly contradictory use of magnets for their advantages in providing an attractive force for fastening, mounting, holding, or alignment, while at the same time it is desired to minimize or eliminate any effect on magnetically sensitive components in the charger or receiver or devices or parts nearby. This contradiction can be resolved by realizing that it is possible to create magnets with a net magnetic field that is zero or small in areas near or far from the magnet and at the same time that the part retains its magnetic or attractive properties at close distances and can provide attractive forces.

[0093] To achieve small overall net magnetic field, it is important to realize that the magnetic field is a vector and fields from several magnets or parts or poles of the same magnet add to provide the total sum of the field at any location in space.

[0094] Many magnets such as Rare Earth magnets are made using a sintering process whereby the basic material components such as Iron, Nickel, Cobalt, and/or Rare Earth material are refined and then combined in the desired composition and melted in a furnace to produce starting ingots for a magnet. The ingots are then ground and the resulting particles are placed in a jig or mold with the desired shape and dimensions and pressed into shape while an external magnetic field is applied to orient the particles. By applying the appropriate magnetic field in the desired direction, in plane, out of plane, radial, or multi-pole poling of the magnet can be achieved. For example, multi-pole magnets are created by pulse magnetization. To create a linear period multi-pole magnet, a magnetizing fixture with a back and forth copper wire arrangement is used. Application of a short current pulse from a capacitor through the fixture produces a magnetic field strong enough to magnetize material in the vicinity of the wire pattern. By controlling the shape and size of the induced magnetic field various magnet types can be created. The resulting part is then treated in a sintering furnace to compact the material before further testing of the parameters and coating of the final magnet to avoid corrosion. As an example, multi-pole magnets with periodicity of 1-2 mm in substrates of 2 mm thick or less have been studied for micro-actuator applications (J.Topfer, and V. Christoph, "Multi-pole Magnetization of NdFeB Sintered Magnets and Thick Films for Magnetic Micro-Actuators", Sensors and Actuators, A 113 (2004) 257-263 AND J. Töpfer, B. Pawlowski, H. Beer, K. Plötner, P. Hofmann, M. Herfurth, "Multi-pole magnetization of NdFeB magnets for magnetic

micro-actuators and its characterization with a magnetic field mapping device, J. Magn. Magn. Mater. 270 (2004) 124–129).

[0095] Töpfer, et al. manufactured NdFeB square magnets of 50 x 50 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part and characterized it. **Figure 16** shows Measured z-component (along the axial direction of magnetization) of the magnetic flux density of this magnet measured by moving a Hall Sensor along the middle of one edge of the square to the opposite edge of the square 250 micrometers above the surface of the magnet as shown in the inset. The results show that in such a magnet, the field peaks at the edges and in the center, a strong demagnetization field exists that almost reduces the magnetic flux to zero at this center, thereby not providing much attractive or retention force for such thin magnets.

[0096] In **Figure 17**, the same researchers compare the performance of a 50 x 50 x 1 mm^3 magnet with one of 10 x 10 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part. The smaller magnet retains its magnetic flux to a greater degree at its center and has higher peaks at the edges. Also note that the peak of the magnetic flux is higher for this magnet.

[0097] To further retain high flux density in a magnet, the same shape part can be periodically poled in a multi-pole pattern as shown in **Figure 18**. Here, the 10 x 10 x 1 mm^3 magnet is magnetized periodically with a periodicity of 2 mm as shown on the top Figure 18. The bottom figure shows the measured magnetic flux density. It can be seen that flux density follows the poling pattern but in addition, comparing the magnitude of the flux density, it can be seen that the peak values are about twice the peak value of the flux density in a uniformly magnetized magnet. In addition, the magnetic flux does not show any sign of demagnetization and reduction of the peak values at the center of the magnet that is seen in Figures 16 and 17. Overall, multi-pole magnetization can provide a method for achieving higher and more uniform magnetic flux in a magnet. These characteristics are desirable for applications described here where retention and alignment of parts are required.

[0098] An important aspect of the performance of the multi-pole magnets described here is the performance of these magnets away from the surface of the magnets. **Figure 19** shows the drop off of maximum flux density value for a 10 x 10 x 1 mm^3 magnet magnetized periodically with a periodicity of 1 and 2 mm as shown on the top as a function of distance between the probe and the top of the magnet. It can be seen that the flux density drops off very quickly and reaches small values for over 1 mm. This is a result of the geometry shown on the top of the figure. With multiple poles present, as the distance between the probe and the magnet increases, the probe measures the sum of the flux density from the multiple poles present and this value approaches zero quickly away from the surface. At the same time, near the surface, the flux density is larger for the multi-pole magnet as compared to a single pole magnet, and increases as the pole periodicity increases (up to a limit given the physical dimensions of the

magnet, its thickness, etc.). It is important to recall that the peak for a uniformly magnetized magnet of same dimension was only around 0.13 T (< 1/3 of the 1 mm periodically poled similarly sized magnet value) as shown in Figures 18 and 19. At the same time, as discussed above, the uniformly magnetized magnet also showed a very significant reduction of the flux density at its center which is not present for the multi-pole magnet.

[0099] In summary, the results above demonstrate that properly designed multi-pole magnets can provide significantly higher and more uniform flux density near their surface while at the same time providing much lower flux densities away from the surface.

[00100] These characteristics can be used to provide the combination of characteristics that are useful for mounting, holding, attachment, and alignment purposes for the applications discussed earlier. By using multi-pole magnets higher retention and alignment force can be provided, while reducing the effect of any stray fields on nearby magnetically sensitive components, parts, or materials.

[00101] **Figure 20** shows several magnet types that are magnetized perpendicular to the magnet surface (axially), in accordance with various embodiments. For example, **Figure 20** shows (a) rectangular magnet magnetized in a checkerboard pattern, (b) square magnet magnetized in a checkerboard pattern, (c) rectangular magnet magnetized in a single direction multi-pole pattern, (d) square magnet magnetized in a single direction multi-pole pattern, (e) disc magnet magnetized into 4 sections, (f) disc magnet magnetized into 8 sections, (g) ring magnet magnetized into 8 sections, and (h) disc magnet magnetized into concentric circular sections. These patterns are shown by way of illustration and it is obvious that many types of magnets and shapes can be devised for various applications with regular or irregular shapes that have multi-pole magnetic patterns.

[00102] For applications in securing or mounting of parts to another part, a multi-pole magnet similar to magnets in **Figure 20** or another appropriate shape and size and number of poles can be devised for the device to be mounted or the mount and combined with a matching magnet or ferromagnet or other magnetically attractable material on the opposite part (device or mount) to provide attraction between the two parts. Since each magnet includes a number of poles, this approach allows both for central alignment between the two parts (i.e. their respective magnets or magnetically attractable material are centered with respect to one another); and stepped or rotational alignment between the two parts (i.e. their respective magnets or magnetically attractable material can be center-aligned with respect to one another, and then rotated around those centers in steps corresponding to the number of poles, wherein at each step the full magnetic attraction is provided). This allows for novel uses of such magnets, for example to allow parts to be attached to one another in a variety or particular number of relative orientations.

[00103] In accordance with an embodiment, in applications such as shown in Figure 11-15, the appropriately designed magnet can be used instead of the uniformly magnetized magnets of

earlier design, to provide stronger or similar attractive force while producing minimal or zero magnetic field away from the magnet not to disturb other magnetically sensitive parts or devices.

[00104] As an example, in accordance with various embodiments, ring or arc multi-pole magnets such as those shown in **Figure 21** can be used with the coil to provide alignment. It will be evident that improvements such as cuts or discontinuities, etc. for reduction of eddy currents can be implemented as in singly poled magnets described for example in U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein. For example, the ring magnet in **Figure 22** shows an implementation of such a discontinuity at the bottom of the figure.

[00105] While most of the description below is based on the inductive method of power transfer, the embodiments described here can be implemented with either the inductive method or the conductive method or the magnetic resonance method, optical, or other methods for power transfer some of which have been described above. Inductive methods of power transfer are described above as an example of the more general wireless power transfer.

[00106] Furthermore, the type of magnets discussed above may be used with magnetic shielding material commonly in use for reduction of AC or DC magnetic field such as mumetal, etc. available from Magnetic Shield Corporation or material such as thin flexible sheets available from Maruwa or nano materials such as Finemet from Hitachi Corp or ferromagnetic or alloys of ferromagnetic materials such as iron, nickel and cobalt. For example in the case of the inductive charger or receiver described above, the area behind a coil can be covered by a magnetic shield material and a square, rectangle, ring or arc of multi-pole magnet can be attached around and/or on such a shield and be used for attraction and alignment of the charger and receiver coil to each other. Figure 22 shows such an arrangement where multi-pole magnets (multi-pole ring (left) and arc (right) magnet on or around an inductive coil) and magnetic shielding material are used behind a coil. Here, the magnetic shield layer or material shields behind the coil provides shielding from the alternating magnetic field of the coil. An optional cut / discontinuity in the ring (shown at the bottom of the ring magnet on the left) prevents or reduces eddy currents during operation of the inductive coil.

[00107] In addition, heat transfer layers can be incorporated to spread the heat generated. Such layers need to be designed not to interfere with the operation of the coils. Since alternating magnetic fields are generated and detected in an inductive system, use of a metal layer behind the coil would produce eddy currents and loss. One method for providing thermal conductivity with metal layers is where a metal layer with discontinuous portions is placed behind and/or around the coil. In this case, the metal layer can comprise rectangular slices that can conduct heat away from the center of a coil while, due to discontinuity between the slices, the electrons can not flow in a circular motion due to the alternating magnetic field. The pattern described here has a number of triangular slices but any other pattern which can provide heat transport but does not allow carriers to circulate in a rotational pattern due to the alternating magnetic field can be implemented.

[00108] Alternatively, multi-pole magnets can be manufactured by way of taking a single poled magnet, cutting it into appropriate sections, and reassembling the pieces and attaching them together with an adhesive, glue, or other bonding agent or other material; or alternatively a holder, etc. or clamp or screws or external force or other methods, so that the multi-pole geometry is achieved. For example, a single poled axially poled (out of plane of ring) ring can be cut into 4, 8, 16, or another number of even or odd sections, and half of the sections turned over and reassembled to provide a multi-pole magnet. To aid in assembly of such a magnet, it may be necessary to attach or place the parts on to another solid continuous piece. This piece may be magnetic, ferromagnetic, or non-magnetic itself. For example, in the ring magnet example above, the pieces of the ring magnet can be attached and reassembled in a multi-pole geometry on a stainless steel, iron, Nickel, plastic, or copper, etc. ring to aid in assembly and to hold the sections together. The properties of the backing material, its thickness, etc. can also be optimized to provide necessary performance. For example, use of a ferromagnetic material as backing can further provide a path for the magnetic flux in that section and provide further tighter coupling between sections and reduction of magnetic field away from the ring. It may also be desirable to sandwich the magnet on both sides with similar or dissimilar backing material or layers, or use multiple backing layers to further engineer symmetric or asymmetric properties on the two sides of the multi-pole magnet.

[00109] **Figure 23** shows a multi-pole ring magnet with radially magnetized sections. In use of the magnet for inductive charging applications, a cut or break in the circle or arc magnets as described earlier can be used.

[00110] While in the above description, emphasis has been given to affixing electronic parts, batteries, electric parts, etc to other parts or components or cases, holders, etc., the processes, systems, and methods described above can be similarly used to permanently or temporarily fix, attach, align, or establish relation between any two or more parts of the same or different items, products, areas, etc., including those not directly related to electronics. Examples include in

lighting, furniture, automotive, mechanical instruments or machines, electronics, electrical systems and components, batteries, cases, purses, clothing, footwear, or any other number of applications. Other examples can be developed in accordance with other applications.

[00111] Some aspects of the present invention can be conveniently implemented using a conventional general purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as will be apparent to those skilled in the art.

[00112] In some embodiments, the present invention includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of the present invention. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, DVD, CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00113] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

Claims:

What is claimed is:

1. A system for providing universal or improved compatibility and transfer of wireless power to mobile devices and batteries, comprising:

a charger including a charger coil and one or more half-bridge drivers and/or microcontroller units or other current and/or voltage controlling components, wherein the charger includes a circuit or other components that measures the current through and/or voltage across the charger coil, and wherein the microcontroller unit receives a communication signal from a detection/demodulation circuit and makes appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output, for using in powering or charging a mobile device and/or battery.

2. The system of claim 1, wherein the charger is used with a mobile device having a receiver that is coupled to a receiver coil and a receiver circuit and that includes a capacitor in parallel or series with the receiver coil to produce a tuned receiver circuit.

3. The system of claim 1, wherein the receiver further includes a microcontroller that is used to measure various values such as output voltage, current, temperature, state of charge, battery full status, end of charge, etc. and to report those values back to the charger to provide a closed loop system with the charger.

4. The system of claim 1, wherein communication between the charger and receiver is provided through the power transfer coil or an antenna, or through a separate coil, a radio frequency link , an optical communication system or a combination of these, and wherein the communication in any of these methods can be bi-directional and/or uni-directional.

5. The system of claim 1, wherein the charger and receiver communicate to provide optimal charging information, including the charger periodically activates the charger coil with a drive signal of appropriate frequency, during which ping process, if a receiver coil is placed on top or close to the charger coil, power is received through the receiver coil and the receiver circuit is energized, and wherein the receiver microcontroller is activated by the received power and performs an initiation process whereby the receiver ID, its presence, power or voltage requirements, receiver or battery temperature or state of charge or other information is sent back to the charger.

6. A method for providing universal or improved compatibility and transfer of wireless power to mobile devices and batteries, comprising the steps of:

providing a charger including a charger coil and one or more half-bridge drivers and/or microcontroller units or other current and/or voltage controlling components, wherein the charger includes a circuit or other components that measures the current through and/or voltage across the charger coil, and wherein the microcontroller unit receives a communication signal from a detection/demodulation circuit and makes appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output, for using in powering or charging a mobile device and/or battery.

7. A system for attachment or fastening of one or more device, component, or part thereof to another device, component, or part thereof, using a multi-pole magnet comprising:

a first magnet attached to or included within a first one of the device, component, or part thereof, wherein the first magnet includes more than one magnetic pole; and

a second magnet or a magnetic or ferromagnetic material attached to or included within or on second of the device, component, or part thereof, which is magnetically attracted to the first magnet to provide a measure of alignment, attachment or fastening of the first and second devices, components, or parts.

8. The system of claim 7, wherein the multi-pole magnet has an appropriate shape, size and number of poles, which can be mounted within or upon the electronic device and/or battery, and used with a matching magnet or a ferromagnetic material in a base unit, surface, part, cradle, holder or other device, to provide attraction and/or alignment between the electronic device and/or battery and other device.

9. The system of claim 7, wherein the multi-pole magnet is a square or rectangular magnet magnetized in a linear or checkerboard pattern.

10. The system of claim 7, wherein the multi-pole magnet is a square or rectangular magnet magnetized in a single direction multi-pole pattern.

11. The system of claim 7, wherein the multi-pole magnet is a disc, ring, oval, or similarly shaped magnet magnetized into a plurality of sections.

12. The system of claim 7, wherein the multi-pole magnet is a disc magnet magnetized into a plurality of concentric circular or alternating sections around its center

13. The system of claim 7, wherein the multi-pole allows both for central alignment between the two parts, so that their respective magnets or magnetically attractable material are centered with respect to one another, and also stepped or rotational alignment between the two parts, so that their respective magnets or magnetically attractable material can be center-aligned with respect to one another and then rotated around those centers in steps corresponding to the number of poles, wherein at each step the full magnetic attraction is provided.

14. The system of claim 7, including a backing material which can be optimized to provide necessary performance or to alter the path for the magnetic flux in various sections

15. A method for the use of magnets in electronic devices and/or battery, and in particular to devices or parts having proximity to magnetic sensors, comprising the steps of:

providing a first magnet attached to or included within a first one of the device, component, or part thereof, wherein the first magnet includes more than one magnetic pole, and a second magnet or a magnetic or ferromagnetic material attached to or included within or on second of the device, component, or part thereof, which is magnetically attracted to the first magnet to provide a measure of alignment, attachment or fastening of the first and second devices, components, or parts.

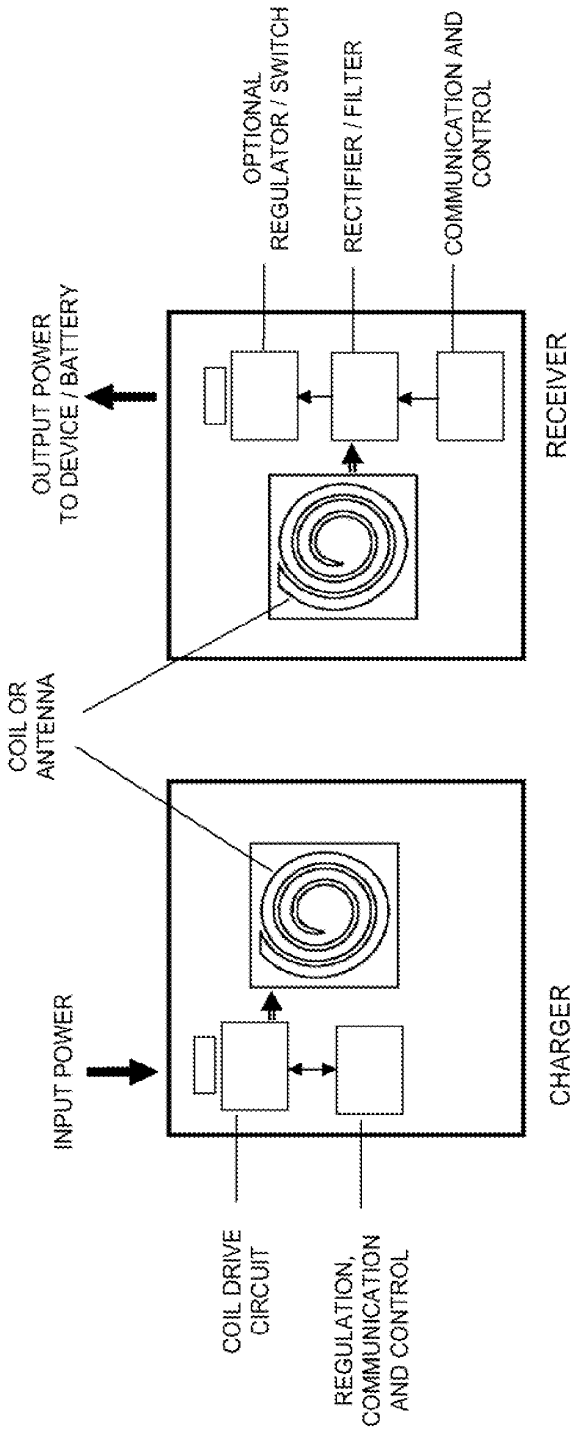

OPTIONAL REGULATOR / SWITCH
RECTIFIER / FILTER
COMMUNICATION AND CONTROL
OUTPUT POWER TO DEVICE / BATTERY
RECEIVER
COIL OR ANTENNA
INPUT POWER
CHARGER
COIL DRIVE CIRCUIT
REGULATION, COMMUNICATION AND CONTROL

FIGURE 1

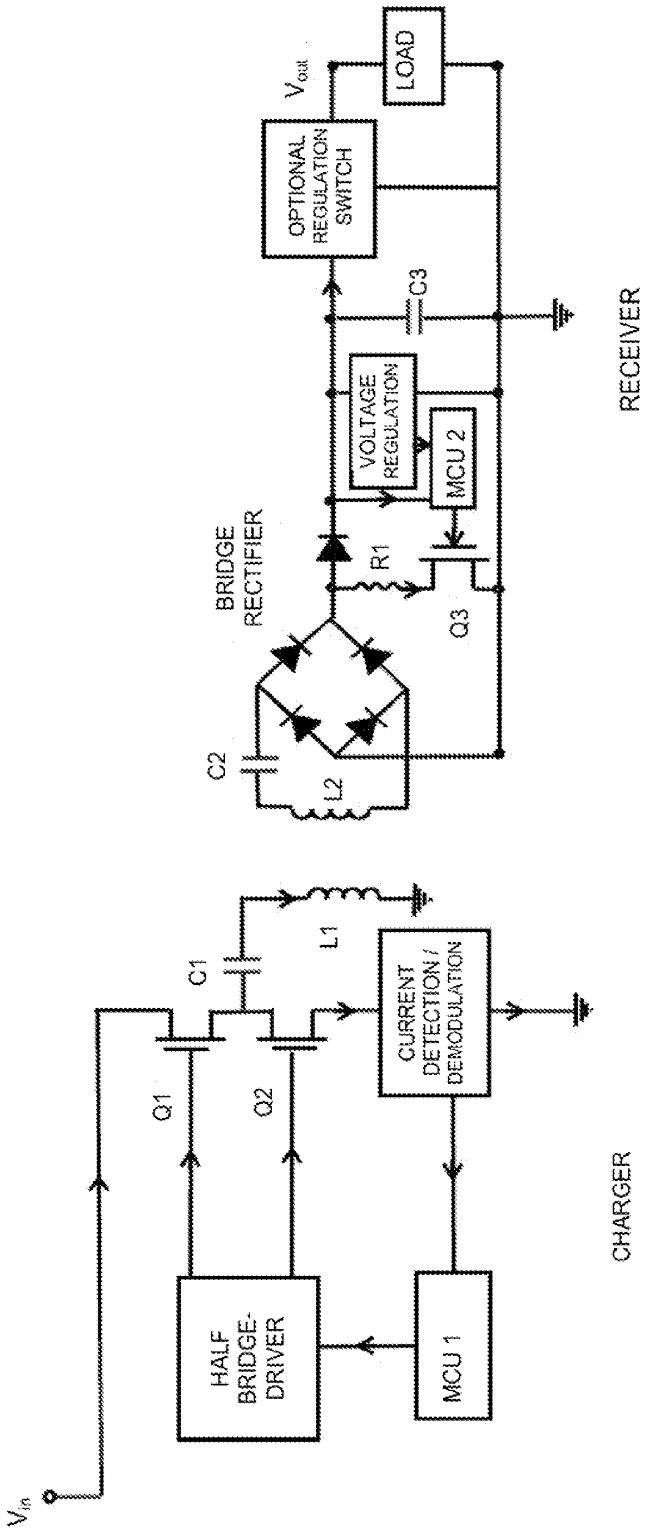

LOAD
V_{out}
OPTIONAL REGULATION SWITCH
C3
VOLTAGE REGULATION
MCU 2
RECEIVER
BRIDGE RECTIFIER
R1
Q3
C2
L2
L1
C1
CURRENT DETECTION / DEMODULATION
Q1
Q2
CHARGER
HALF BRIDGE-DRIVER
MCU 1
V_{in}

FIGURE 2

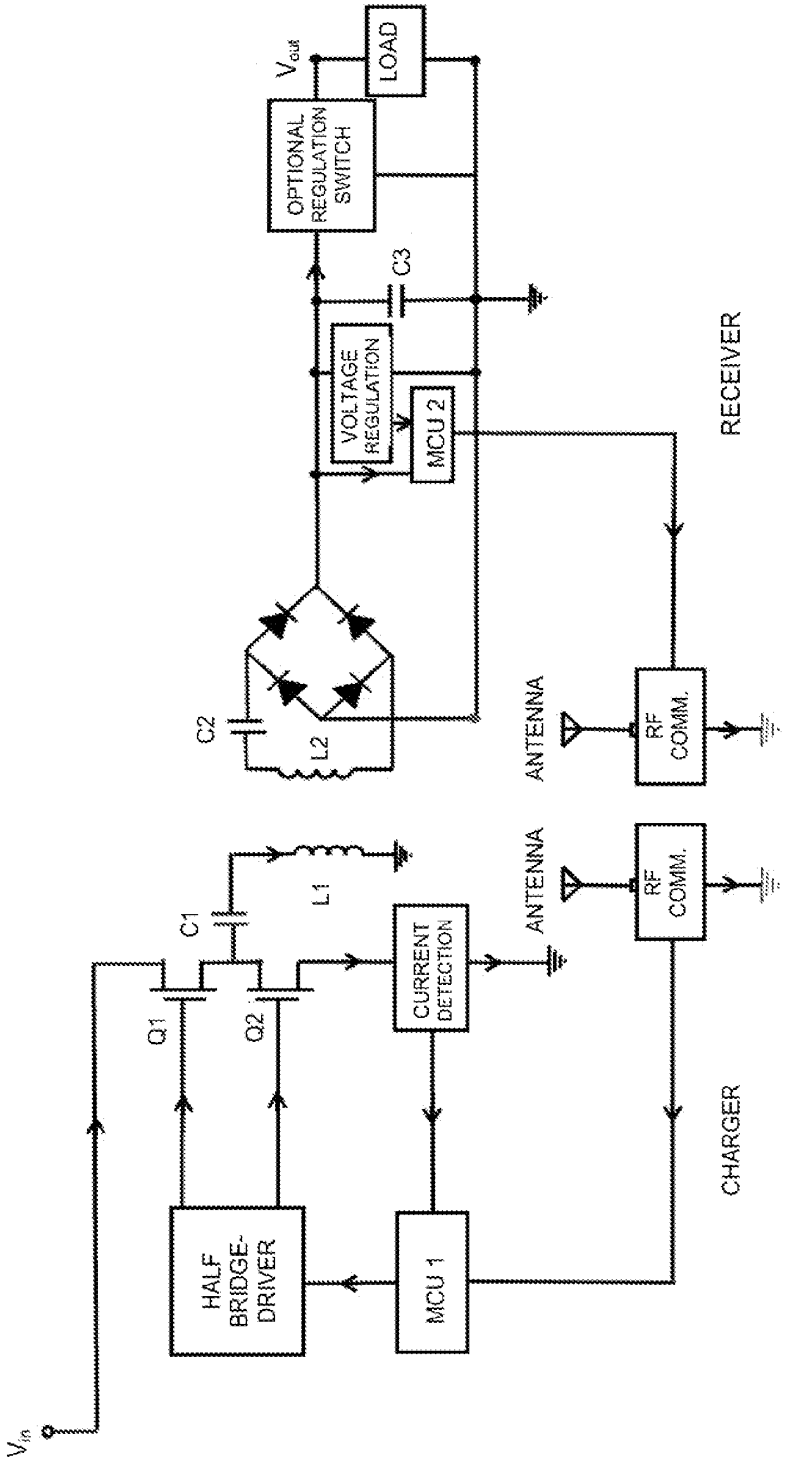

LOAD
V_{out}
OPTIONAL REGULATION SWITCH
C3
VOLTAGE REGULATION
MCU 2
RECEIVER
C2
L2
ANTENNA
RF COMM.
L1
C1
ANTENNA
RF COMM.
CURRENT DETECTION
Q1
Q2
CHARGER
HALF BRIDGE-DRIVER
MCU 1
V_{in}

FIGURE 3

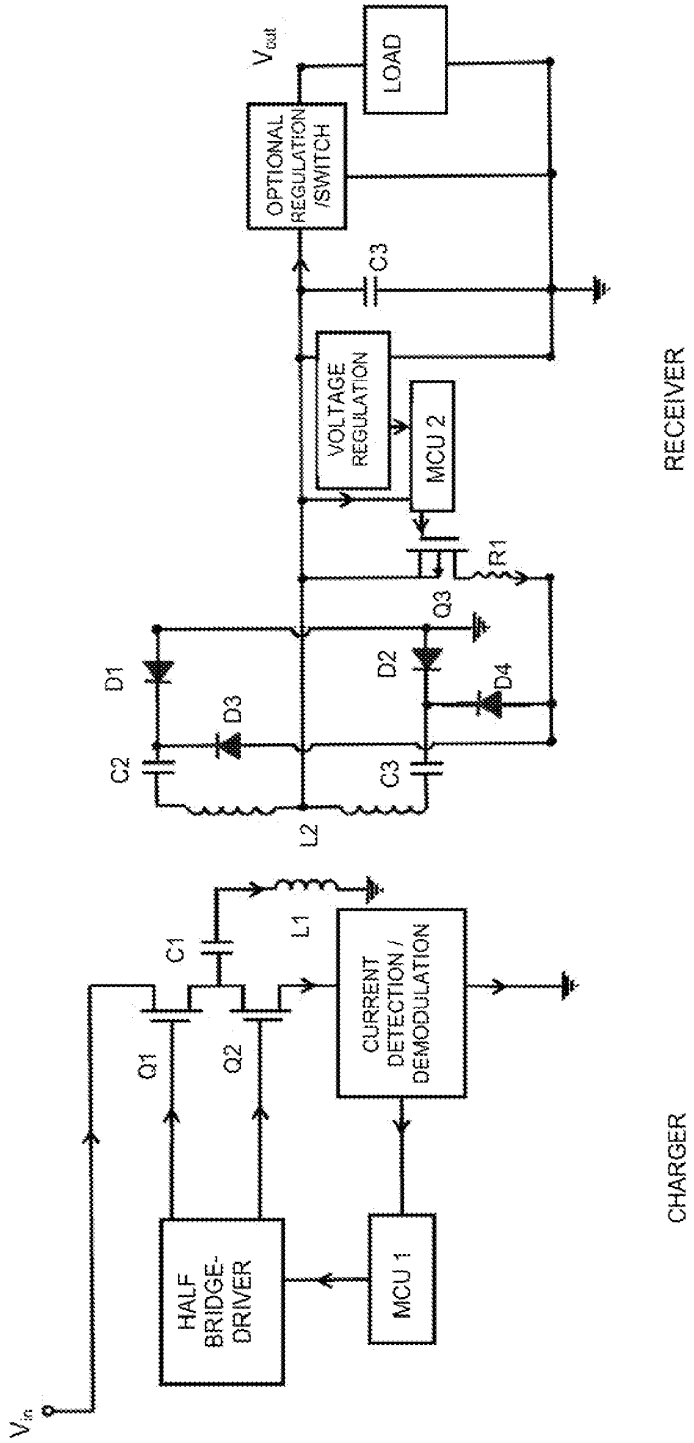

V_{out}
LOAD
OPTIONAL REGULATION /SWITCH
C3
VOLTAGE REGULATION
MCU 2
R1
Q3
D1
D2
D4
D3
C2
C3
L2
RECEIVER
C1
L1
CURRENT DETECTION / DEMODULATION
Q1
Q2
HALF BRIDGE-DRIVER
MCU 1
V_{in}
CHARGER

FIGURE 4

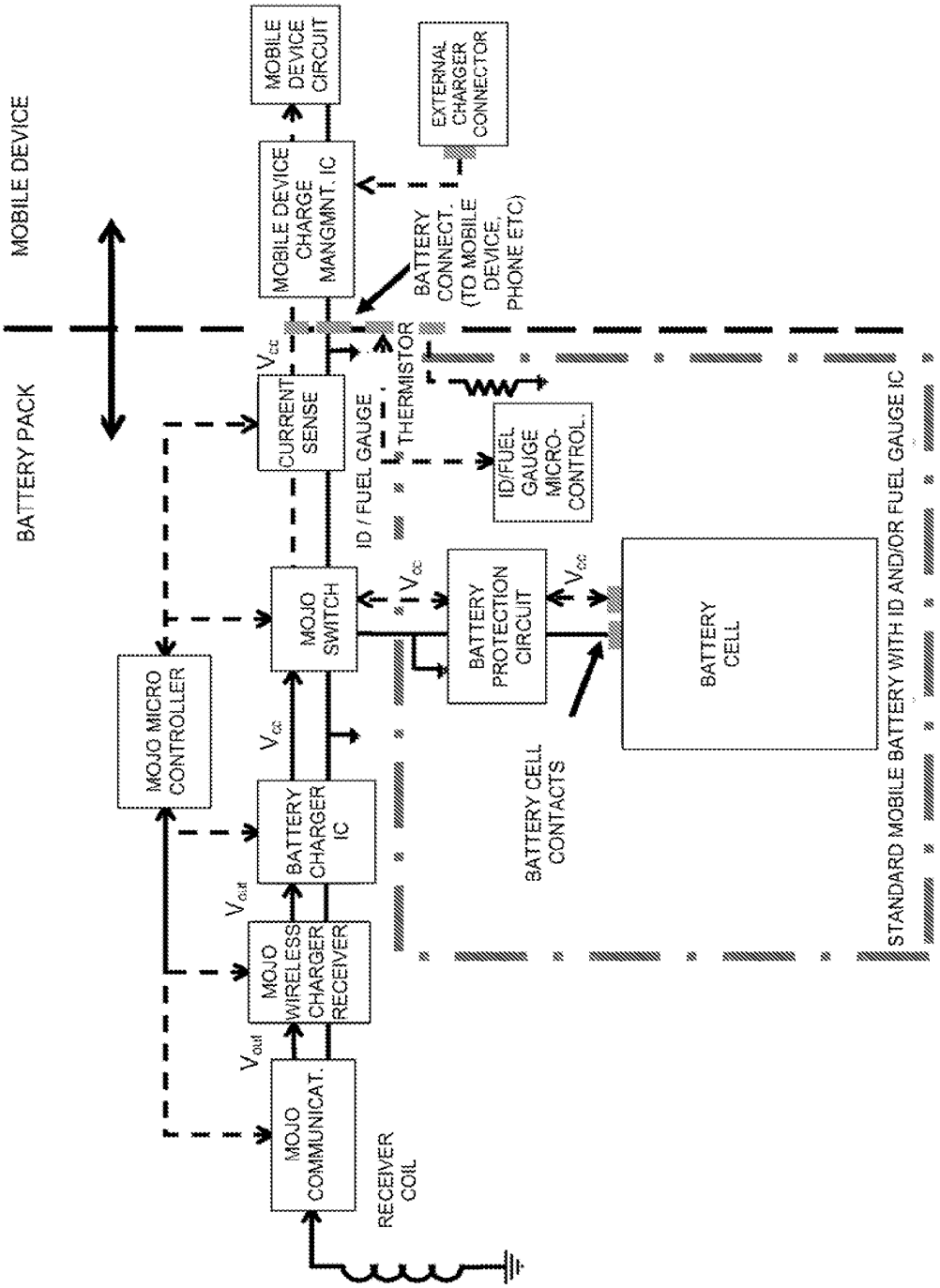

MOBILE DEVICE
BATTERY PACK
MOBILE DEVICE CIRCUIT
EXTERNAL CHARGER CONNECTOR
MOBILE DEVICE CHARGE MANGMNT. IC
BATTERY CONNECT. (TO MOBILE DEVICE, PHONE ETC)
THERMISTOR
CURRENT SENSE
ID / FUEL GAUGE
ID/FUEL GAUGE MICRO-CONTROL.
MOJO SWITCH
BATTERY PROTECTION CIRCUIT
BATTERY CELL
MOJO MICRO CONTROLLER
BATTERY CHARGER IC
MOJO WIRELESS CHARGER RECEIVER
MOJO COMMUNICAT.
RECEIVER COIL
BATTERY CELL CONTACTS
STANDARD MOBILE BATTERY WITH ID AND/OR FUEL GAUGE IC

FIGURE 6

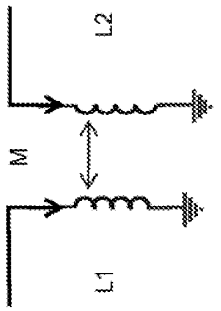


FIGURE 5

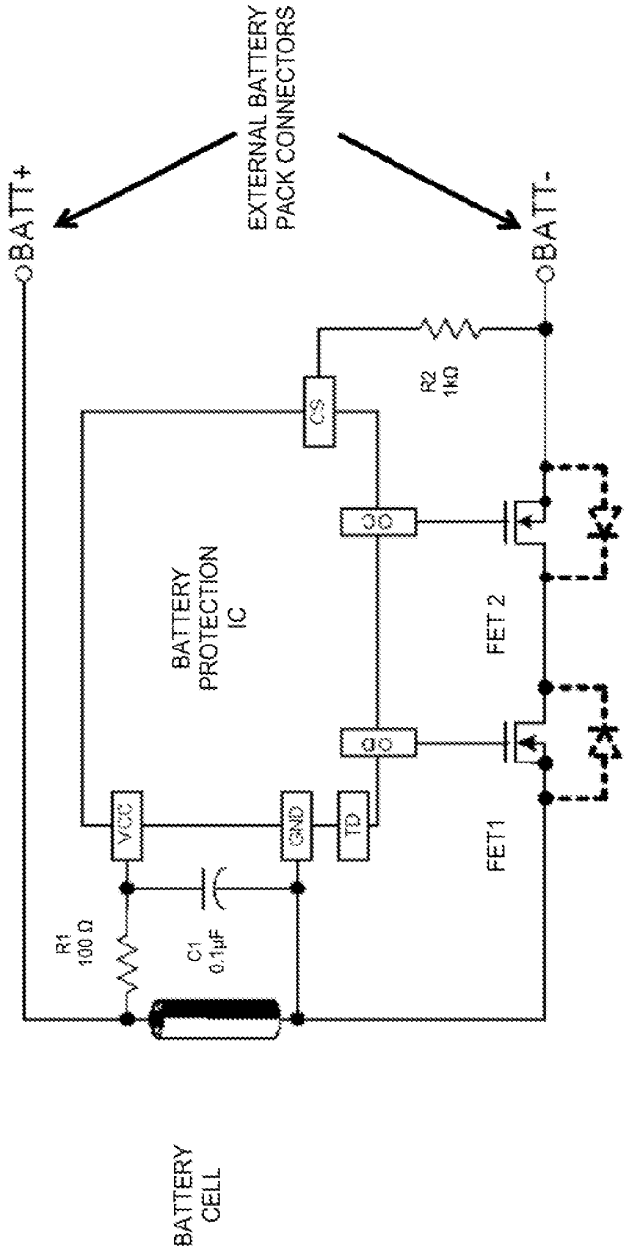


FIGURE 7

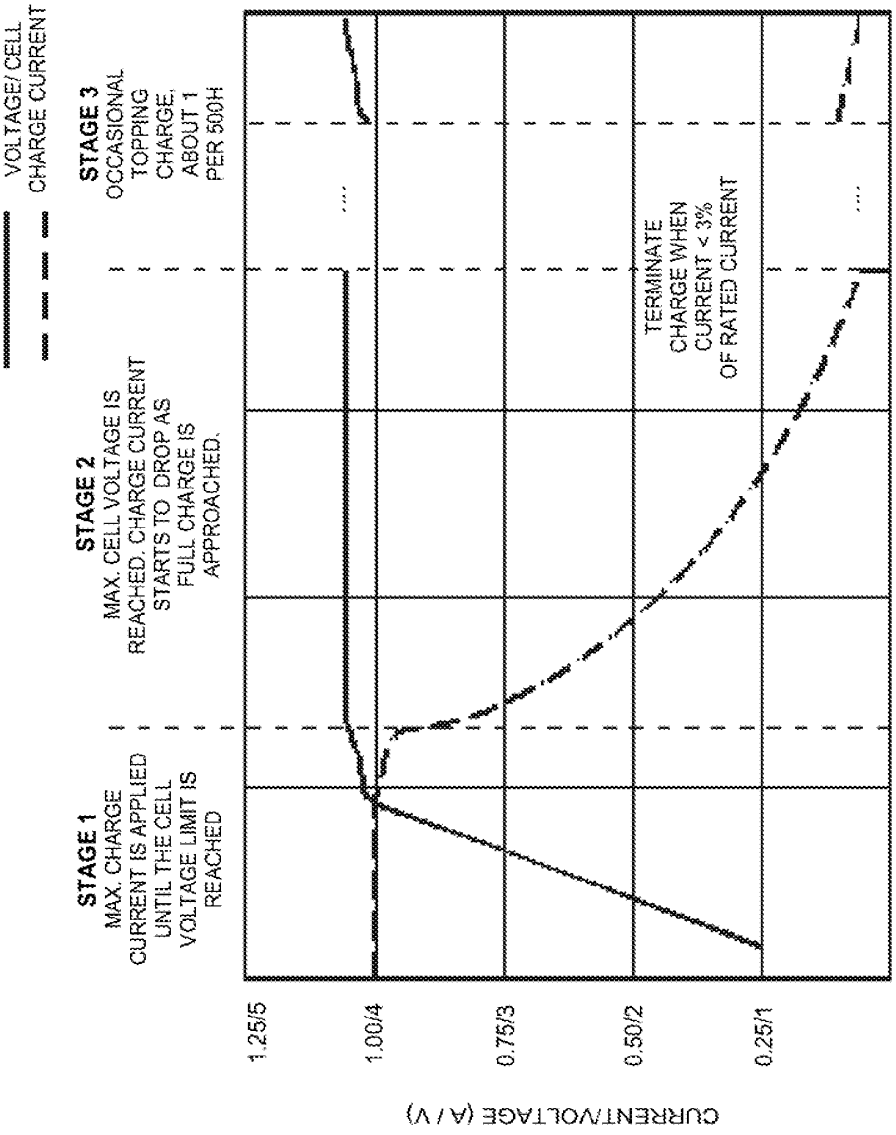

VOLTAGE/ CELL
CHARGE CURRENT
STAGE 1
MAX. CHARGE CURRENT IS APPLIED UNTIL THE CELL VOLTAGE LIMIT IS REACHED
STAGE 2
MAX. CELL VOLTAGE IS REACHED. CHARGE CURRENT STARTS TO DROP AS FULL CHARGE IS APPROACHED.
STAGE 3
OCCASIONAL TOPPING CHARGE, ABOUT 1 PER 500H
TERMINATE CHARGE WHEN CURRENT < 3% OF RATED CURRENT
1.25/5
1.00/4
0.75/3
0.50/2
0.25/1
CURRENT/VOLTAGE (A / V)
1
2
3
TIME (HRS)

FIGURE 8



FIGURE 9

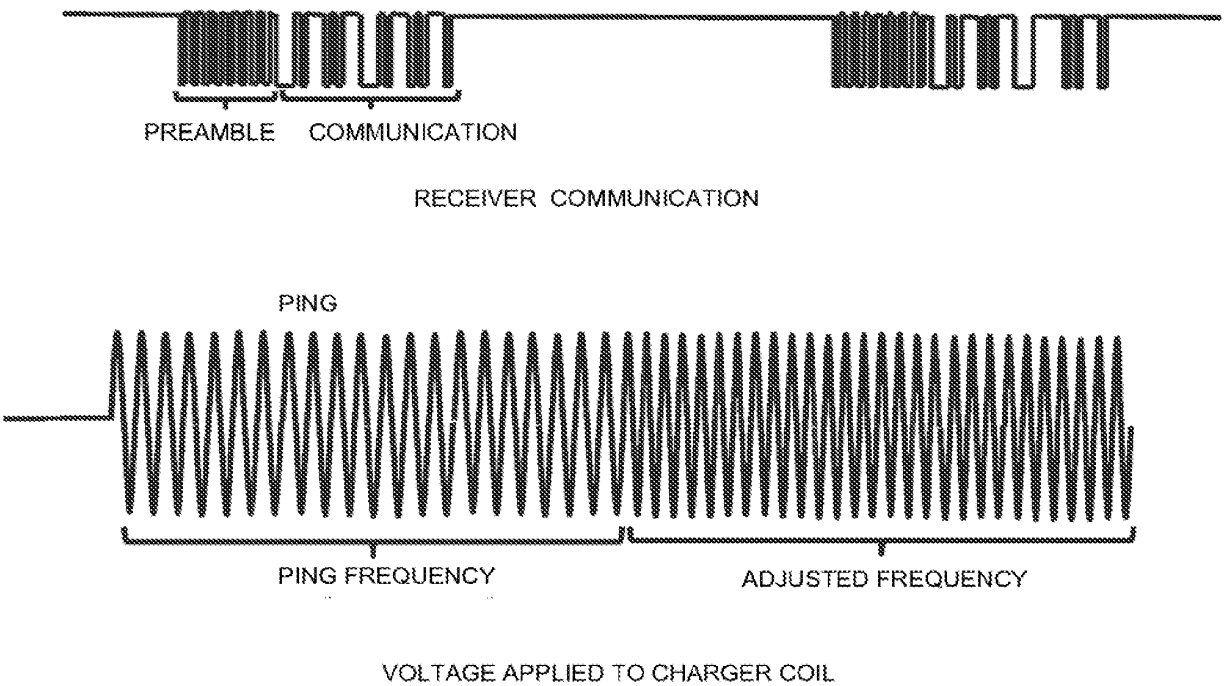


FIGURE 10

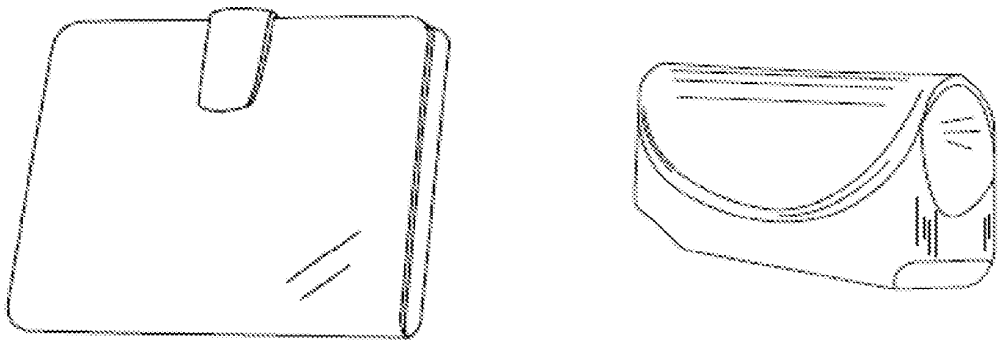


FIGURE 11

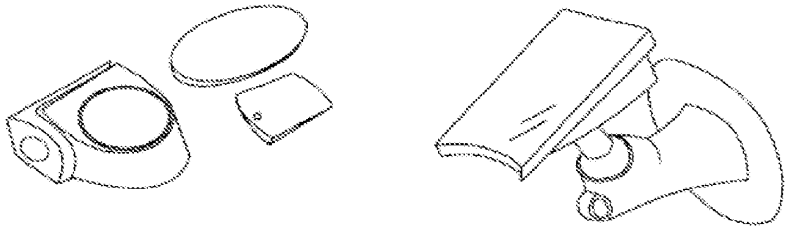
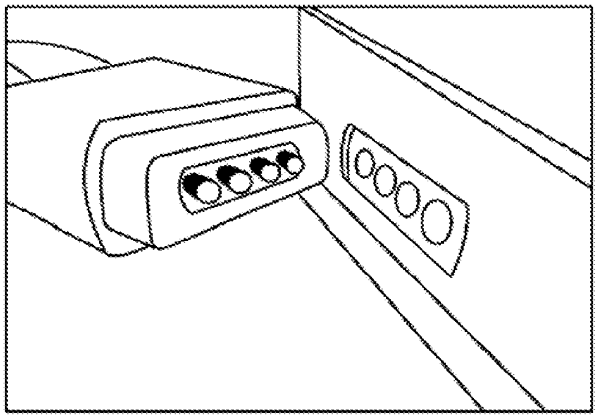


FIGURE 12



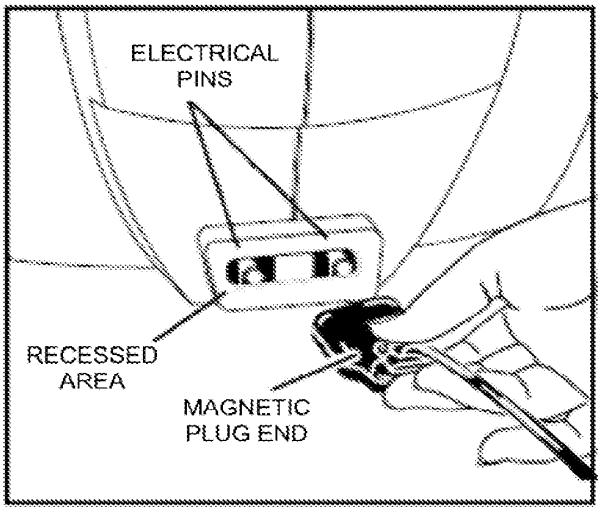
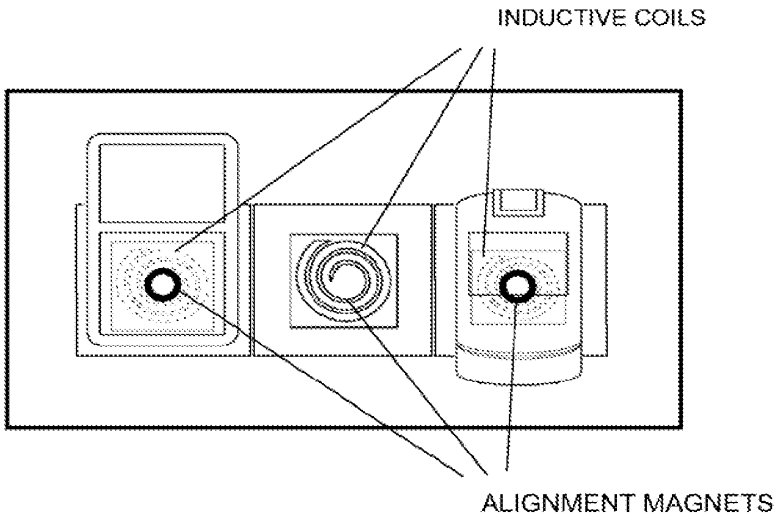


FIGURE 13


INDUCTIVE COILS
ALIGNMENT MAGNETS

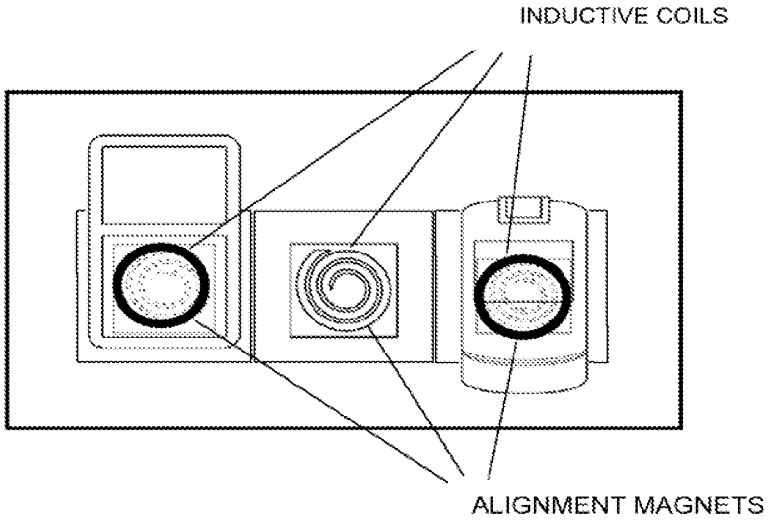

INDUCTIVE COILS
ALIGNMENT MAGNETS

FIGURE 14

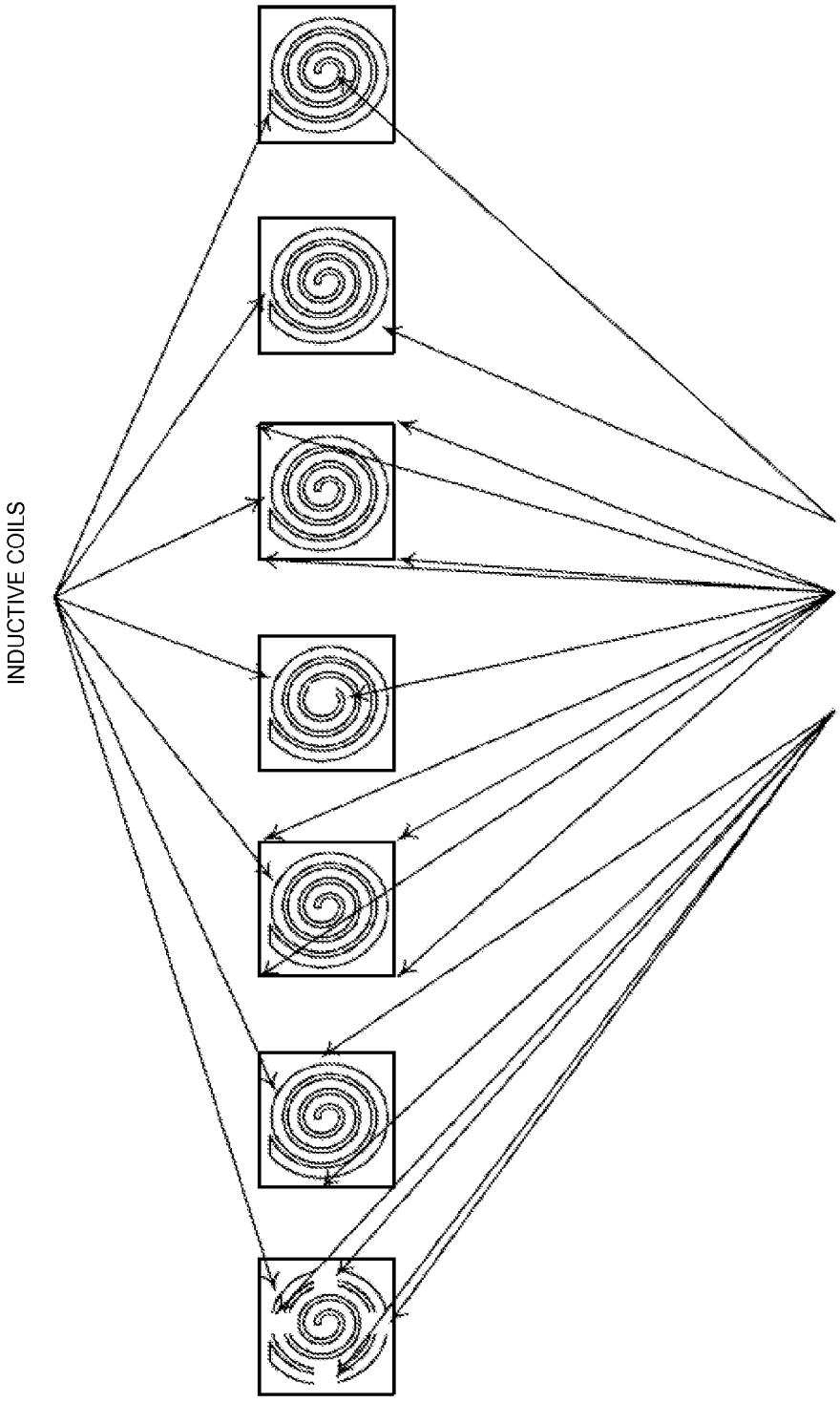


FIGURE 15

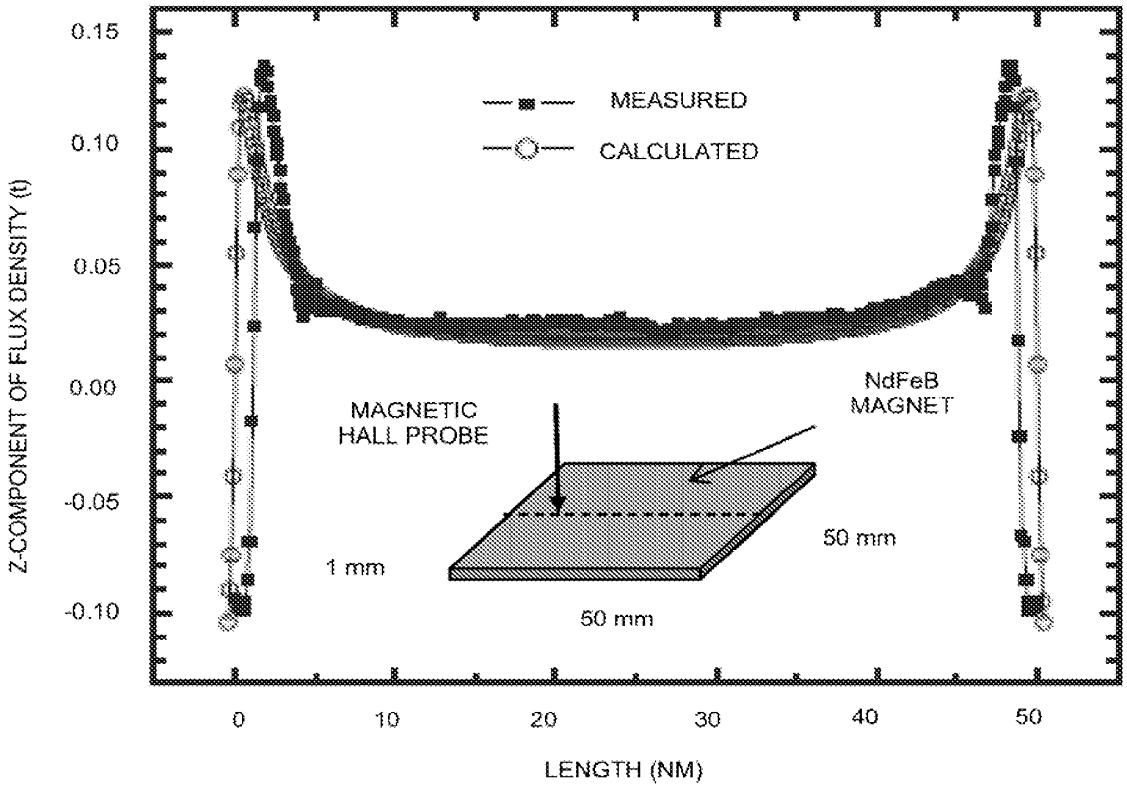

0.15
0.10
0.05
0.00
-0.05
-0.10
Z-COMPONENT OF FLUX DENSITY (t)
MEASURED
CALCULATED
MAGNETIC
HALL PROBE
NdFeB
MAGNET
1 mm
50 mm
50 mm
0
10
20
30
40
50
LENGTH (NM)

FIGURE 16

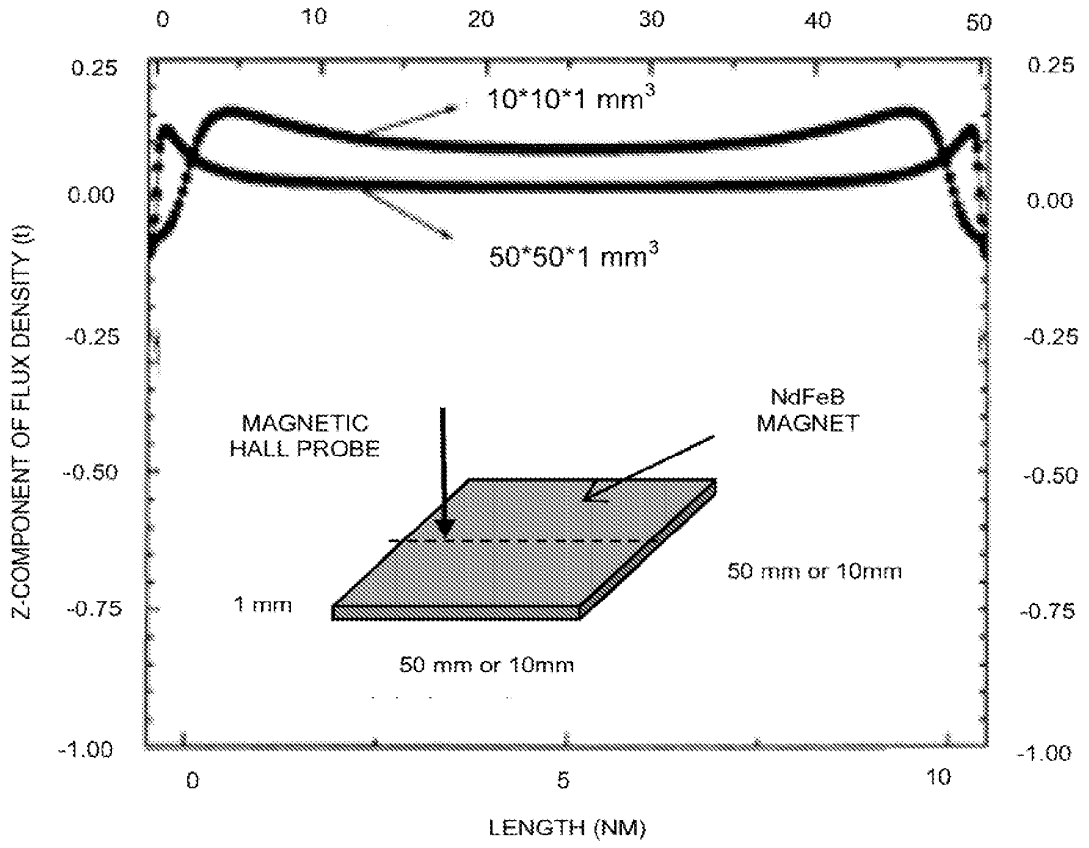

0
10
20
30
40
50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Z-COMPONENT OF FLUX DENSITY (t)
10*10*1 mm3
50*50*1 mm3
MAGNETIC HALL PROBE
NdFeB MAGNET
1 mm
50 mm or 10mm
50 mm or 10mm
0
5
10
LENGTH (NM)

FIGURE 17

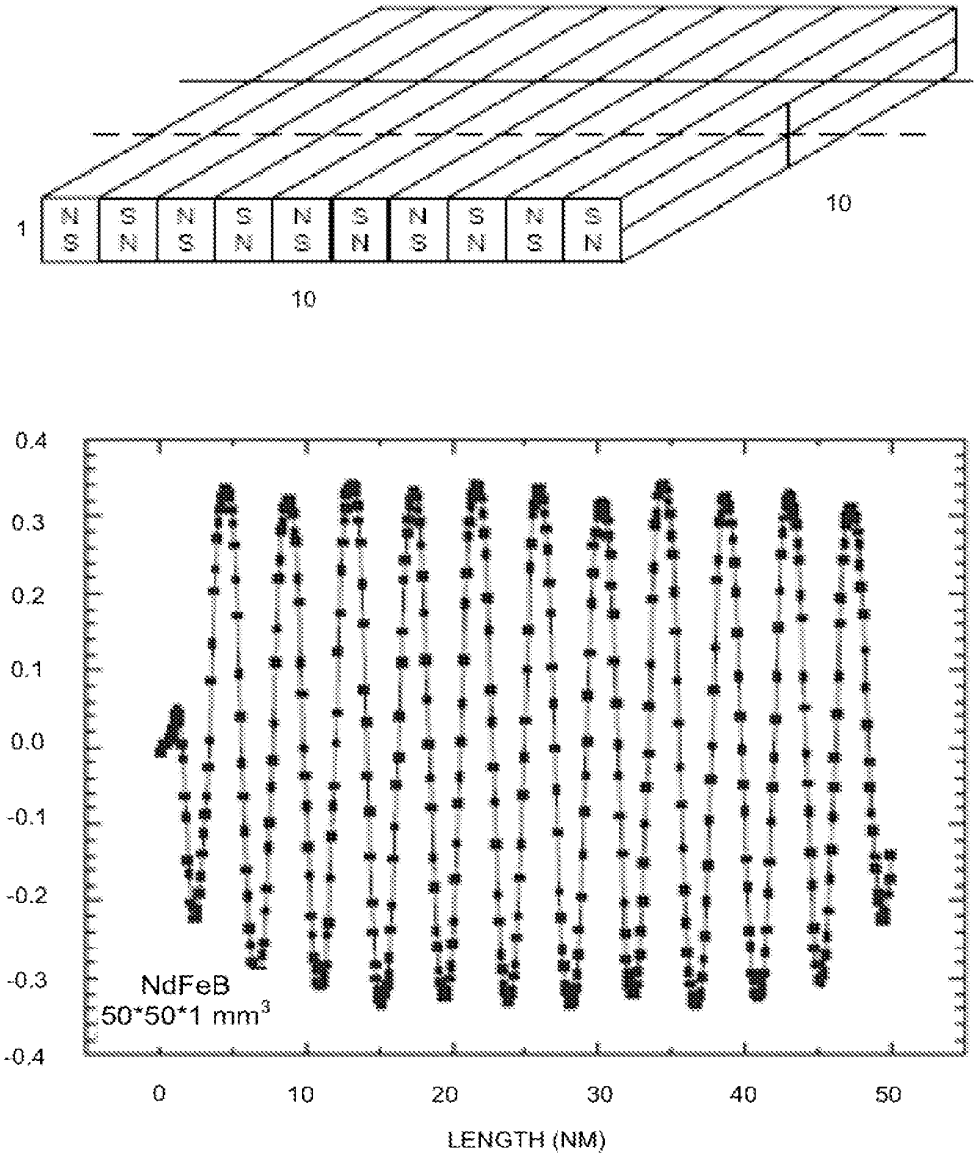
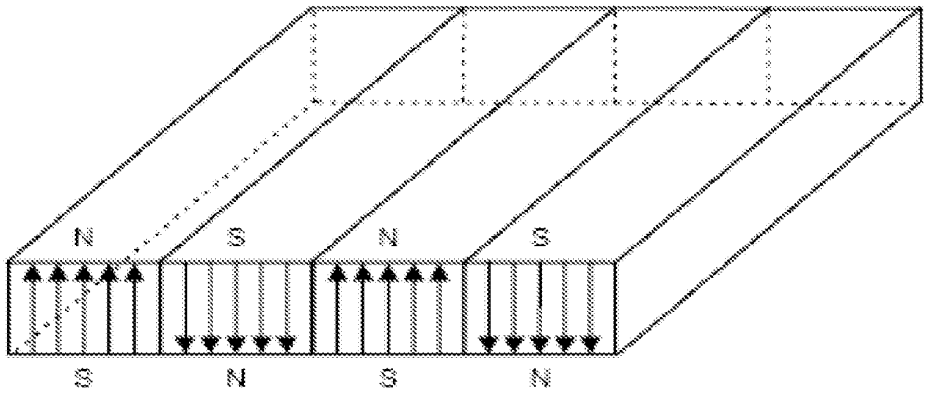

1
10
10
N S N S N S N S N S
S N S N S N S N S N
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
Z-COMPONENT OF FLUX DENSITY (t)
NdFeB
50*50*1 mm3
0
10
20
30
40
50
LENGTH (NM)

FIGURE 18


N
S
N
S
S
N
S
N

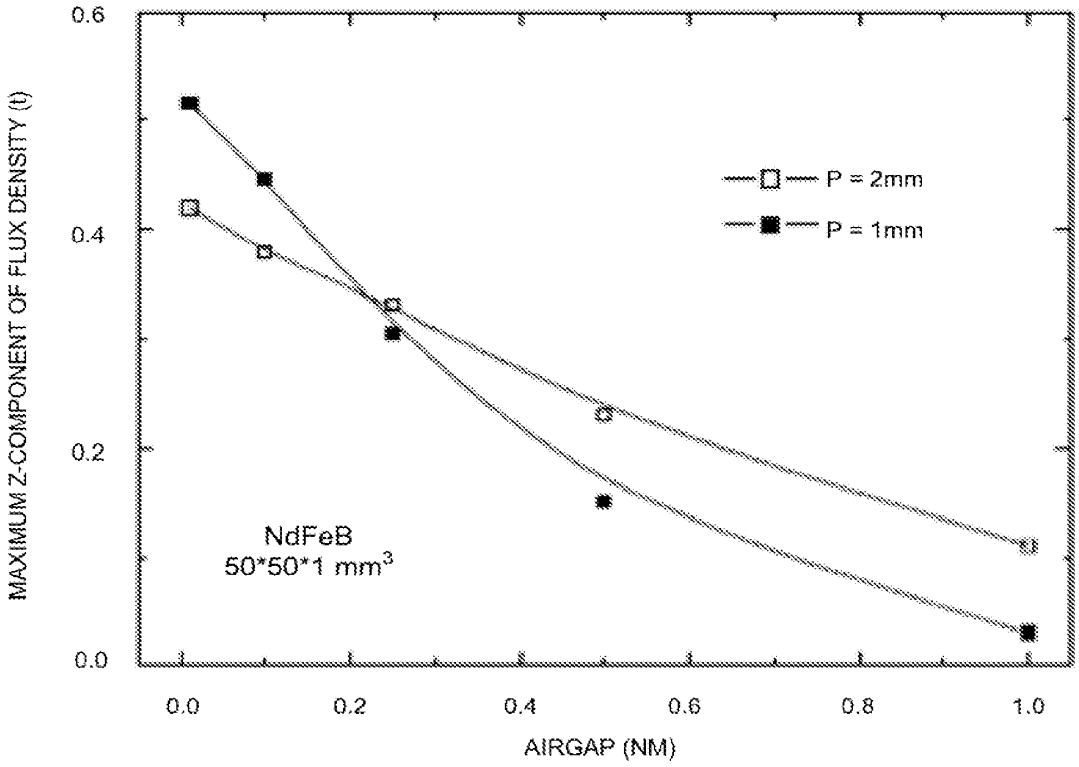

MAXIMUM Z-COMPONENT OF FLUX DENSITY (t)
0.6
0.4
0.2
0.0
P = 2mm
P = 1mm
NdFeB
50*50*1 mm3
0.0
0.2
0.4
0.6
0.8
1.0
AIRGAP (NM)

FIGURE 19

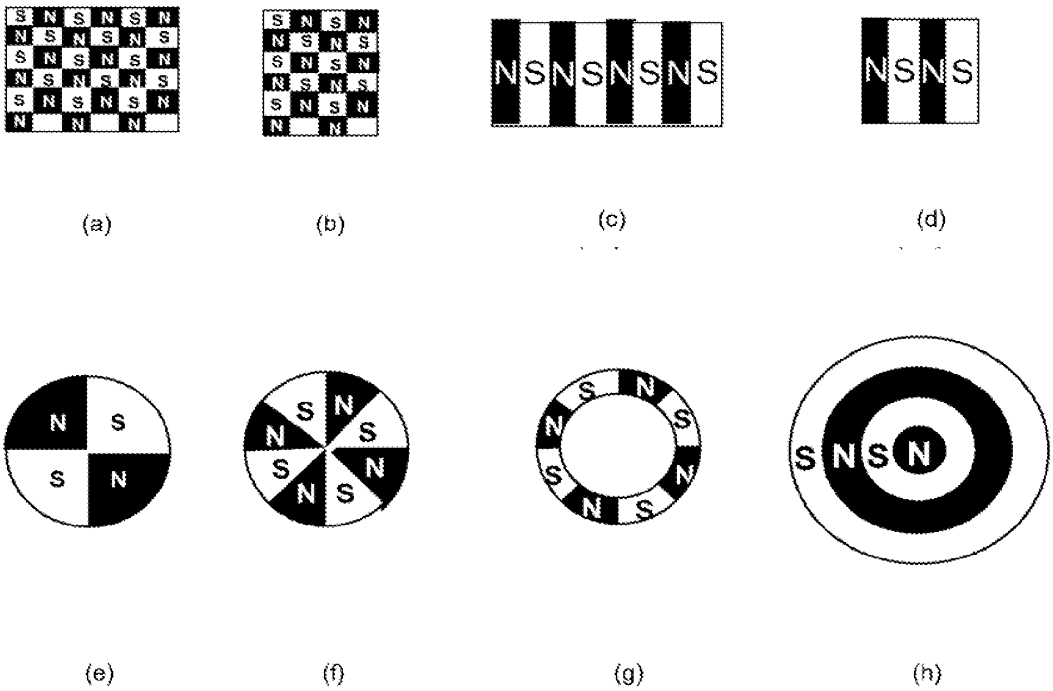


FIGURE 20



FIGURE 21

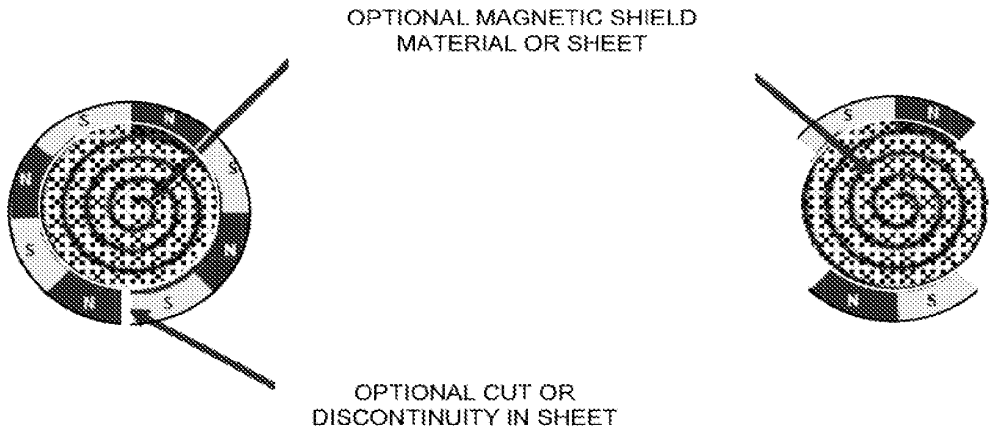


FIGURE 22

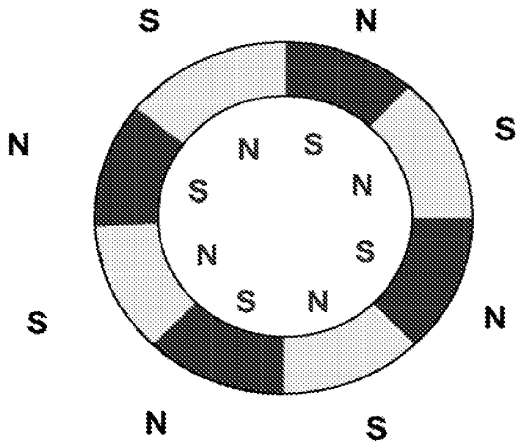


FIGURE 23

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference AFPA01035WO0	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2013/033352	International filing date *(day/month/year)* 21 March 2013	(Earliest) Priority Date *(day/month/year)* 21 March 2012
Applicant MOJO MOBILITY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☒ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 30

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/033352

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1 ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 17-18
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/033352

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/00 (2013.01)
USPC - 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B60L1/00, 11/18; H01F 5/00, 38/14; H02J 7/00, 7/02, 17/00 (2013.01)
USPC - 307/10.1, 104; 310/49.03; 320/107, 108, 110, 137

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - H01F38/14; H02J7/025, 17/00 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Google Scholar, Google Patents, Patbase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	WO 2011/156768 A2 (PARTOVI) 15 December 2011 (15.12.2011) entire document	1-12,15,16,19-23,25-32, 34-62 --- 13,14,24,33,81
X -- Y	US 2011/0050164 A1 (PARTOVI et al) 03 March 2011 (03.03.2011) entire document	63-75,77-80,82-84 --- 13,14,76,81
Y	US 2009/0167449 A1 (COOK et al) 02 July 2009 (02.07.2009) entire document	24,33,76
A	US 2008/0067874 A1 (TSENG) 20 March 2008 (20.03.2008) entire document	1-16, 19-84

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2013	14 JUN 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

Electronic Acknowledgement Receipt	
EFS ID:	17266762
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Nancy McElrath
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	30-OCT-2013
Filing Date:	17-JAN-2012
Time Stamp:	17:32:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	9_Tang_CorelessPrintedCircuit_431_437.pdf	187092 301c18c923cdfd300c965db3b5ef176712c91893	no	7
Warnings:					
Information:					

2	Non Patent Literature	10_Tang_CorelessPrintedCircuitPCBHighPower_943_944.pdf	750755 c5e024179a17cebb7822816d05f92e2f4585297a	no	2
Warnings:					
Information:					
3	Non Patent Literature	11_Borenstein_ManTriesWirelessly.pdf	1029959 9e4225b08d57ac86d512c04e827aba975006fee7	no	5
Warnings:					
Information:					
4	Non Patent Literature	12_Murph_WildChargerCharges.pdf	561375 952e506f6026fa2dd5e3efc3eb32ff2f6edcdac8	no	2
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5	Non Patent Literature	13_GizmoWatch_PitstopATableTop.pdf	969383 761d39ca8bbe61e3e56950f79dd2d6c5591060d5	no	5
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6	Non Patent Literature	14_UNKNOWN_CuttingtheCord.pdf	644513 15d981c7a9ea26ae9b3d0d64830ad161f20cfcca	no	1
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Information:					
7	Non Patent Literature	15_Bishop_MicrosoftSurfaceBrings.pdf	2120129 9d9d5682c1867aa36629160098bd4effe166c00b	no	7
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8	Non Patent Literature	16_Wildcharge_TheWireFeePower.pdf	631639 7d8a2c2f704879d7d3e2a19fa80dbaf940812a4d	no	3
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Information:					
9	Non Patent Literature	17_Economist_ScienceTechnologyQuarterly.pdf	170581 b507140b3cc33473ed16fec384d5134486b72ff8	no	4
Warnings:					
Information:					
10	Foreign Reference	1_WO_03_096512.pdf	3229279 cf9b92db37b18bb7fdeac04719a829a5868e6482	no	76
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Information:					

11	Foreign Reference	2_WO_03_105308.pdf	2477398 0fb0b8a5c39c80e4fedff67a5bccfcfa4e442f6a	no	71
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Information:					
12	Foreign Reference	3_WO_2005_109598.pdf	2225633 d7e03b5f8bc909b1b6e00c7b73dbab56c69cc289	no	48
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13	Non Patent Literature	1_Hui_ANewGenerationUniversalContactless_Vol_20.pdf	1886008 9d93835c70ae702d796f696cccd5d618d5a5e0af	no	8
Warnings:					
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14	Non Patent Literature	2_Tang_EvaluationoftheShieldingEffects_Vol_17.pdf	1945501 1a81a711164d3ab6c30a6f26fc6469e93ae90761	no	9
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15	Non Patent Literature	3_Liu_AnAnalysisOFaDoubleLayer_1767_1772.pdf	472541 21e561819c5feca1e4084f8a8d76048065e25d5f	no	6
Warnings:					
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16	Non Patent Literature	4_Liu_EquivalentCircuitModeling_21_29.pdf	1161060 152e01f18326fba244c8acbfa392e519c82fef7d	no	9
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17	Non Patent Literature	5_Liu_SimulationStudyExperimentalVerification_2202_2210.pdf	5774958 c97610f5804ce23270dc91d27cf742b3f45a432a	no	9
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18	Non Patent Literature	6_Liu_OptimalDesignHybridWinding_455_463.pdf	1371272 c7c29b4ecd22e0426cae15d66777430170b24af2	no	9
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19	Non Patent Literature	7_Karalis_EfficientWirelessNonRadiative_34_48.pdf	1163088 5d1d6fb25a4775e06cb2b0ef043e2b0c4fddadc6	no	15
Warnings:					
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20	Non Patent Literature	8_Su_MutualInductanceCalculation_1115_1124.pdf	1105315 6ab51bce94ae2edf79cbfe48f41a798da4490680	no	10
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21	Non Patent Literature	9_Hui_CorelessPrintedBoardPCBTransformer_Vol_11.pdf	3548540 7e13fc24eec9db97157b0b40a7118891cac9000e	no	48
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Information:					
22	Non Patent Literature	10_Sekitani_ALargeAreaFlexible_4-pgs.pdf	981879 5a3e3eef544f49cc3295d8dc5a20e1ab5d8342ec	no	4
Warnings:					
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23	Non Patent Literature	11_Choi_ANewcontactlessBatteryCharger_2001_p58_p59.pdf	550852 a09e315c8520b7ad0ab354b233e046627649faa9	no	2
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Information:					
24	Non Patent Literature	12_Hui_CorelesPCBTranformersForPowerMOSFET_Vol_14.pdf	251752 3b70bc785c7190850daa6a96d8d5237e14bfd3a0	no	9
Warnings:					
Information:					
25	Non Patent Literature	13_Tang_CorelessPlanarPCBTransformers_Vol_15.pdf	278020 011dd10bc600716609abc60f5aca7c1ccd50eefb	no	11
Warnings:					
Information:					
26	Non Patent Literature	14_Hatanaka_PowerTransmissionofaDesk_Vol_38.pdf	202370 091c04ce927a3cc977665da882451bbf8f01734b	no	3
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Information:					
27	Non Patent Literature	15_Fernandez_DesignIssuesofaCorelessTtransformer_2002.pdf	1813896 82d6336b12bbb0f93c4591d0b1ab8f03b1d64312	no	7
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28	Non Patent Literature	16_Hui_ANewGenerationUniversalContactless_Vol_20.pdf	1886008 19006ed487b7219e6974239bbec800813bec8689	no	8
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Information:					

29	Non Patent Literature	17_Liu_OptimalDesignofaHybridWinding_2006_p2568_p2575.pdf	453729 f27133e34ef11cb5ce1558456e70d423cc3368d8	no	8
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30	Non Patent Literature	18_Topfer_MultiPoleMagnetization_2004_p257_p263.pdf	1677408 df11d9be7f21589c4b2d107e5c220d4fed46e20d	no	7
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31	Non Patent Literature	19_Topfer_MultiPoleMagnetization_2004_p124_p129.pdf	470348 3adc88e488e6fcf7a25d97bbbabc75f9b6db86f4	no	6
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32	Non Patent Literature	20_Sakamoto_ANovelHighPowerConverter_p4755_p4757.pdf	656330 15706c4727c2b84d02371eb5e397c161573eb293	no	3
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Information:					
33	Non Patent Literature	21_Hui_SomeElectromagneticAspectsOfCoreless_Vol_15.pdf	148793 84ee1ee600645f5c0a8258600a7a5bba4977699b	no	6
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34	Non Patent Literature	22_Waffenschmidt_LimitationofInductivePowerTransfer.pdf	797007 3e1a4773c6463c65c417df99b2a75f9e0f36b77a	no	10
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Information:					
35	Non Patent Literature	23_STOKES_PalmStrikesBack__Jan_2009_6_pgs.pdf	649691 2ee0570d8c9caed205fc11a61a4b79d8c796908e	no	6
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36	Non Patent Literature	24_SULLIVAN_WireFreeTechnology_2006_2_pgs.pdf	399740 e81126061c2005a2bc0b1a0174e19b3b8d47076d	no	2
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37	Non Patent Literature	25_KIM_WirelessChargerNewPalmPhone.pdf	1037194 306c49bd6ce4a78da453f9b5e74df7749076251e	no	2
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38	Non Patent Literature	26_Compeau_REDZENMARKETING_CouldThisBetheMojo_Jun_5_2009.pdf	330280 2c87e7e12846dd561062a754fcef5d39b1f506d0	no	3
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39	Non Patent Literature	27_Fulton_Innovation_ThePublicDebutECoupled.pdf	87375 e4f558d9444fcdf0b683f30115bebd685f0146c7	no	2
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40	Non Patent Literature	28_MILLER_PalmMayMakePreScarce_1_pg.pdf	221785 ca044225986f8408367cb21c9378c159177d48aa	no	1
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41	Non Patent Literature	29_MURAKAMI_ConsiderationCordlessPowerStation_Sep_1996_3_pgs.pdf	809537 590ec7bce90ef9d90eba98e2ee338c98366ef02d	no	3
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42	Non Patent Literature	30_Epson_airtrans_12_8_2008_2_pgs.pdf	165936 c3264db9b8c910f8da5ab766752cb534f601debe	no	2
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43	Non Patent Literature	31_Choi_ANewcontactlessBatteryCharger_2001_p58_p59.pdf	550852 26774168daa496cc8c27fb27fbc577acff6885f6	no	2
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44	Non Patent Literature	32_IPER_PCTUS_2010_032845_111011_AFPA1026WO0.pdf	196960 53d705cc44dbda3ff131b967d7306c44a3b104b0	no	7
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45	Non Patent Literature	33_wipower_11_18_2011_2_pgs.pdf	390390 d82f9a7f81083ebfe0ba2472dc9ac8df05a7dc1e	no	2
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46	Non Patent Literature	34_powerbyproxi_11_18_2011_2_pgs.pdf	193264 015b8d28e01ce4b77dfb88447e0a6818a18a8adf	no	2
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Information:					

47	Non Patent Literature	35_Now_Charge_Your_iPhone 4_powermat_2.pdf	231411 c0420725bb271ee0a30fab745b4b4a98c7963125	no	1
Warnings:					
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48	Non Patent Literature	36_witricity_11_18_2011.pdf	195011 daf0689a3e1446e0dc11f5b3cb0cee0ad062f9db	no	1
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49	Non Patent Literature	37_convenientpower_11_18_2 011_1_pg.pdf	73360 7a922d53179e2b130635ac4242aa534d78f67f8f	no	1
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50	Non Patent Literature	38_nigelpower_11_18_2011_2 _pgs.pdf	277184 f482924a8973b5315b5ba2299456b550cba74ff3	no	2
Warnings:					
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51	Non Patent Literature	39_haloipt_11_18_2011_1_pg. pdf	117203 442e745ff79f9a9cffd36ce005eff625be90ece2	no	1
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52	Non Patent Literature	40_qualcomm_11_18_2011_5_ pgs.pdf	599927 a817cc822dca670e5aa7482632756707dc8a6c2d	no	5
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53	Foreign Reference	JP_2006_246633.pdf	1141077 bec37e0f9bc57948284bbe0392fe2f38c4c8221c	no	24
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54	Foreign Reference	WO_2011_156768_A2.pdf	2682290 bd2b215ceb912b7b6021217822569cb684b5bfc8	no	49
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55	Non Patent Literature	ISR_PCTUS_2013_033352_061 413_AFPA1035WO0.pdf	176468 fe23b844c4a0fc80fdd6c63f92378d1ea9f59cfe	no	3
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Total Files Size (in bytes):	54121346

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0	4453

23910 7590 09/11/2013

FLIESLER MEYER LLP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

EXAMINER	
FANTU, YALKEW	
ART UNIT	**PAPER NUMBER**
2859	

NOTIFICATION DATE	DELIVERY MODE
09/11/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

officeactions@fdml.com
pctoa@fdml.com

Office Action Summary	Application No. 13/352,096	Applicant(s) PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	Art Unit 2859	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01/17/2012*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-39* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-39* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *5/30/2012* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some * c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

1. The instant application with Application Number 13/352,096 filed on 01/17/2012 is presented for examination. Claims 1-39 are pending.

OBJECTION

2. **Claims 1- 5, 7-11, 13-21** are objected to because; on claim 1, line 1; claim 2, line number 4; claim 3, line number 3; claim 4, line number 1, the phrases " … and/or ... are not clear whether the limitation that follows the term is alternative use or must be included all the list in the claims. Claims 7—11, 13—21, etc. show similar phrases that need to be corrected. Claim 5, line number 3 shows a one side bracket followed by comma seems a typographical error. Claim 26, on the last line, the phrase "... capabilities/function can be added as needed..." is unclear whether the recited limitation is an assumption or backed by facts.

The above are but a few specific examples of indefinite and functional or operational language used throughout the claims, and are only intended to illustrate the extensive revision required to overcome the objection made in this office action. The above-mentioned corrections therefore, are in no way a complete and thorough listing of every indefinite and functional or operational language used throughout the claims. Applicant is required to revise all of the claims completely, and not just correct the indefinite and functional or operational language mentioned.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-39 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Partovi (US 2007/0182367).

3. **With respect to claims 1, 29 and 38**, Partovi discloses a system for use in charging and/or powering one or more devices and/or batteries by wireless power **(Figs. 1-26)**, comprising: one or more components including a ferromagnetic, ferrite, or other magnetic material or layer, which are used to modify the magnitude and/or phase of an electromagnetic field in one or multiple dimensions **(Fig. 2, 120 and 160; figs. 1-4 and 15)**.

4. **With respect to claims 2 and 30,** Partovi discloses wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within one or more wireless chargers or power supplies and/or the electronics, coils, magnetic material, or magnets therein **(Figs. 2, 112)**, and/or one or more wireless power receivers and/or the electronics, coils, magnetic materials, or magnets therein **(Fig. 2, 114)**; and used in charging or powering the one or more devices and/or batteries **(Para. # 0050 and 0051)**.

5. **With respect to claims 3 and 31,** Partovi discloses wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is

used to provide a degree of position independence in charging or powering the one or more devices and/or batteries **(Para. # 0060)**.

6. **With respect to claims 4 and 32,** Partovi discloses wherein the modifying the magnitude and/or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area **(Para. # 0058 and 0059)**.

7. **With respect to claim 5,** Partovi discloses wherein the ferromagnetic, ferrite, or other magnetic material or layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron), carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof **(Para. # 0013)**.

8. **With respect to claims 6 and 33,** Partovi discloses , wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed **(Fig. 10, SW 268; Para. # 0110-0117)**.

9. **With respect to claims 7 and 34,** Partovi discloses wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer

through application of one or more DC and/or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof **(Para. # 0096)**.

10. **With respect to claims 8 and 35,** Partovi discloses wherein the permanent magnet and/or electromagnet is incorporated behind, in front, around or at the center of the receiver and/or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed **(See Figs, 1, and 3-4)**.

11. **With respect to claims 9 and 36,** Partovi discloses, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC and/or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer **(Para. # 0013; Figs. 11 and 17)**.

12. **With respect to claims 10, 11 and 37,** Partovi discloses, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices and/or batteries by wireless power **(Para. # 0096);** the power at the devices and/or batteries charged or powered by

wireless power is unregulated or regulated at wireless power receivers connected to the devices and/or the batteries **(Para. # 0081 and 0082)**.

13. **With respect to claim 12,** Partovi discloses, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the receivers or a combination thereof **(Para. # 0081; see also Fig. 11)**.

14. **With respect to claims 13 -16** Partovi discloses, wherein the power at the devices and/or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, and power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters **(Para. # 0070)**.

15. **With respect to claim 17** Partovi discloses, wherein the chargers and/or receivers include one or more microcontrollers or programmable parts and/or memory **(Fig. 11, 204 (MCU2); Para. # 0125)**.

16. **With respect to claim 18,** Partovi discloses wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil and/or load modulation or through an RF or optical link or through RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), etc. or through the Wireless Power Consortium (WPC) or other protocols or standards,

developed for wireless power, or other communication protocols, or combination thereof **(Para. # 0125)**.

17. **With respect to claim 19,** Partovi discloses wherein the presence of the one or more receivers is detected by the one or more chargers and/or power supplies and/or causes a change in the operating behavior or characteristics of the chargers and/or power supplies **(Para. # 0049)**.

18. **With respect to claim 20,** Partovi discloses wherein, the chargers and/or receivers may consist of one set of electronics and/or coils or several sets of similar or dissimilar electronics and/or coils to provide flexibility in wirelessly charging devices and/or batteries at different voltages, powers, current levels, geometries or functions and/or communication and regulation or detection protocols **(See Figs. 2-5; Para. # 0060)**.

19. **With respect to claim 21,** Partovi discloses wherein, the chargers and/or receivers may include shielding materials such as ferromagnetic or other magnetic materials and/or metal or other conductive layers, and/or thin metal layers covering a portion or all of the charger and/or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system **(Para. # 0040 and 0086)**.

20. **With respect to claims 22-24 and 39,** Partovi discloses, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system and wherein one or more repeater antennas or coils and/or one or more ferrite or ferromagnetic or magnetic material or switching

layers and optionally magnets and/or electromagnets are used to extend the range between the charger and receiver while controlling the emissions **(Para. # 0080)**.

21. **With respect to claim 25,** Partovi discloses, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, etc., airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, etc., cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, etc., industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system **(Para. # 0096)**.

22. **With respect to claim 26,** Partovi discloses, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary (non-rechargeable) or rechargeable battery, solar cell, fuel cell, mechanical (hand crank, wind source, etc.), nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities/functions can be added as needed **(Para. # 0014; Fig. 18, 356)**.

23. **With respect to claim 27,** Partovi discloses, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products **(Para. # 0096)**.

24. **With respect to claim 28,** Partovi discloses, wherein the receiver and/or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device etc. to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or

packaging to display promotional information or instructions, or to illuminate **(Para. # 0061)**.

Conclusion

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The prior art disclosed in PTO 892 and not used above disclose related apparatus and method.

a. Park et al US 2002/0089305 discloses contactless battery charger.

b. WON et al. US 2011/0221391 discloses method of wireless charging.

c. Hui US 2007/0029965 discloses inductive battery charging.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to YALKEW FANTU whose telephone number is (571)272-8928. The examiner can normally be reached on M-F: 7 - 4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, DREW A. DUNN can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/YALKEW FANTU/
Primary Examiner, Art Unit 2859

Notice of References Cited	Application/Control No. 13/352,096	Applicant(s)/Patent Under Reexamination PARTOVI, AFSHIN	
	Examiner YALKEW FANTU	Art Unit 2859	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,889,384 A	03-1999	Hayes et al.	320/108
*	B	US-2002/0089305 A1	07-2002	Park et al.	320/108
*	C	US-2007/0029965 A1	02-2007	Hui, Ron Shu-yuen	320/112
*	D	US-2007/0182367 A1	08-2007	Partovi, Afshin	320/108
*	E	US-2007/0279002 A1	12-2007	PARTOVI, AFSHIN	320/115
*	F	US-2009/0096413 A1	04-2009	Partovi et al.	320/108
*	G	US-2010/0207771 A1	08-2010	Trigiani, Antonio	340/636.1
*	H	US-2011/0187318 A1	08-2011	Hui et al.	320/108
*	I	US-2011/0221387 A1	09-2011	Steigerwald et al.	320/108
*	J	US-2011/0221391 A1	09-2011	WON et al.	320/108
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	L	US-			
	M	US-			

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	S					
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NON-PATENT DOCUMENTS

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	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	Art Unit
	YALKEW FANTU	2859

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320	108	9/5/2013	YF

SEARCH NOTES		
Search Notes	Date	Examiner
320/109,139,150;455/all with text search was conducted	9/5/2013	YF
Inventor's search in PALM and eDAN was conducted	9/5/2013	YF
EAST Search (See Printout)	9/5/2013	YF
Related applications search was conducted	9/5/2013	YF

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/YALKEW FANTU/ Primary Examiner.Art Unit 2859

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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S49	61	((XIAO-GUANG) near2 (SU)).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2013/06/03 11:11
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S53	857	S52 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S54	76	S53 and (slide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S55	157	S53 and (@pd<"20090619")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S56	17	S54 and S55	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S57	415	320/139.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11

S58	42	S57 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
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S60	4	S59 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S61	202	S59 and (slide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
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S63	170	336/dig.2	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S64	99	S63 and (inductive or wireless)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
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S66	1016	S52 and (cellphone or phone or mobile or pda)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S67	440	S66 and (inductive)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11

S68	143918	"455"/$.ccls. and (telephone or mobile)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
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S70	143918	S69 and (telephone or mobile)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S71	98081	S70 and (inductive or wireless)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S72	916	S71 and (magnetic)(conductors)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S73	407	S72 and (upper or top)(lower or bottom)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S74	32	S73 and (induced near current)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S75	194	S73 and (@pd<"20090619")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S76	56	S75 and (induced current)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S77	37	(inductive near charger)(battery)(phone or telephone or mobile)(primary near secondary near coil)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11

S78	37	(inductive near charger)(battery)(phone)(primary near secondary near coil)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S79	66	(inductive near charger)(battery)(phone)(primary near secondary)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/03 11:11
S81	29	S52 and (inductive near charger)(base)(transmitter coil)(mobile or cell)(charge$3)(power)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2013/06/03 11:19
S83	9	S81 and (@pd<"20111012")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2013/06/03 11:21
S84	27	((AFSHIN) near2 (PARTOVI)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2013/06/03 13:42
S85	1656	320/108.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:23
S86	144	((KIM-YEUNG) near2 (SIP)).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2013/09/05 06:51
S87	61	((XIAO-GUANG) near2 (SU)).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2013/09/05 06:51
S88	644	320/115.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S89	6	("20020089305" | "5991170" | "6016046" | "6124700" | "7109682" | "7133703").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2013/09/05 06:51
S90	2879	320/108,109.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S91	1011	S90 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S92	82	S91 and (slide)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	AND	OFF	2013/09/05 06:51

			JPO; DERWENT; IBM_TDB			
S93	167	S91 and (@pd<"20090619")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S94	17	S92 and S93	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S95	462	320/139.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S96	47	S95 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S97	1673	310/50.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S98	4	S97 and (inductive or wireless)(cell or phone)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S99	202	S97 and (slide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S100	7	S99 and (inductive)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S101	170	336/dig.2	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S102	99	S101 and (inductive or wireless)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	AND	OFF	2013/09/05 06:51

			JPO; DERWENT; IBM_TDB			
S103	7	S102 and (slide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S104	1245	S90 and (cellphone or phone or mobile or pda)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S105	496	S104 and (inductive)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S106	160118	"455"/$.ccls. and (telephone or mobile)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S107	238298	"455"/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S108	160118	S107 and (telephone or mobile)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S109	107948	S108 and (inductive or wireless)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S110	971	S109 and (magnetic)(conductors)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S111	425	S110 and (upper or top)(lower or bottom)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S112	33	S111 and (induced near current)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	AND	OFF	2013/09/05 06:51

			JPO; DERWENT; IBM_TDB			
S113	194	S111 and (@pd<"20090619")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S114	56	S113 and (induced current)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S115	37	(inductive near charger)(battery)(phone or telephone or mobile)(primary near secondary near coil)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:51
S118	35	S90 and (inductive near charger)(base)(transmitter coil)(mobile or cell)(charge$3)(power)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2013/09/05 06:51
S119	9	S118 and (@pd<"20111012")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2013/09/05 06:51
S120	28	((AFSHIN) near2 (PARTOVI)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2013/09/05 06:51
S121	1776	320/109,139.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/09/05 06:54
S122	28	((AFSHIN) near2 (PARTOVI)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2013/09/05 06:55
S123	28	((AFSHIN) near2 (PARTOVI)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2013/09/05 10:07
S124	4	US-7336002-$.DID. OR US-1331018-$.DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2013/09/05 11:31

9/5/2013 1:45:56 PM
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BIB DATA SHEET

CONFIRMATION NO. 4453

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/352,096	01/17/2012	320	2859	AFPA-01032US0

APPLICANTS

Afshin Partovi, Sunnyvale, CA;

**** CONTINUING DATA ***************************

This appln claims benefit of 61/433,883 01/18/2011
and claims benefit of 61/546,316 10/12/2011
and claims benefit of 61/478,020 04/21/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

01/27/2012

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /YALKEW FANTU/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	32	39	3

ADDRESS

FLIESLER MEYER LLP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133
UNITED STATES

TITLE

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

FILING FEE RECEIVED		
2520	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	YALKEW FANTU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/05/2013								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
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	32	✓								
	33	✓								
	34	✓								
	35	✓								
	36	✓								

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13352096	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	YALKEW FANTU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/05/2013								
	37	✓								
	38	✓								
	39	✓								

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0

CONFIRMATION NO. 4453

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

PUBLICATION NOTICE

OC000000056649497

Title:SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Publication No.US-2012-0235636-A1
Publication Date:09/20/2012

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/352,096

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	380
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	620
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	39 minus 20 =	* 19			OR	x 60 =	1140
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 250 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2390

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/352,096	01/17/2012	2816	2520	AFPA-01032US0	39	3

CONFIRMATION NO. 4453

UPDATED FILING RECEIPT

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

OC000000054654339

Date Mailed: 06/12/2012

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Afshin Partovi, Sunnyvale, CA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/433,883 01/18/2011
and claims benefit of 61/546,316 10/12/2011
and claims benefit of 61/478,020 04/21/2011

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 01/27/2012

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/352,096**

Projected Publication Date: 09/20/2012

Non-Publication Request: No

Early Publication Request: No

Title

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Preliminary Class

327

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/352,096

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	380
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	620
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	39 minus 20 =	* 19			OR	x 60 =	1140
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 250 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2390

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/352,096	01/17/2012	2816	2520	AFPA-01032US0	39	3

CONFIRMATION NO. 4453

UPDATED FILING RECEIPT

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

OC000000054654339

Date Mailed: 06/06/2012

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Afshin Partovi, Sunnyvale, CA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/433,883 01/18/2011
and claims benefit of 61/546,316 10/12/2011
and claims benefit of 61/478,020 04/21/2011

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 01/27/2012

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/352,096**

Projected Publication Date: Perfected

Non-Publication Request: No

Early Publication Request: No

Title

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Preliminary Class

327

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION	
Inventor(s):	Afshin Partovi	Art Unit:	2816
Appl. No.:	13/352,096	Examiner:	Unknown
Confirm. No.:	4453		
Filed:	01-17-2012		
Title:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	Customer No.:	23910

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that my residence, mailing address and citizenship are as stated below next to my name. I believe that I am the original, first and sole inventor (if one name is listed below), or first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

the specification of which (check applicable ones):

_____ is filed herewith;

__✓__ was filed with the above-identified "Filed" date and "Appl. No."

_____ was amended on (or amended through) _____.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose information which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

(1) Full name of sole
or first inventor: Afshin Partovi

(1) Residence: 1063 Morse Avenue, #5-100
Sunnyvale, CA 94089

(1) Mailing Address: Same as above

(1) Citizenship: US

(1) Inventor's signature: AP

(1) Date: 5/29/2012

****

Title 37, Code of Federal Regulations, §1.56

SECTION 1.56. DUTY TO DISCLOSE INFORMATION MATERIAL TO PATENTABILITY

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98.* However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

* §§1.97(b)-(d) and 1.98 relate to the timing and manner in which information is to be submitted to the Office.

PTO/SB/22 (09-11)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARMENT OF COMMERCE
Under the paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) AFPA-01032US0
Application Number 13/352,096	Filed 01-17-2012
For SYSTEMS AND METHOD FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	
Art Unit Unknown	Examiner Unknown

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$150	$75	$
☑ Two months (37 CFR 1.17(a)(2))	$560	$280	$ 560
☐ Three months (37 CFR 1.17(a)(3))	$1270	$635	$
☐ Four months (37 CFR 1.17(a)(4))	$1980	$990	$
☐ Five months (37 CFR 1.17(a)(5))	$2690	$1345	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 06-1325.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration Number 45445

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

/Karl F. Kenna/ — Signature
May 30, 2012 — Date
Karl F. Kenna — Typed or printed name
415-362-3800 — Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Attorney Docket No.: AFPA-01032US0
kfk/afpa/1032us0/afpa_1032us0_PetitionExtensionTime.pdf

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

1/32

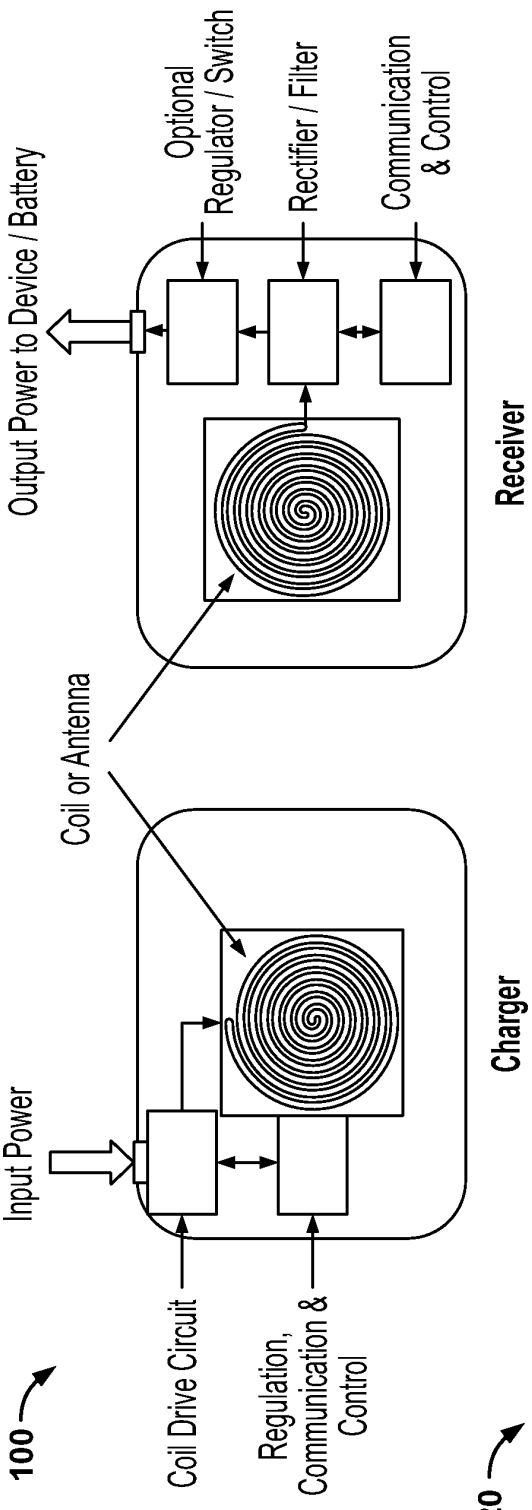


FIG. 1

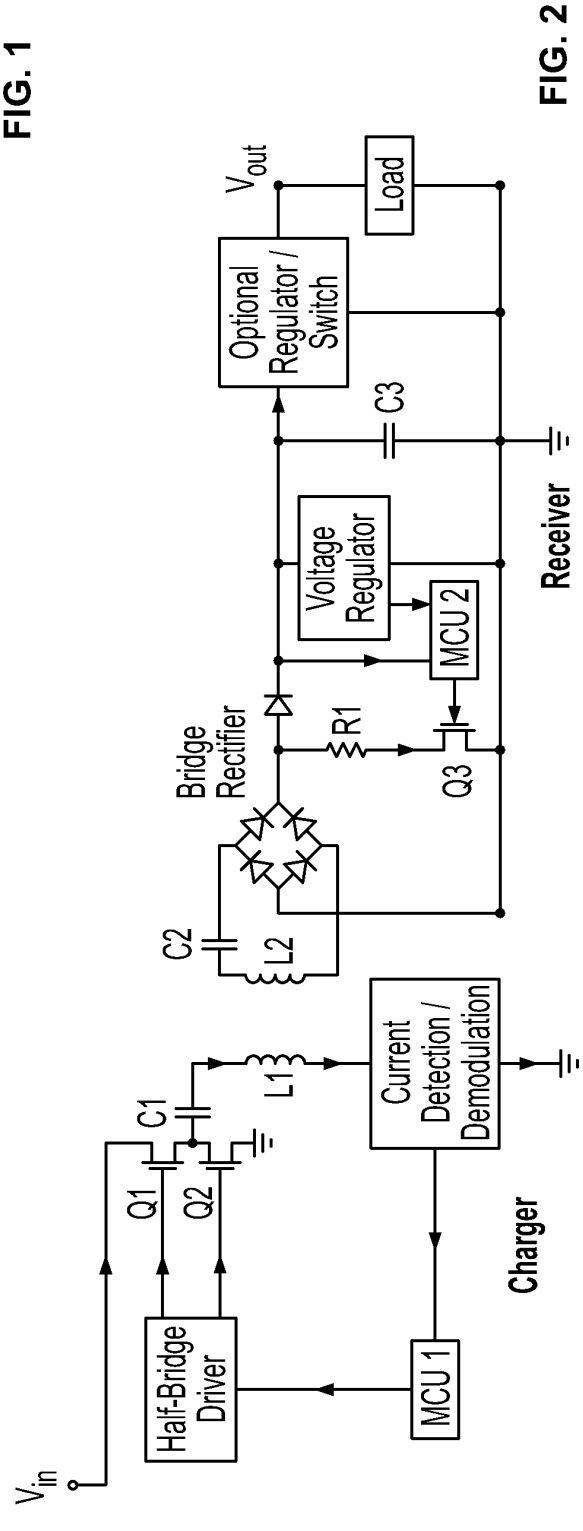


FIG. 2

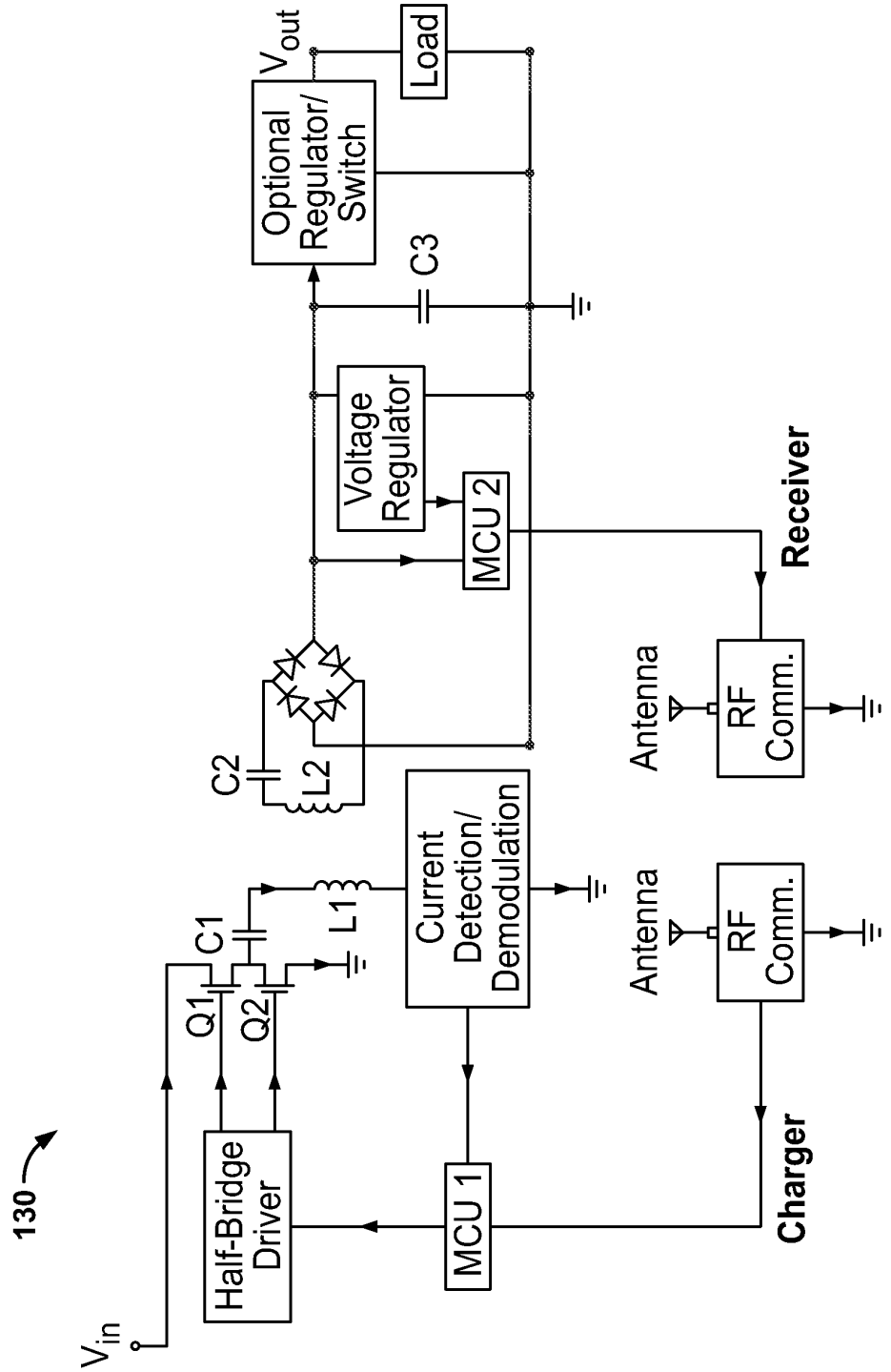

130
V_{in}
Half-Bridge Driver
Q1
Q2
C1
L1
Current Detection/ Demodulation
MCU 1
Charger
C2
L2
Voltage Regulator
MCU 2
Optional Regulator/ Switch
C3
V_{out}
Load
Receiver
Antenna
RF Comm.
Antenna
RF Comm.

FIG. 3

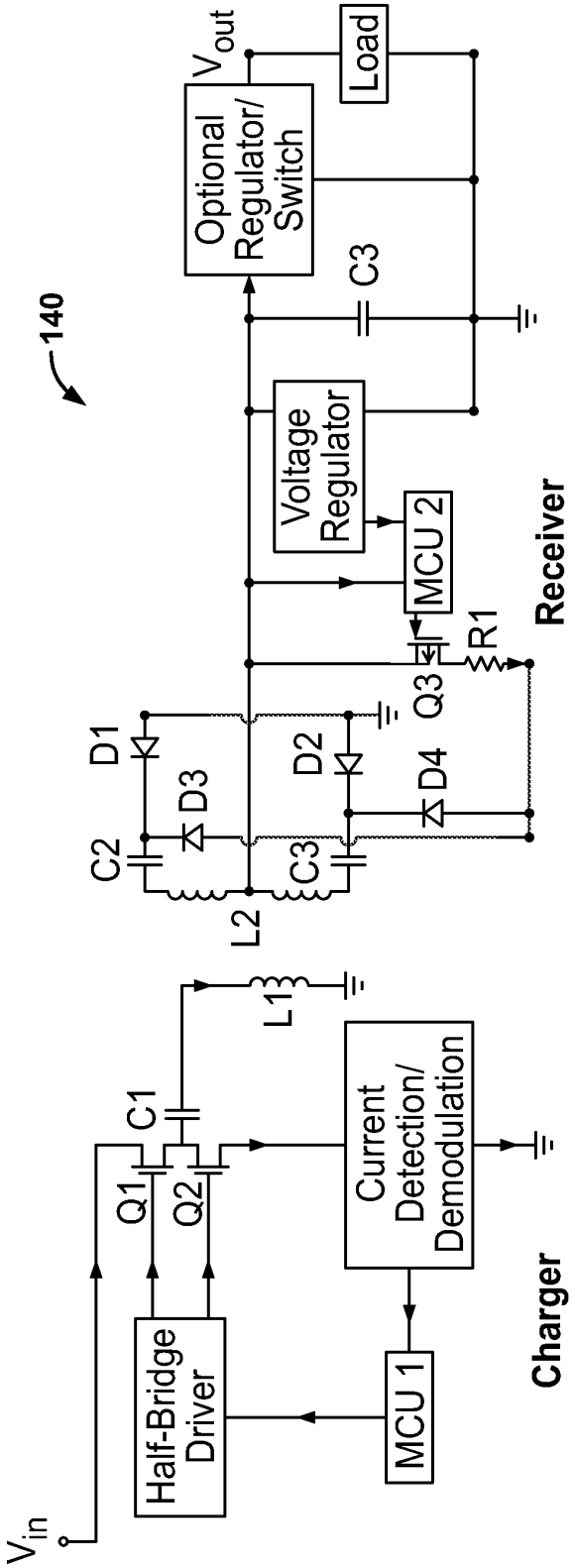

140
Receiver
Charger
V_{in}
V_{out}
Load
Optional Regulator/ Switch
C3
Voltage Regulator
MCU 2
R1
Q3
D1
D2
D3
D4
C2
C3
L2
L1
C1
Q1
Q2
Current Detection/ Demodulation
Half-Bridge Driver
MCU 1

FIG. 4

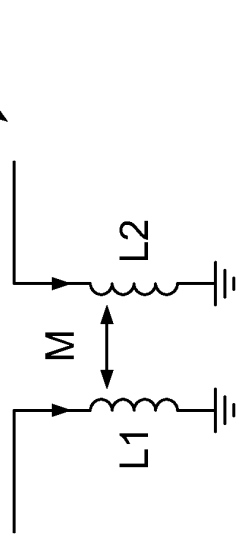

150
L2
M
L1

FIG. 5

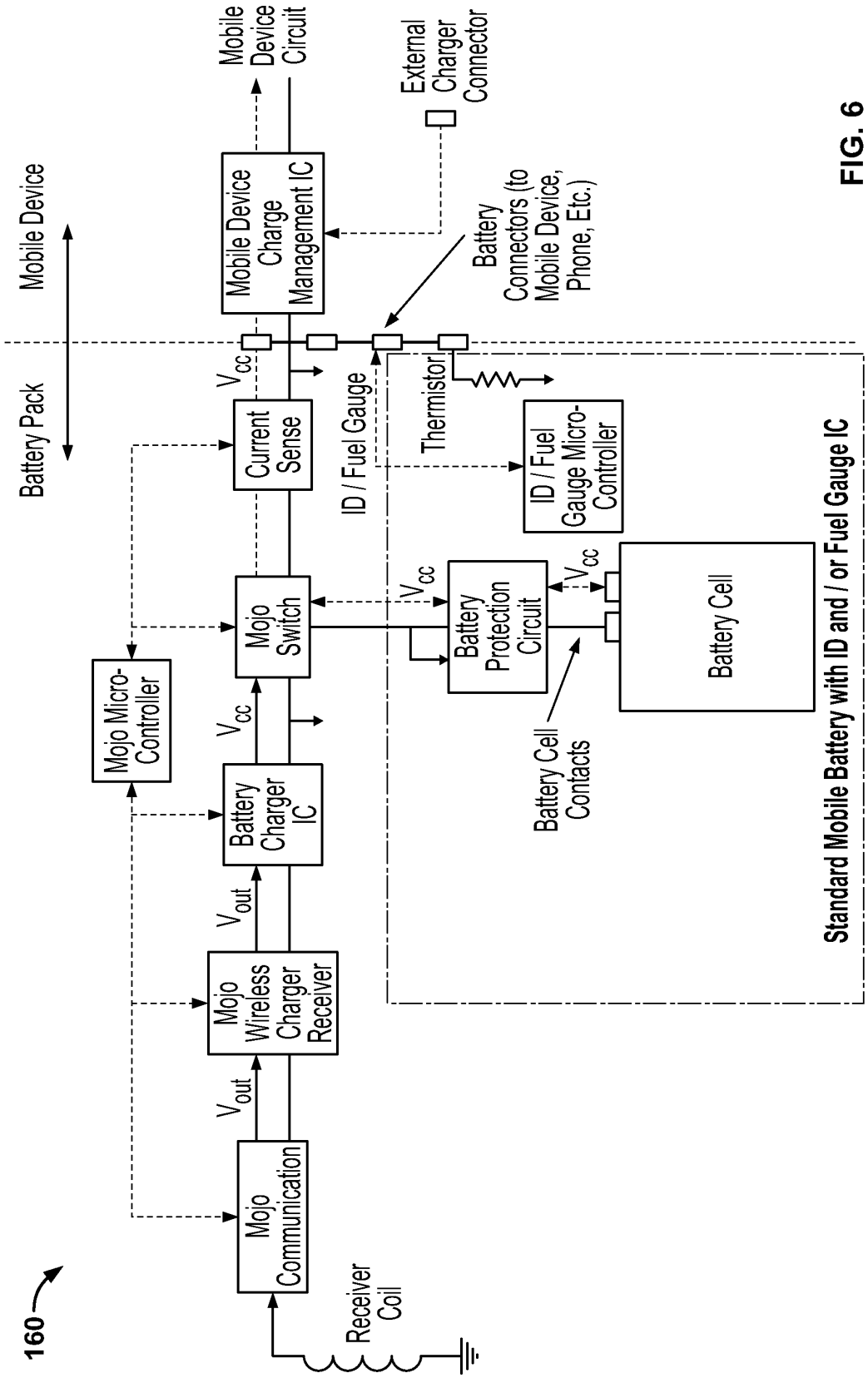

160
Receiver Coil
Mojo Communication
Mojo Wireless Charger Receiver
Mojo Micro-Controller
Battery Charger IC
Mojo Switch
Current Sense
Mobile Device Charge Management IC
Mobile Device Circuit
External Charger Connector
Battery Connectors (to Mobile Device, Phone, Etc.)
Mobile Device
Battery Pack
V_{out}
V_{out}
V_{cc}
V_{cc}
V_{cc}
V_{cc}
ID / Fuel Gauge
Thermistor
ID / Fuel Gauge Micro-Controller
Battery Protection Circuit
Battery Cell
Battery Cell Contacts
Standard Mobile Battery with ID and / or Fuel Gauge IC

FIG. 6

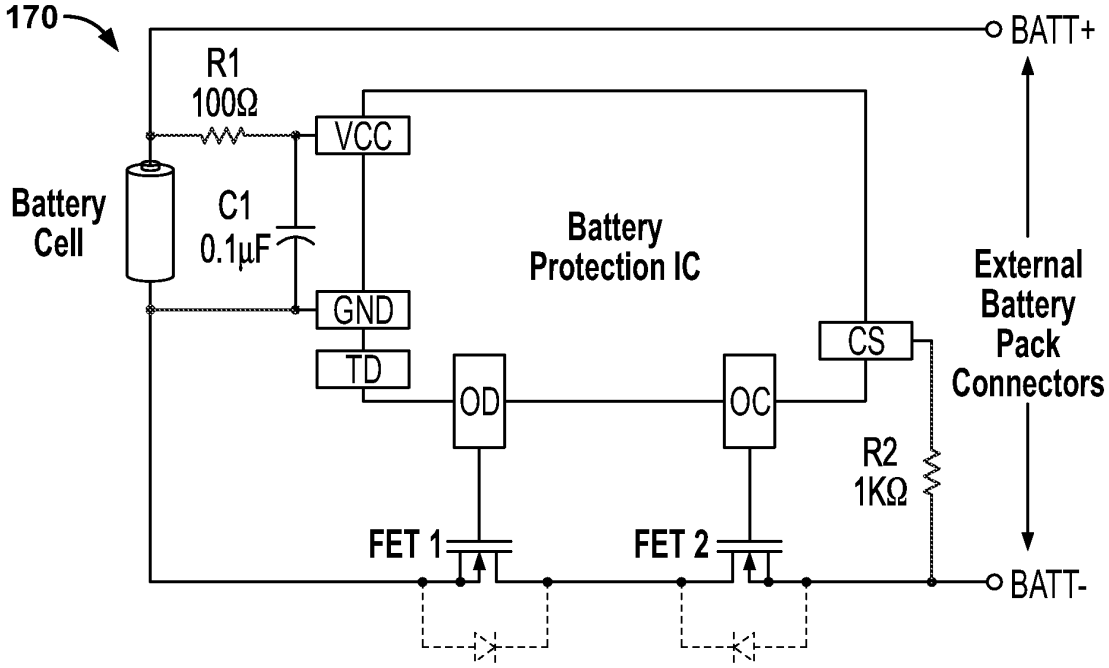

170
BATT+
R1
100Ω
VCC
Battery
Cell
C1
0.1µF
Battery
Protection IC
External
Battery
Pack
Connectors
GND
CS
TD
OD
OC
R2
1KΩ
FET 1
FET 2
BATT-

FIG. 7

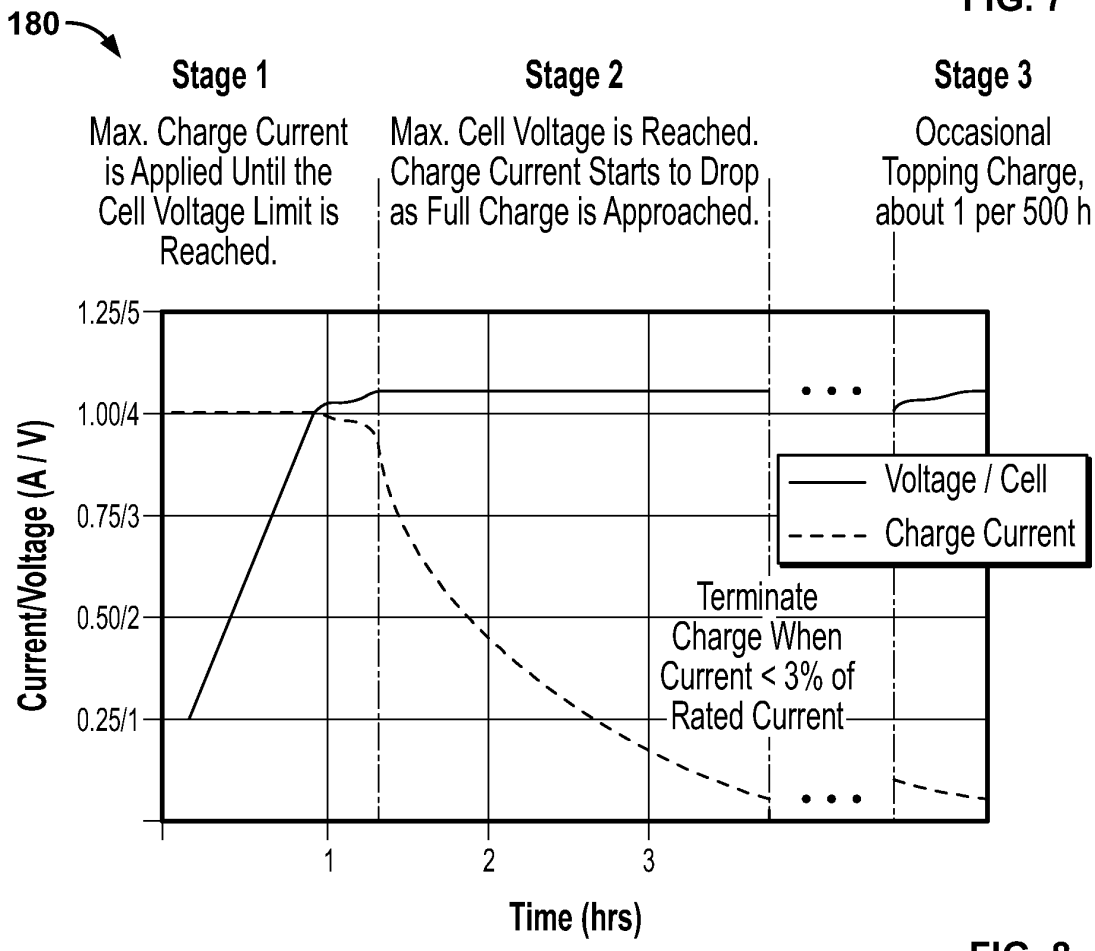

180
Stage 1
Max. Charge Current is Applied Until the Cell Voltage Limit is Reached.
Stage 2
Max. Cell Voltage is Reached. Charge Current Starts to Drop as Full Charge is Approached.
Stage 3
Occasional Topping Charge, about 1 per 500 h
1.25/5
1.00/4
0.75/3
0.50/2
0.25/1
Current/Voltage (A / V)
Voltage / Cell
Charge Current
Terminate Charge When Current < 3% of Rated Current
1
2
3
Time (hrs)

FIG. 8

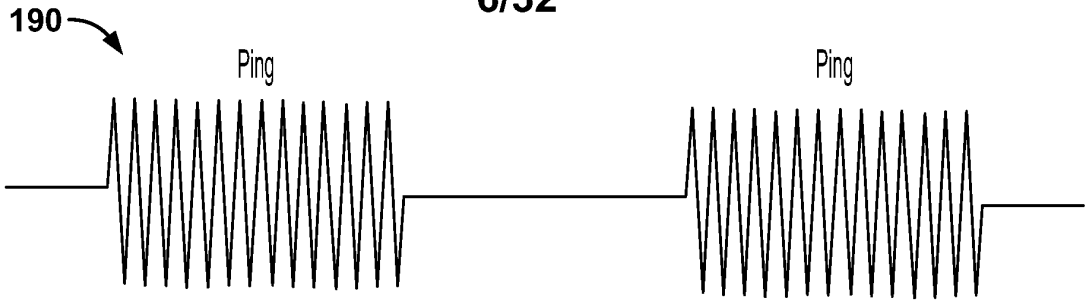


FIG. 9

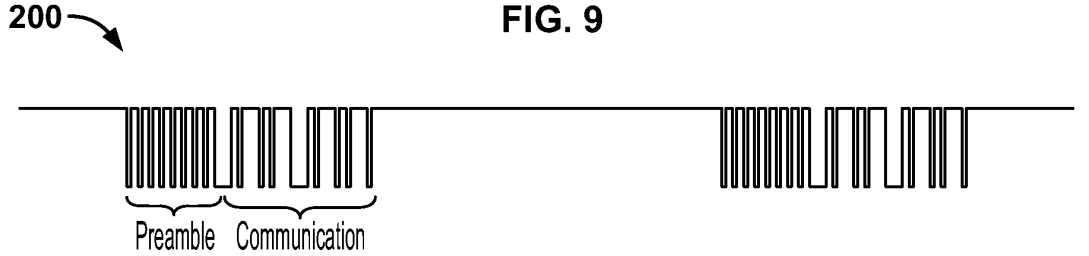


FIG. 10

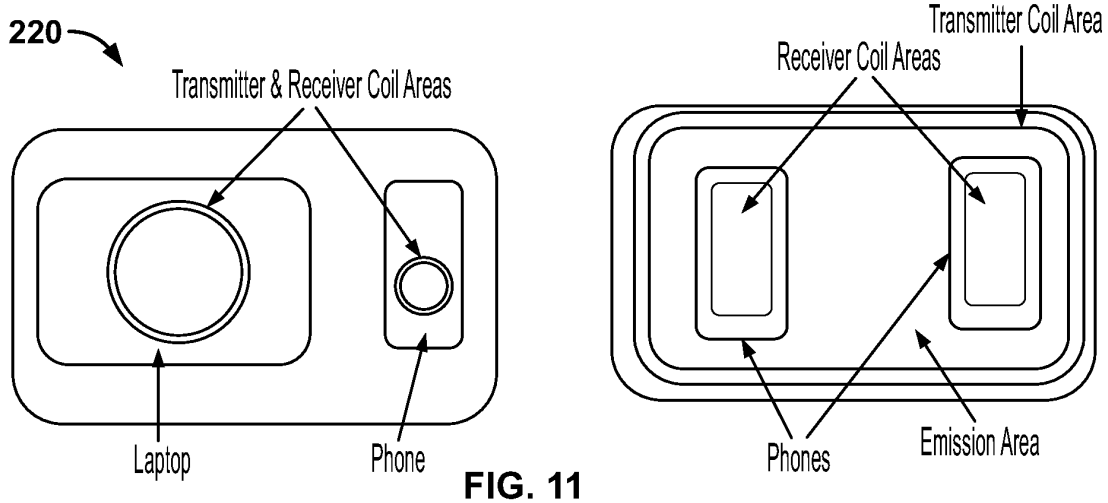


FIG. 11

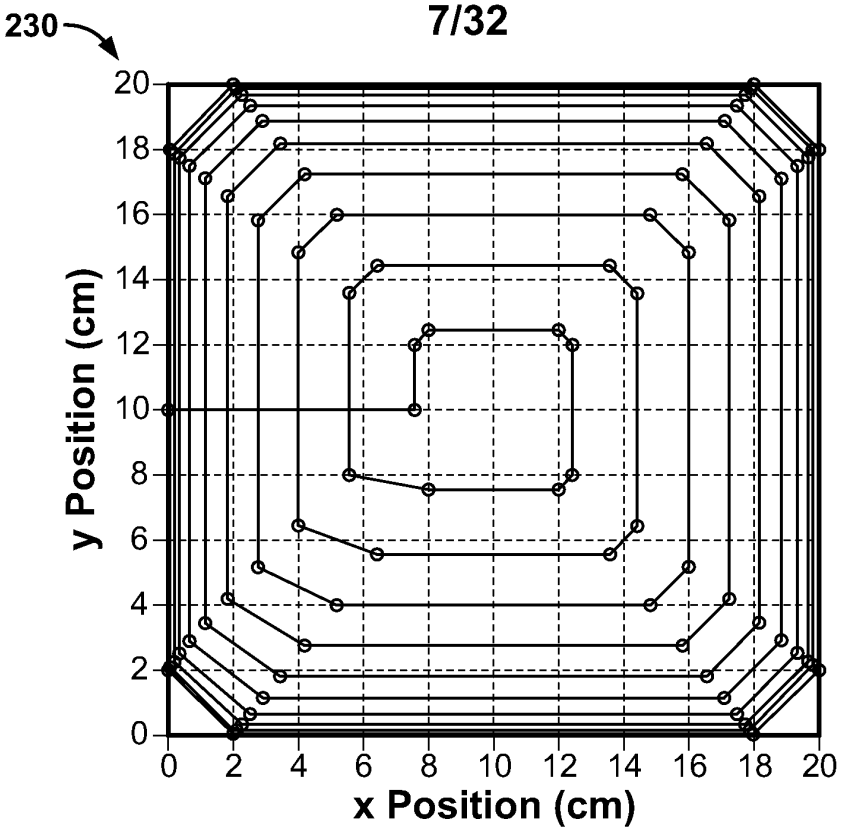

230
y Position (cm)
x Position (cm)
0
2
4
6
8
10
12
14
16
18
20

FIG. 12

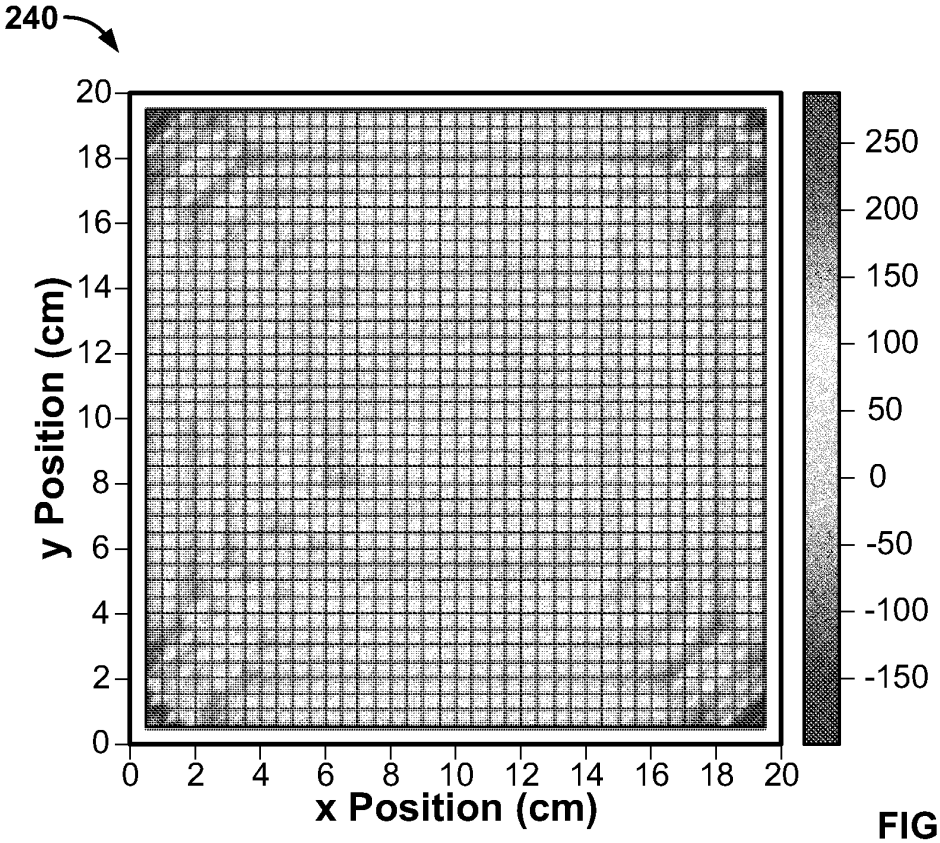

240
y Position (cm)
x Position (cm)
0
2
4
6
8
10
12
14
16
18
20
250
200
150
100
50
0
-50
-100
-150

FIG. 13

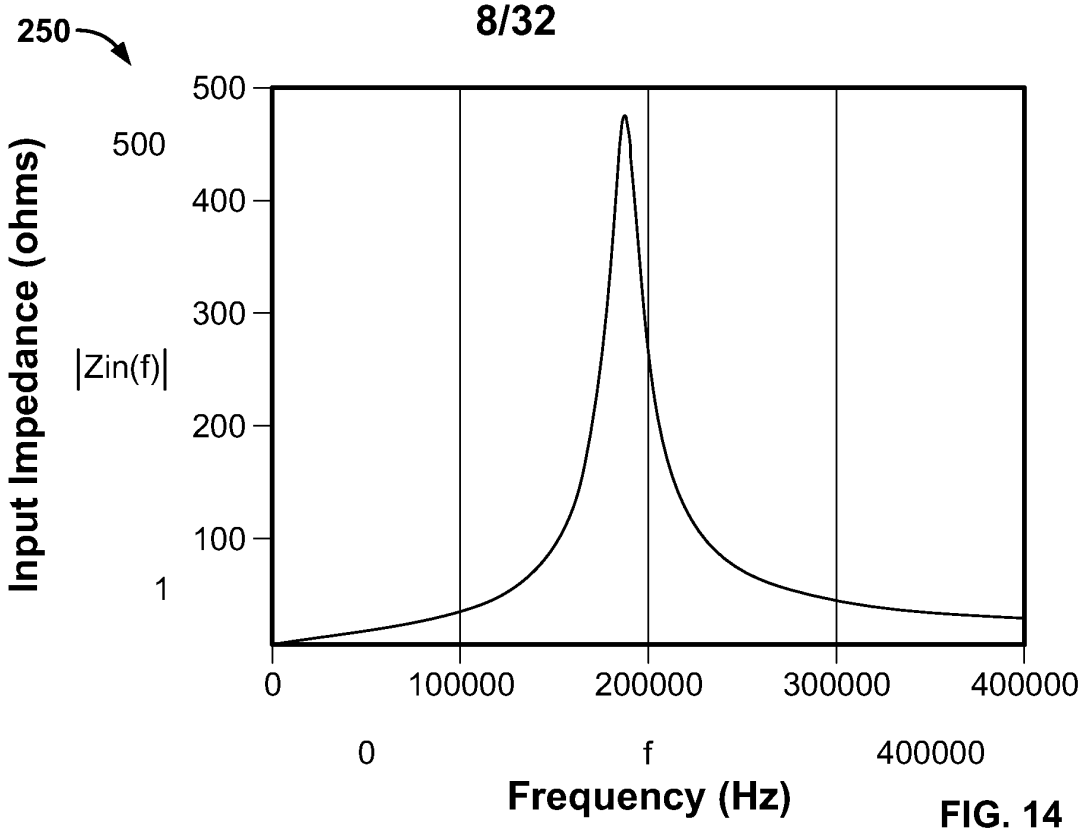

250
Input Impedance (ohms)
500
500
400
300
|Zin(f)|
200
100
1
0
100000
200000
300000
400000
0
f
400000
Frequency (Hz)

FIG. 14

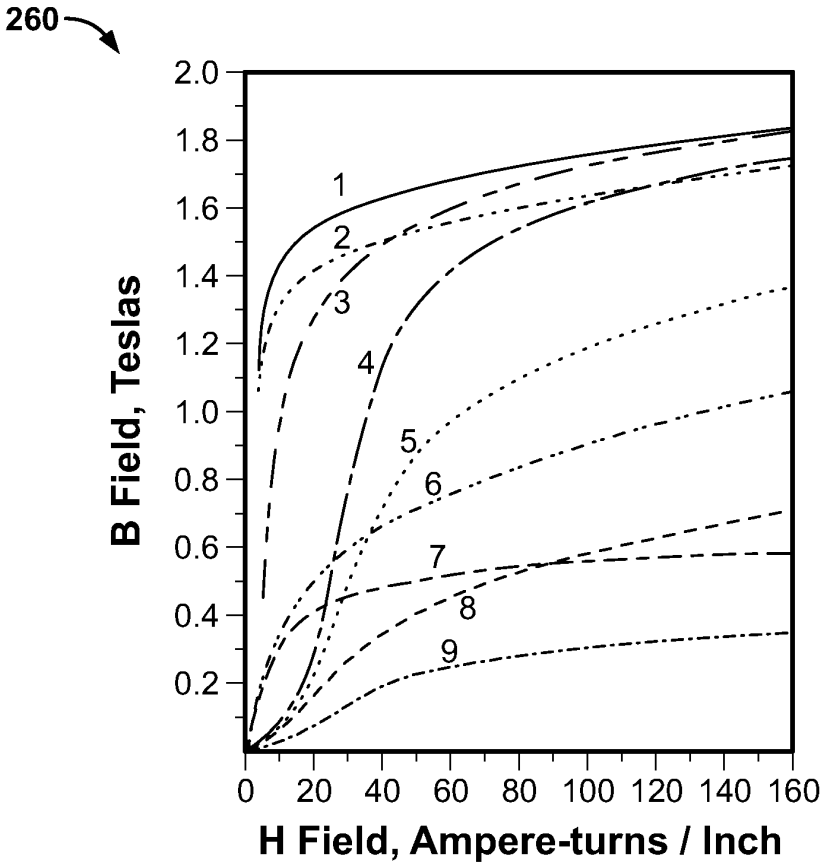

260
B Field, Teslas
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1
2
3
4
5
6
7
8
9
0
20
40
60
80
100
120
140
160
H Field, Ampere-turns / Inch

FIG. 15

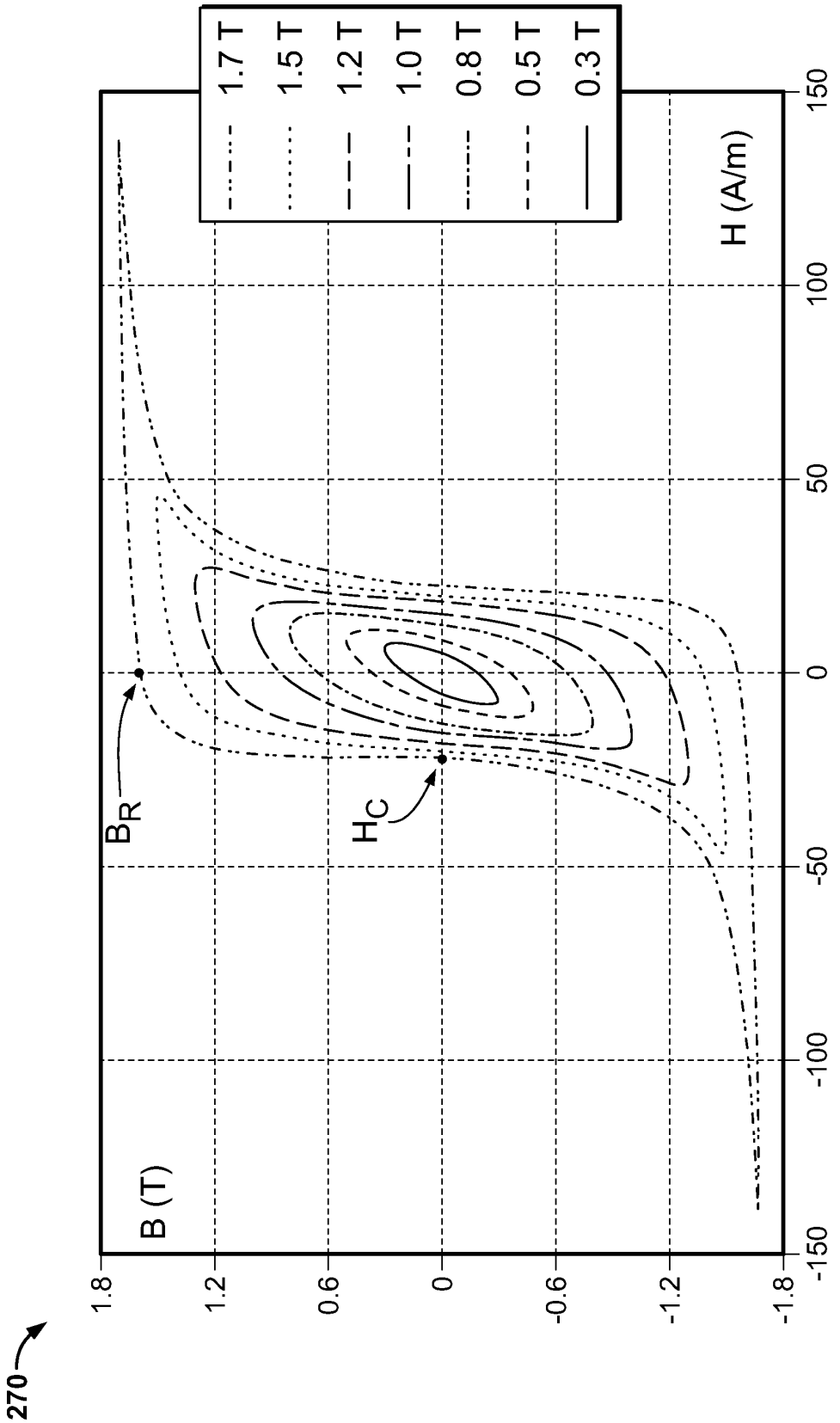

1.7 T
1.5 T
1.2 T
1.0 T
0.8 T
0.5 T
0.3 T
H (A/m)
150
100
50
0
-50
-100
-150
B (T)
1.8
1.2
0.6
0
-0.6
-1.2
-1.8
B_R
H_C
270

FIG. 16

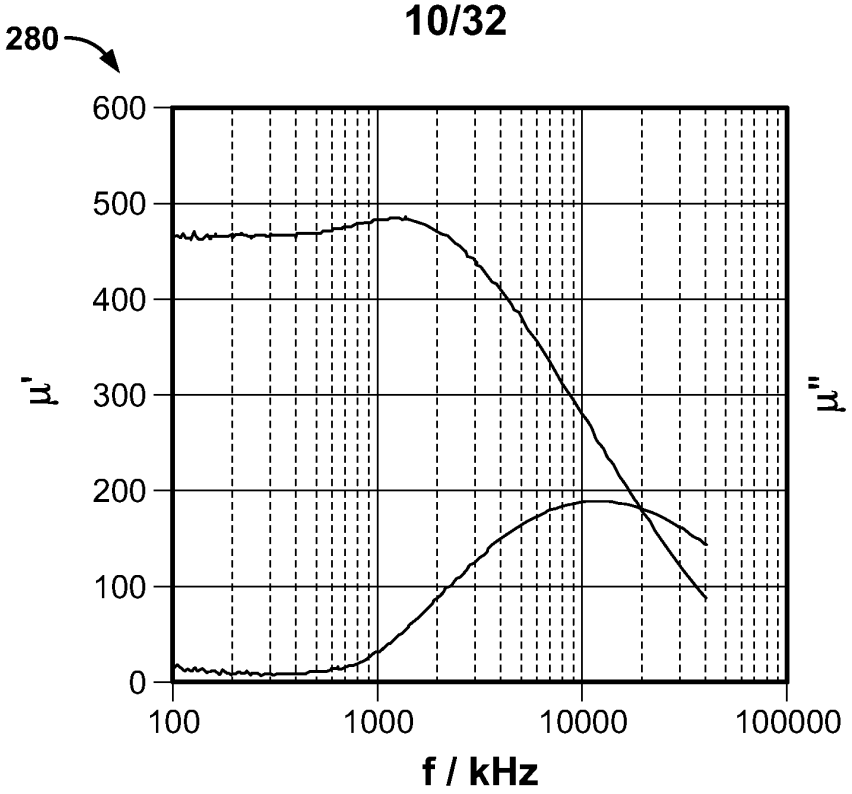

280
600
500
400
300
200
100
0
μ'
μ"
100
1000
10000
100000
f / kHz

FIG. 17

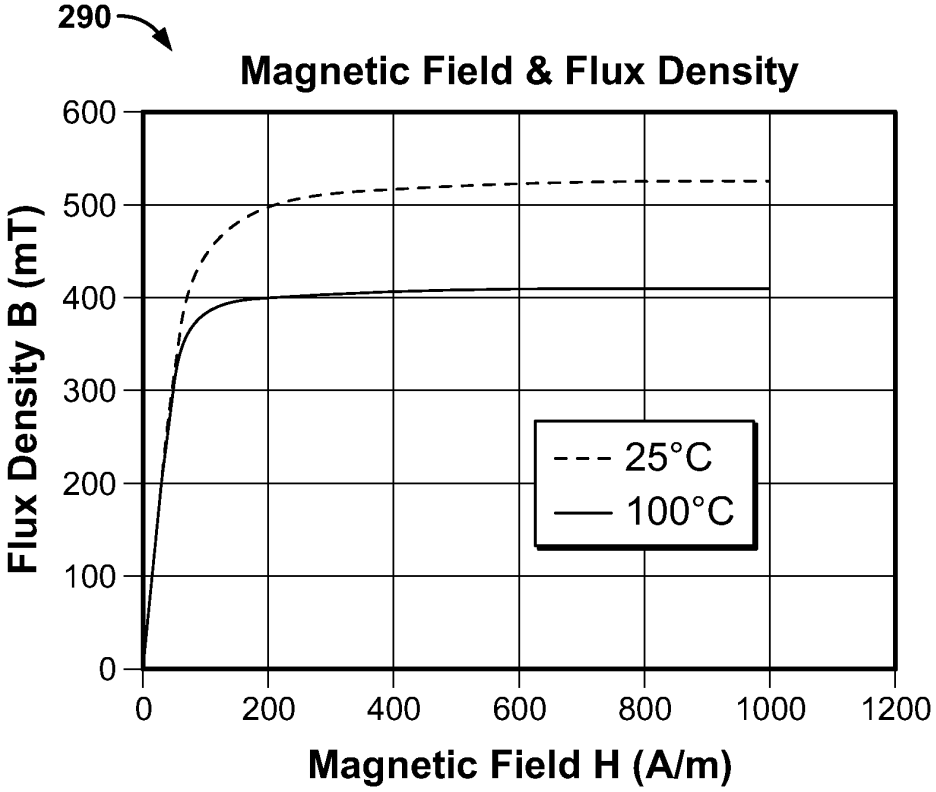

290
Magnetic Field & Flux Density
600
500
400
300
200
100
0
Flux Density B (mT)
0
200
400
600
800
1000
1200
Magnetic Field H (A/m)
25°C
100°C

FIG. 18

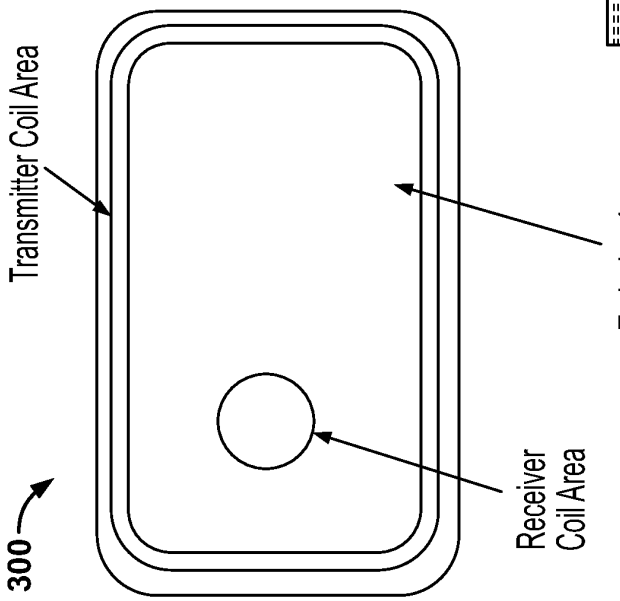

300
Transmitter Coil Area
Receiver Coil Area

FIG. 19

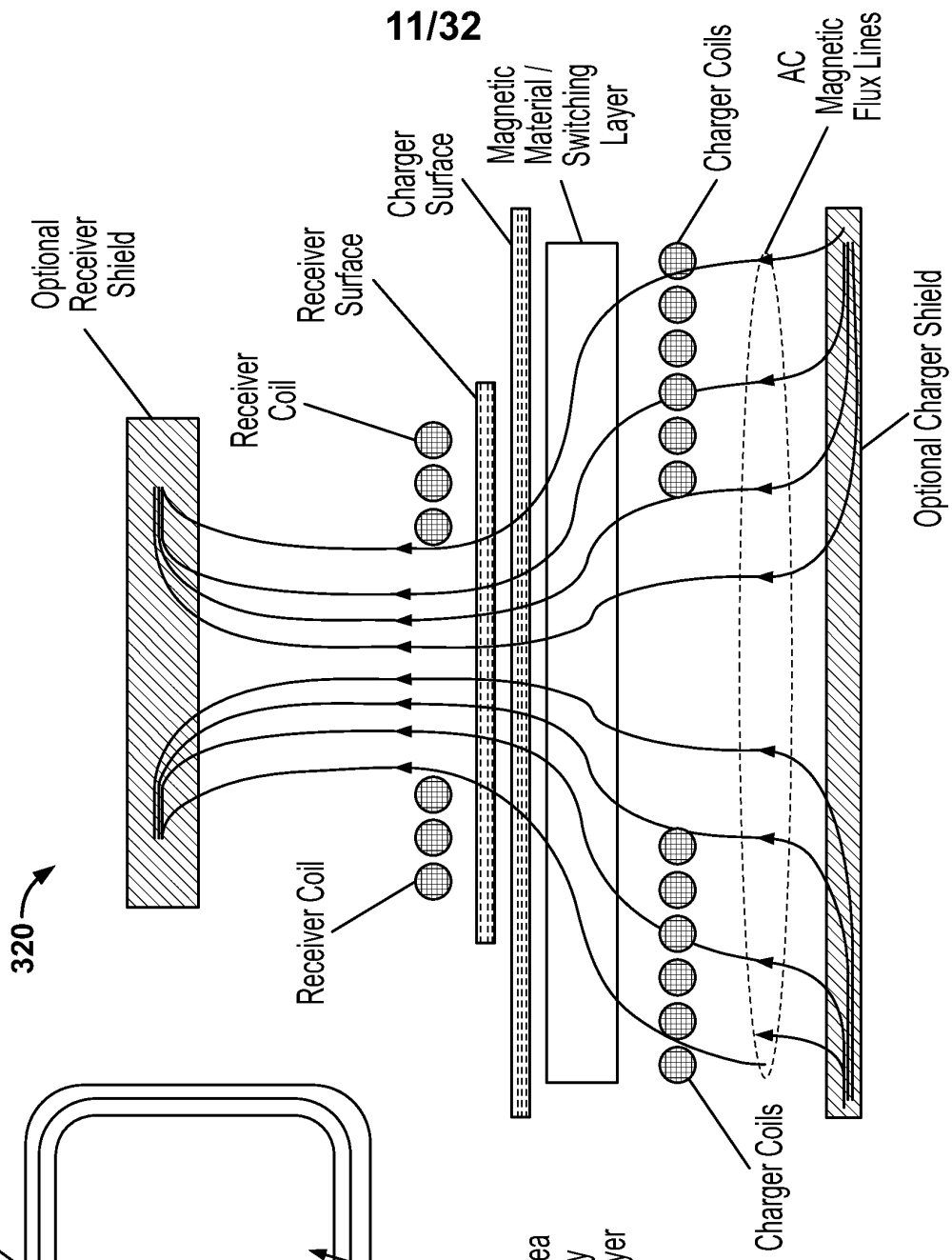

320
Optional Receiver Shield
Receiver Coil
Receiver Surface
Charger Surface
Magnetic Material / Switching Layer
Charger Coils
AC Magnetic Flux Lines
Optional Charger Shield
Receiver Coil
Emission Area Covered by Magnetic Layer
Charger Coils

FIG. 20

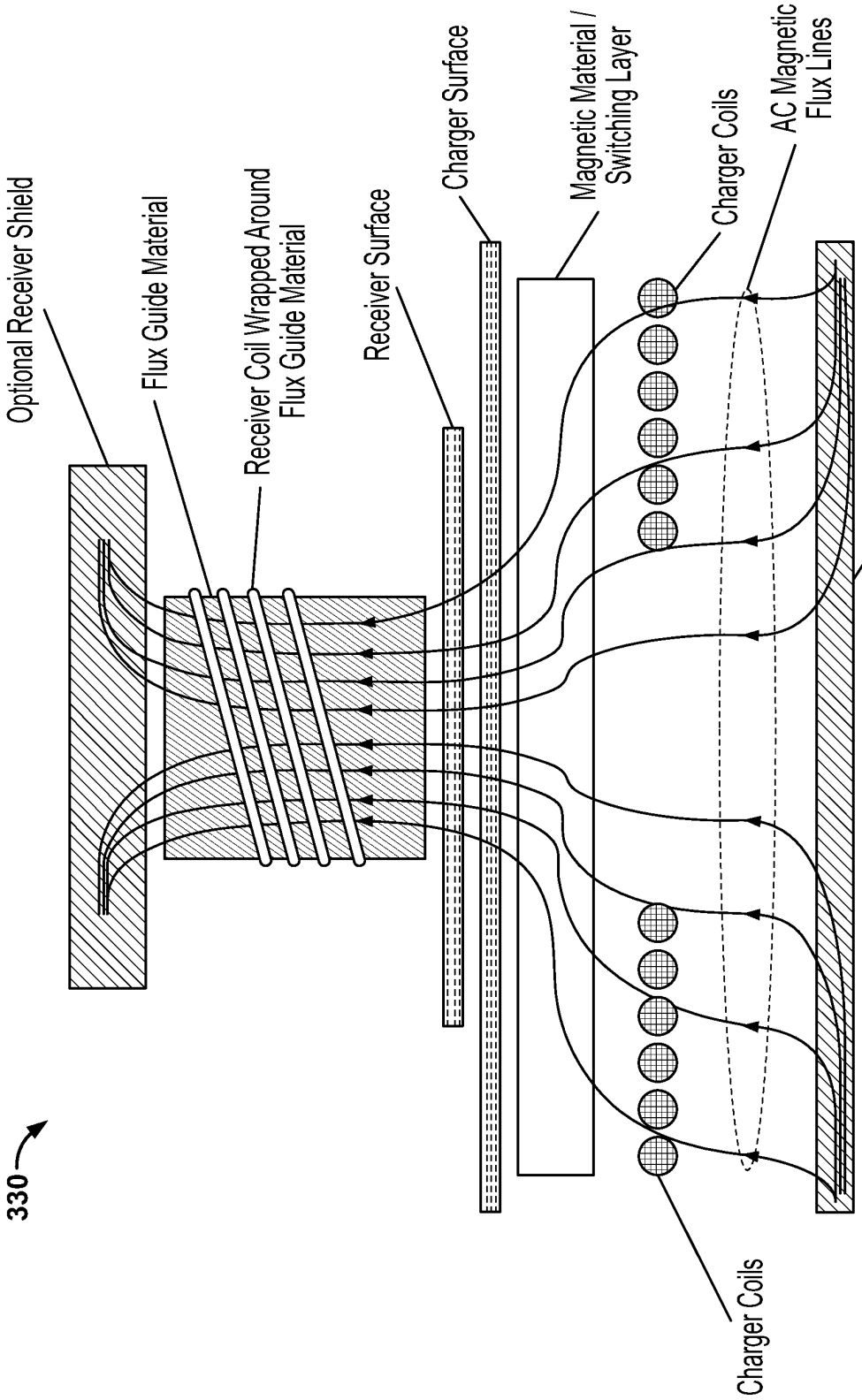

Optional Receiver Shield
Flux Guide Material
Receiver Coil Wrapped Around Flux Guide Material
Receiver Surface
Charger Surface
Magnetic Material / Switching Layer
Charger Coils
AC Magnetic Flux Lines
Optional Charger Shield
Charger Coils
330

FIG. 21

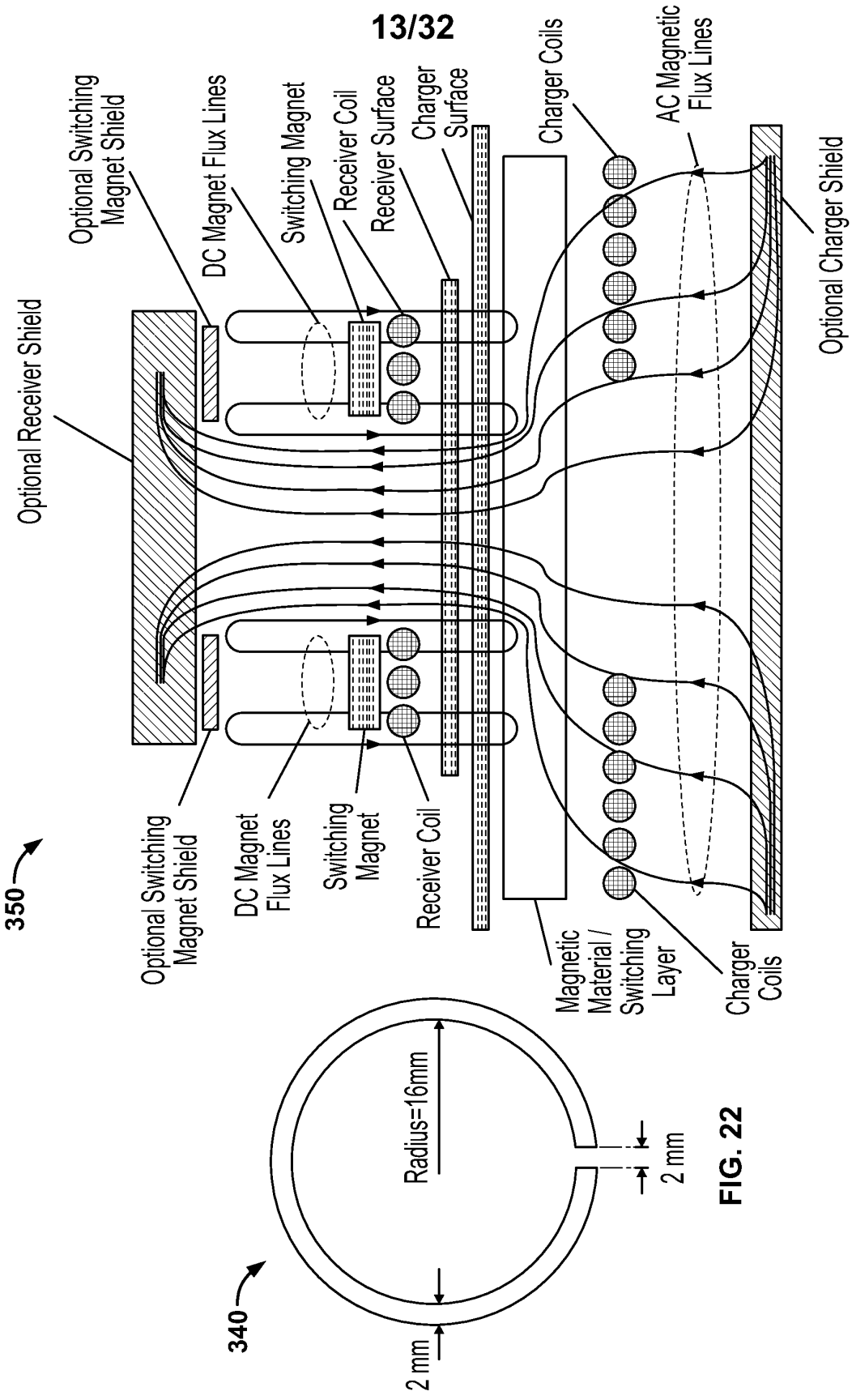

350
Optional Receiver Shield
Optional Switching Magnet Shield
DC Magnet Flux Lines
Switching Magnet
Receiver Coil
Receiver Surface
Charger Surface
Charger Coils
AC Magnetic Flux Lines
Optional Charger Shield
Optional Switching Magnet Shield
DC Magnet Flux Lines
Switching Magnet
Receiver Coil
Magnetic Material / Switching Layer
Charger Coils
340
Radius=16mm
2 mm
2 mm

FIG. 23

FIG. 22

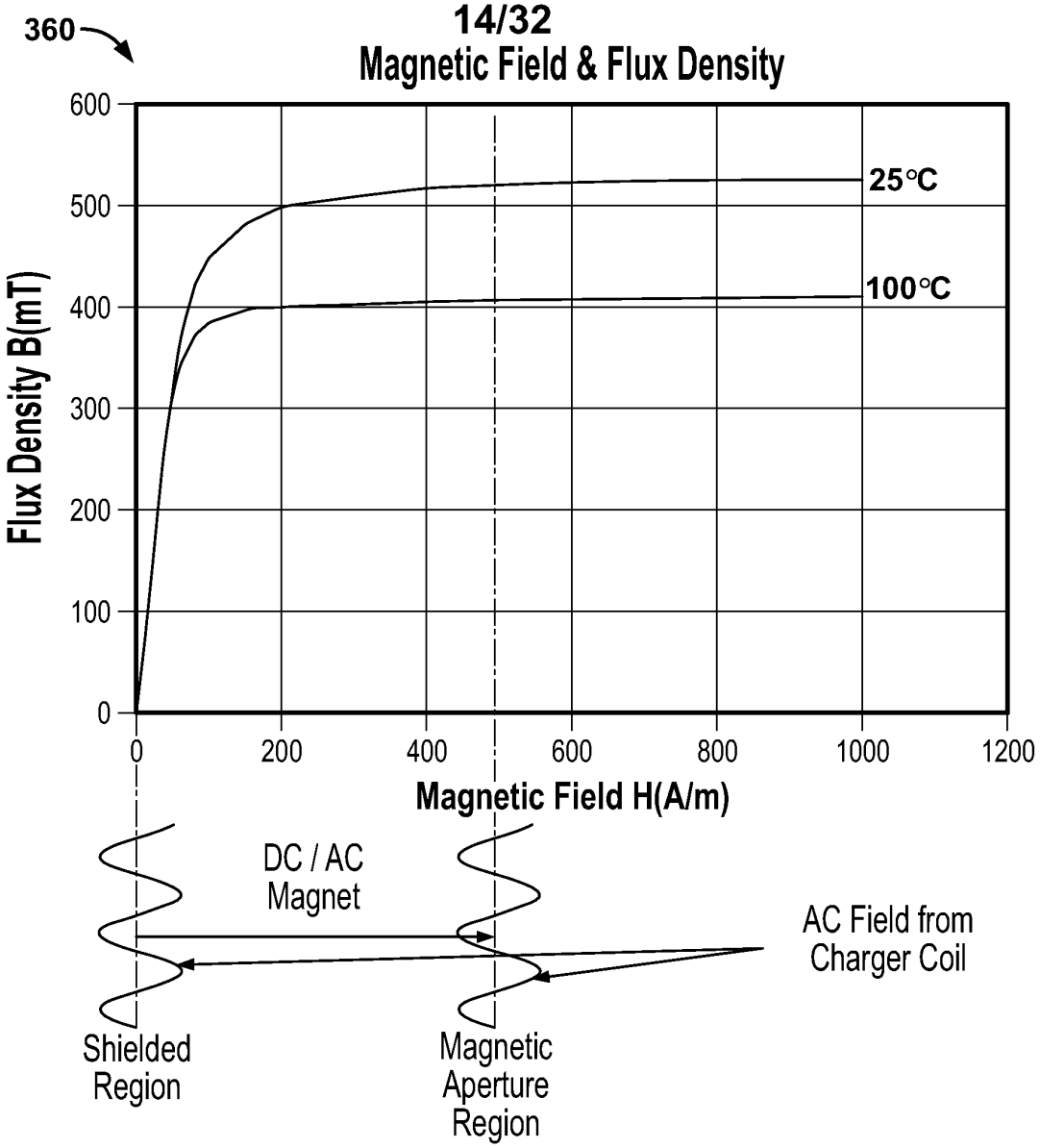

360
Magnetic Field & Flux Density
Flux Density B(mT)
600
500
400
300
200
100
0
25°C
100°C
0
200
400
600
800
1000
1200
Magnetic Field H(A/m)
DC / AC Magnet
AC Field from Charger Coil
Shielded Region
Magnetic Aperture Region

FIG. 24

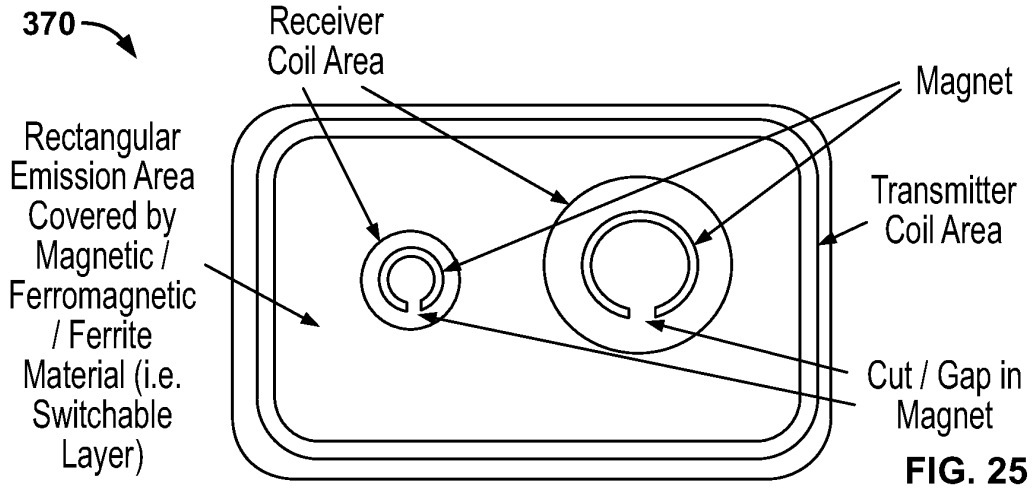

370
Receiver Coil Area
Magnet
Rectangular Emission Area Covered by Magnetic / Ferromagnetic / Ferrite Material (i.e. Switchable Layer)
Transmitter Coil Area
Cut / Gap in Magnet

FIG. 25

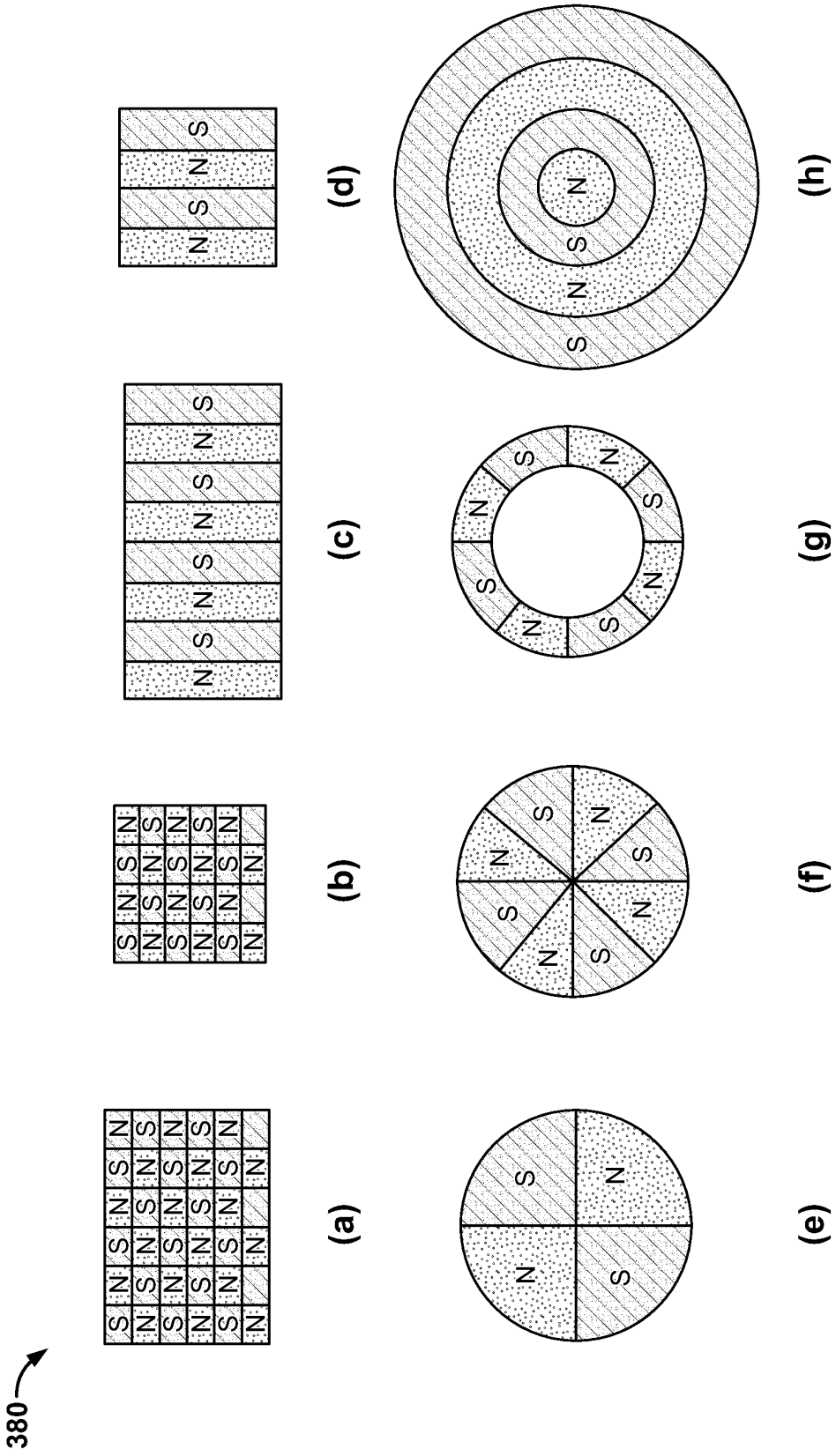


FIG. 26

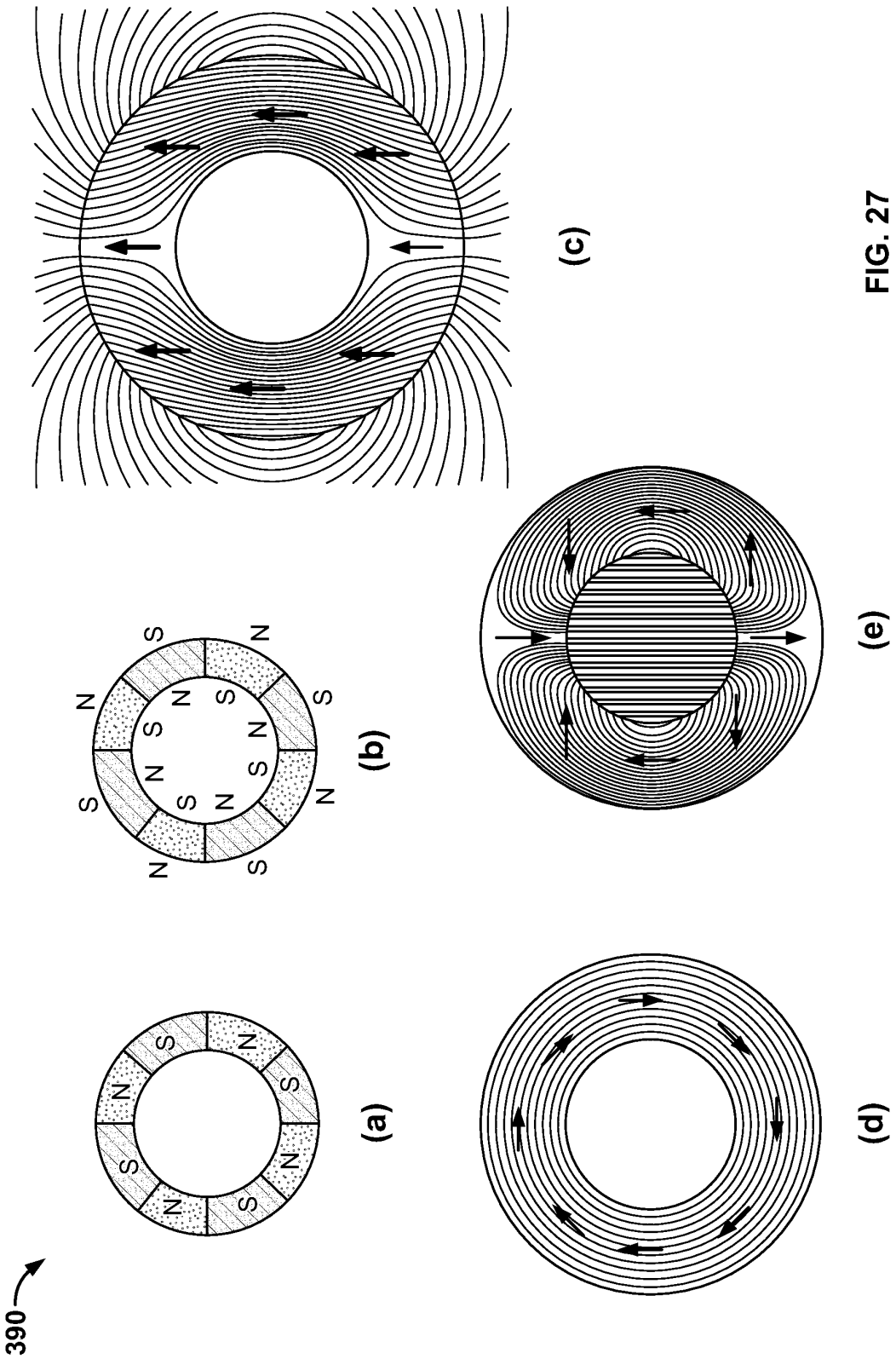


FIG. 27

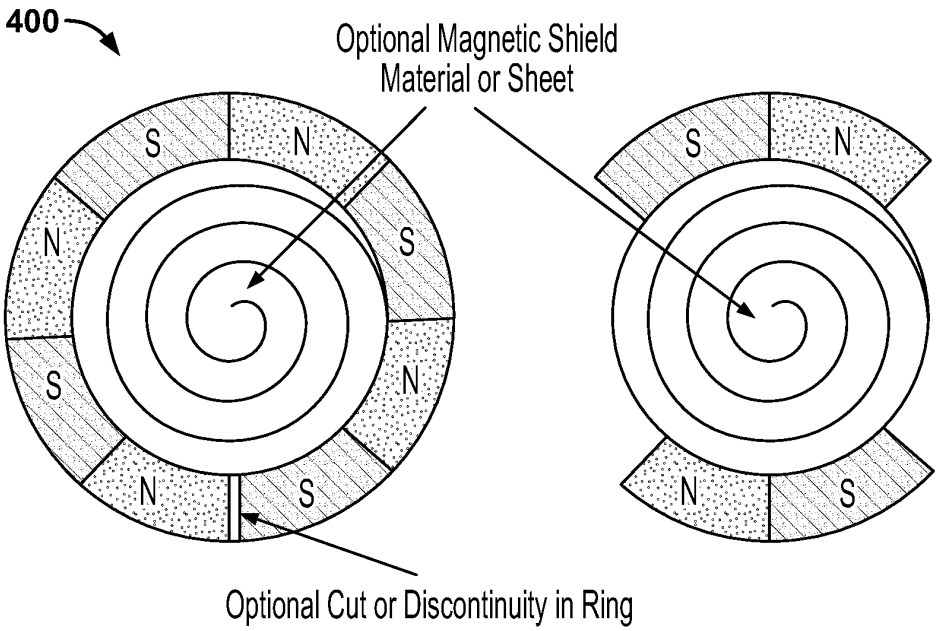


FIG. 28

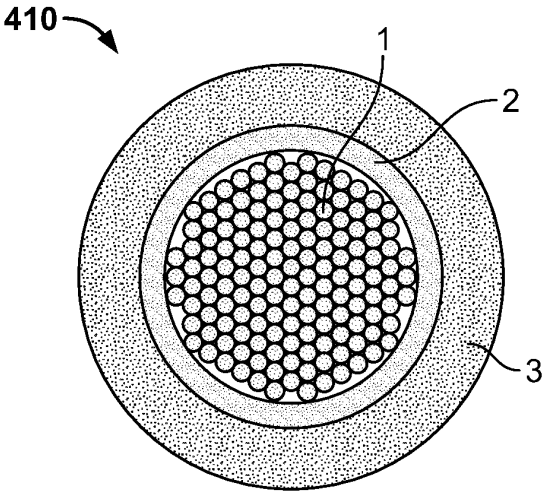


FIG. 29

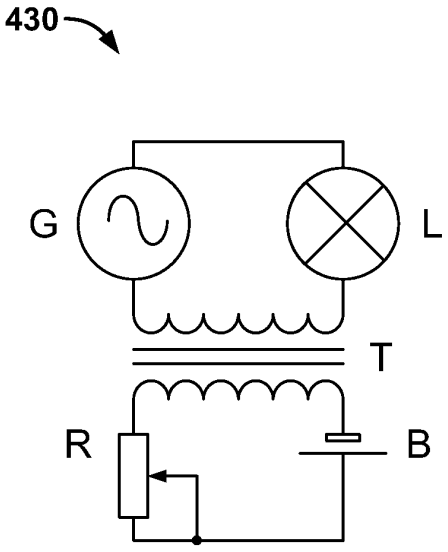


FIG. 30

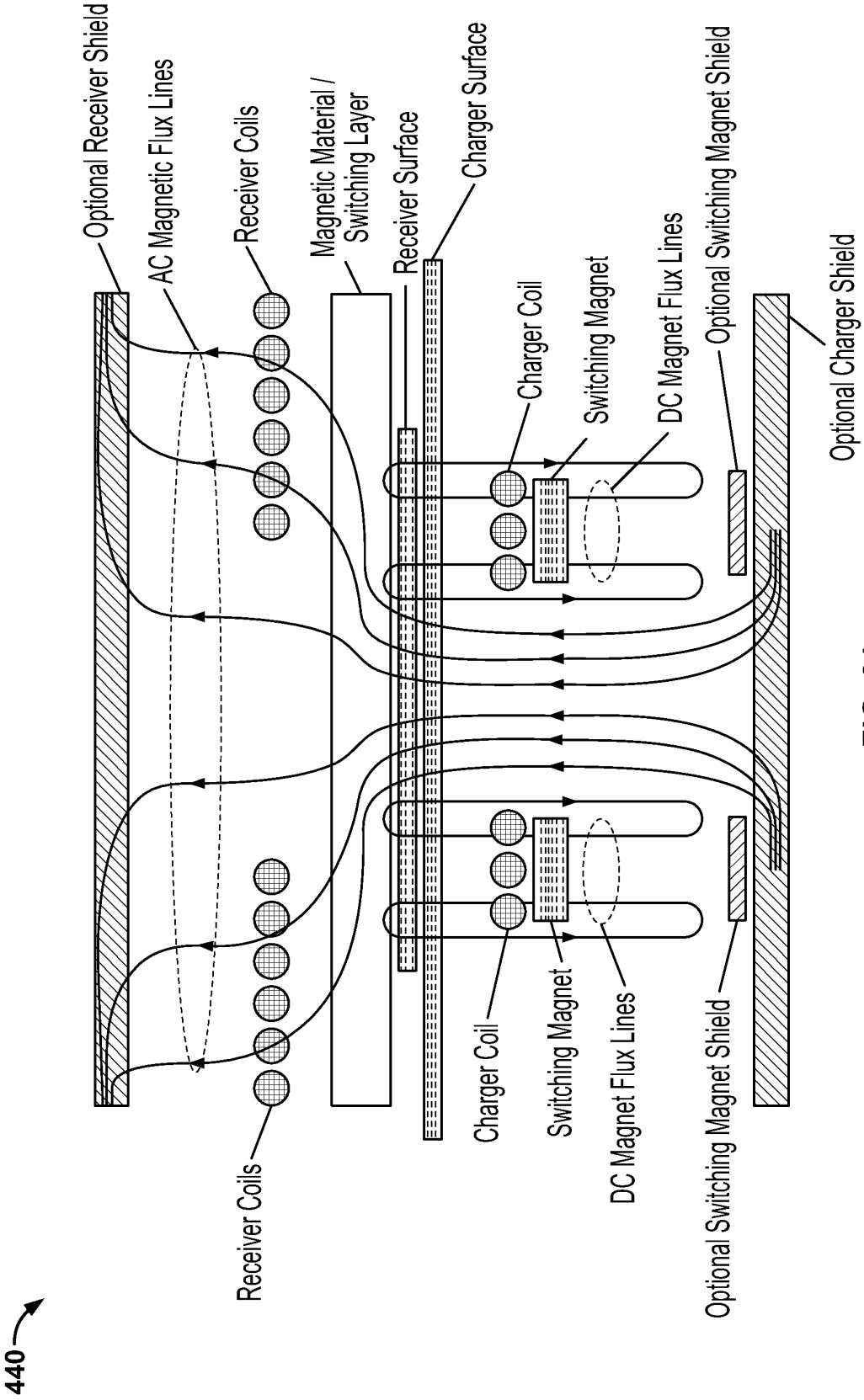

440
Optional Receiver Shield
AC Magnetic Flux Lines
Receiver Coils
Magnetic Material / Switching Layer
Receiver Surface
Charger Surface
Charger Coil
Switching Magnet
DC Magnet Flux Lines
Optional Switching Magnet Shield
Optional Charger Shield
Receiver Coils
Charger Coil
Switching Magnet
DC Magnet Flux Lines
Optional Switching Magnet Shield

FIG. 31

19/32

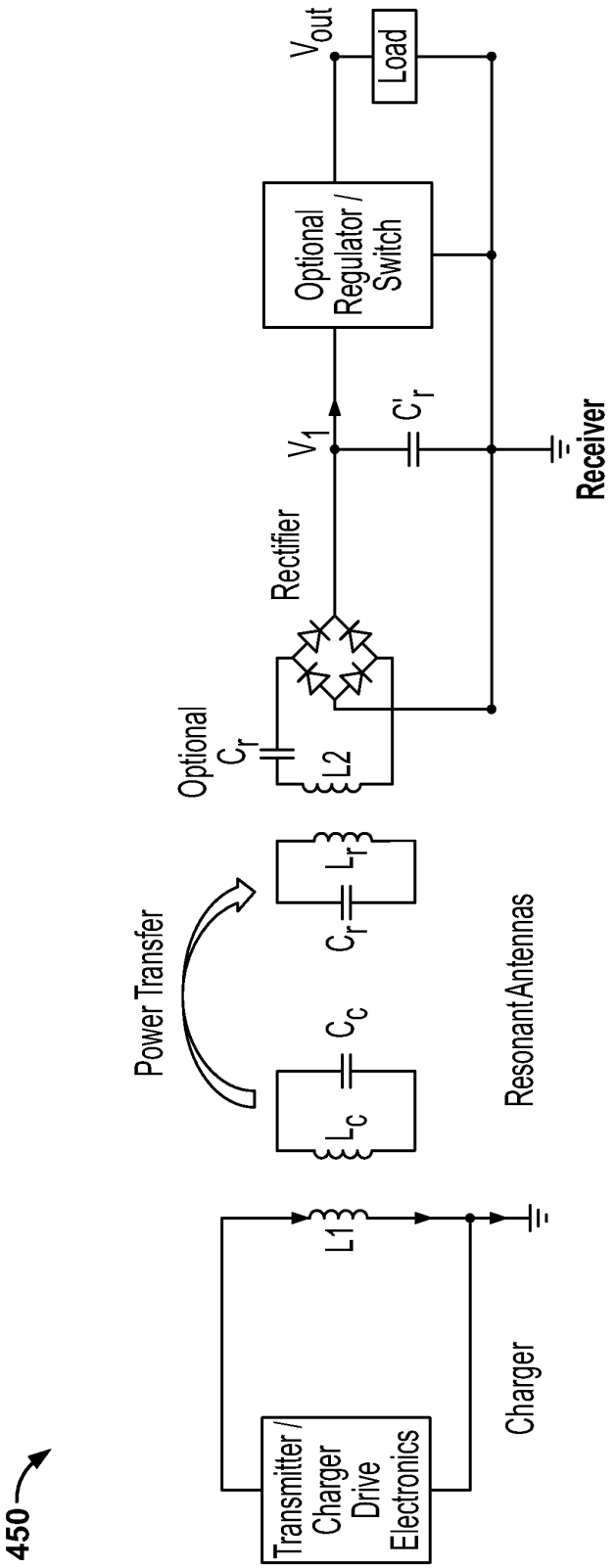

450
Transmitter / Charger Drive Electronics
L1
Charger
Power Transfer
L_c
C_c
C_r
L_r
Resonant Antennas
Optional C_r
L2
Rectifier
V_1
C'_r
Receiver
Optional Regulator / Switch
V_{out}
Load

FIG. 32

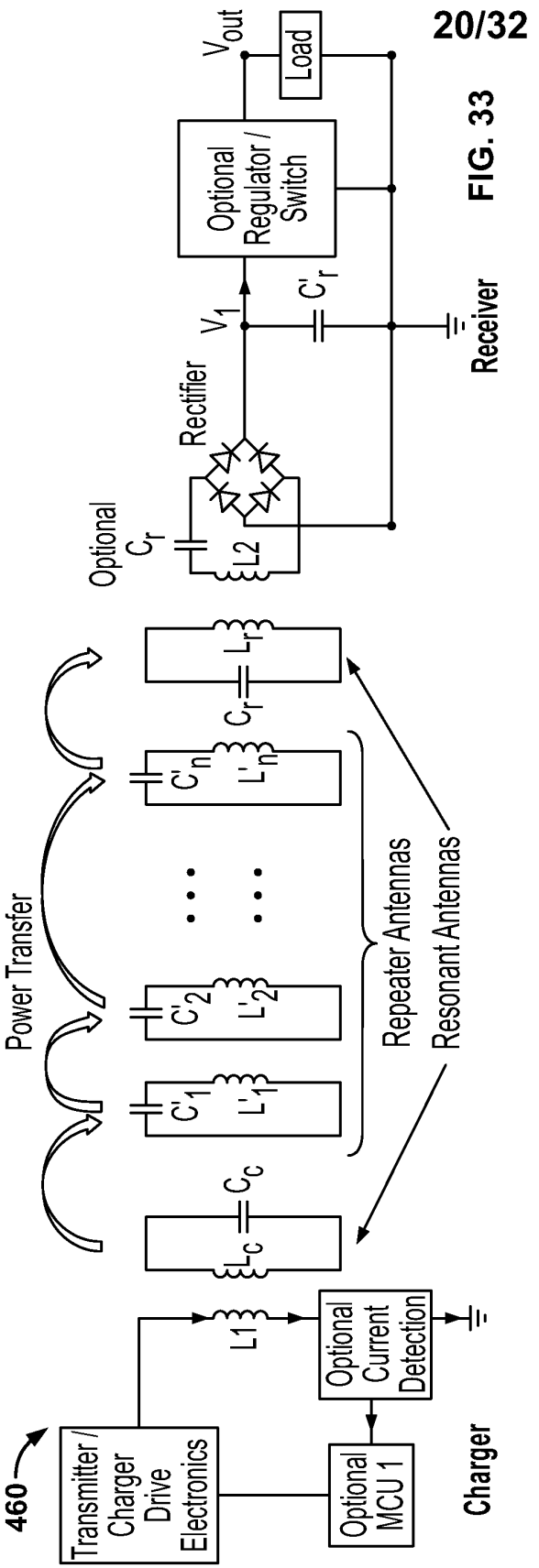

460
Transmitter / Charger Drive Electronics
Optional MCU 1
L1
Optional Current Detection
Charger
Power Transfer
L_c
C_c
C'_1
L'_1
C'_2
L'_2
C'_n
L'_n
C_r
L_r
Repeater Antennas
Resonant Antennas
Optional C_r
L2
Rectifier
V_1
C'_r
Receiver
Optional Regulator / Switch
V_{out}
Load

FIG. 33

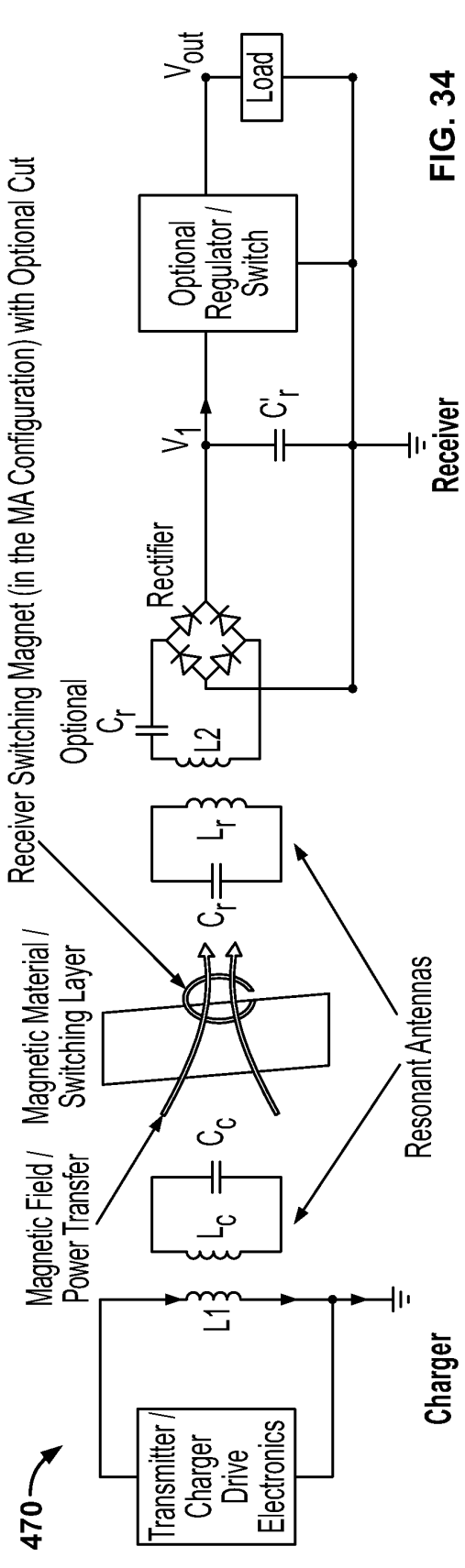

470
Transmitter / Charger Drive Electronics
L1
Charger
Magnetic Field / Power Transfer
Magnetic Material / Switching Layer
Receiver Switching Magnet (in the MA Configuration) with Optional Cut
L_c
C_c
C_r
L_r
Resonant Antennas
Optional C_r
L2
Rectifier
V_1
C'_r
Receiver
Optional Regulator / Switch
V_{out}
Load

FIG. 34

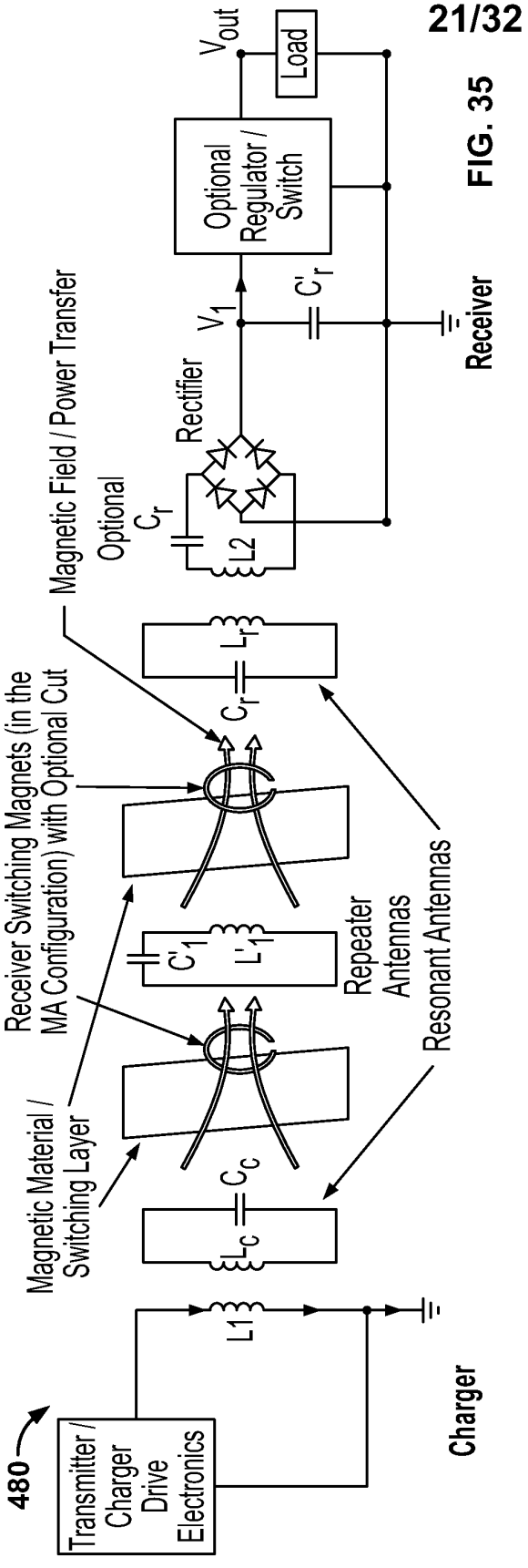

480
Transmitter / Charger Drive Electronics
L1
Charger
Magnetic Material / Switching Layer
Receiver Switching Magnets (in the MA Configuration) with Optional Cut
Magnetic Field / Power Transfer
C_c
L_c
C'_1
L'_1
Repeater Antennas
Resonant Antennas
C_r
L_r
Optional C_r
L2
Rectifier
V_1
C'_r
Optional Regulator / Switch
V_{out}
Load
Receiver

FIG. 35

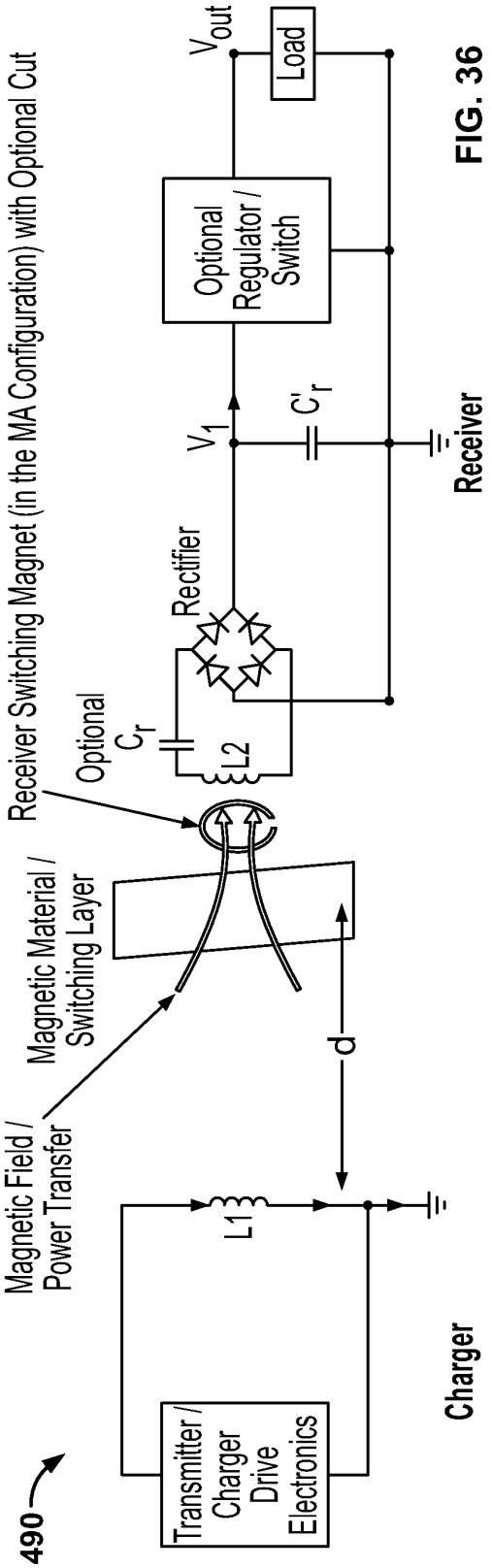

490
Transmitter / Charger Drive Electronics
L1
Charger
Magnetic Field / Power Transfer
Magnetic Material / Switching Layer
Receiver Switching Magnet (in the MA Configuration) with Optional Cut
d
Optional C_r
L2
Rectifier
V_1
C'_r
Optional Regulator / Switch
V_{out}
Load
Receiver

FIG. 36

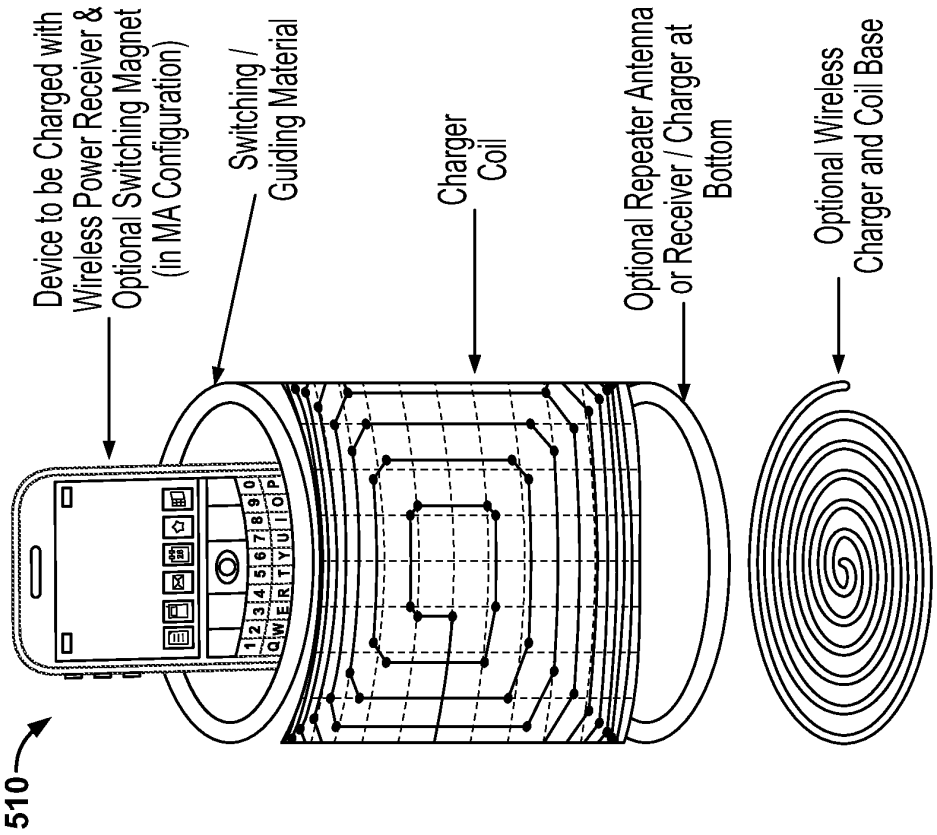

Device to be Charged with Wireless Power Receiver & Optional Switching Magnet (in MA Configuration)
Switching / Guiding Material
Charger Coil
Optional Repeater Antenna or Receiver / Charger at Bottom
Optional Wireless Charger and Coil Base
510

FIG. 38

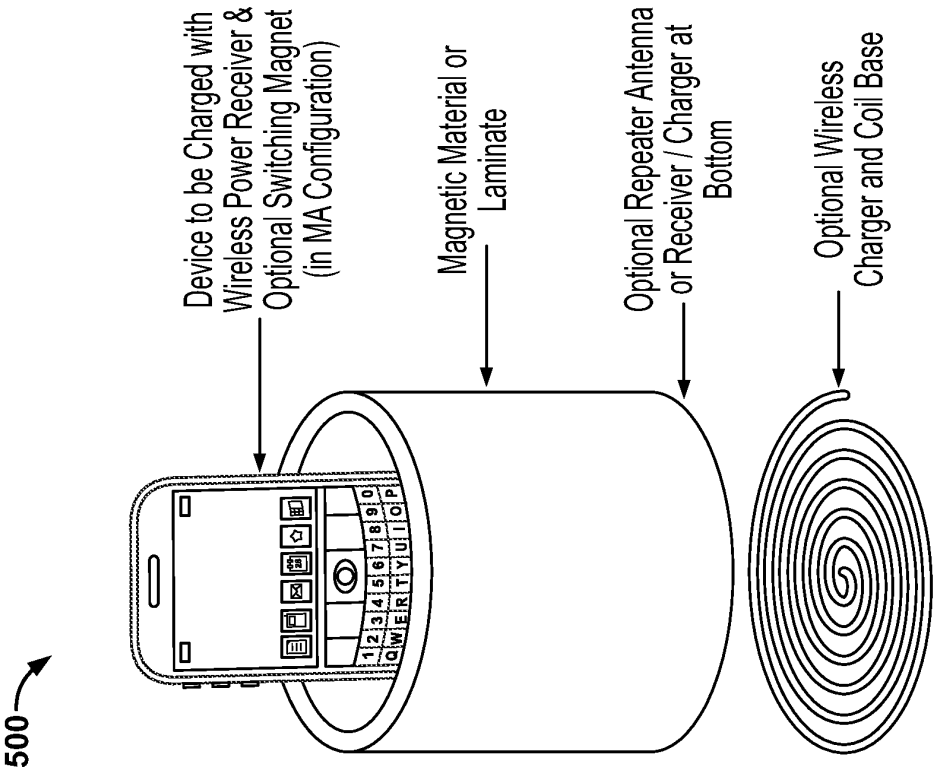

Device to be Charged with Wireless Power Receiver & Optional Switching Magnet (in MA Configuration)
Magnetic Material or Laminate
Optional Repeater Antenna or Receiver / Charger at Bottom
Optional Wireless Charger and Coil Base
500

FIG. 37

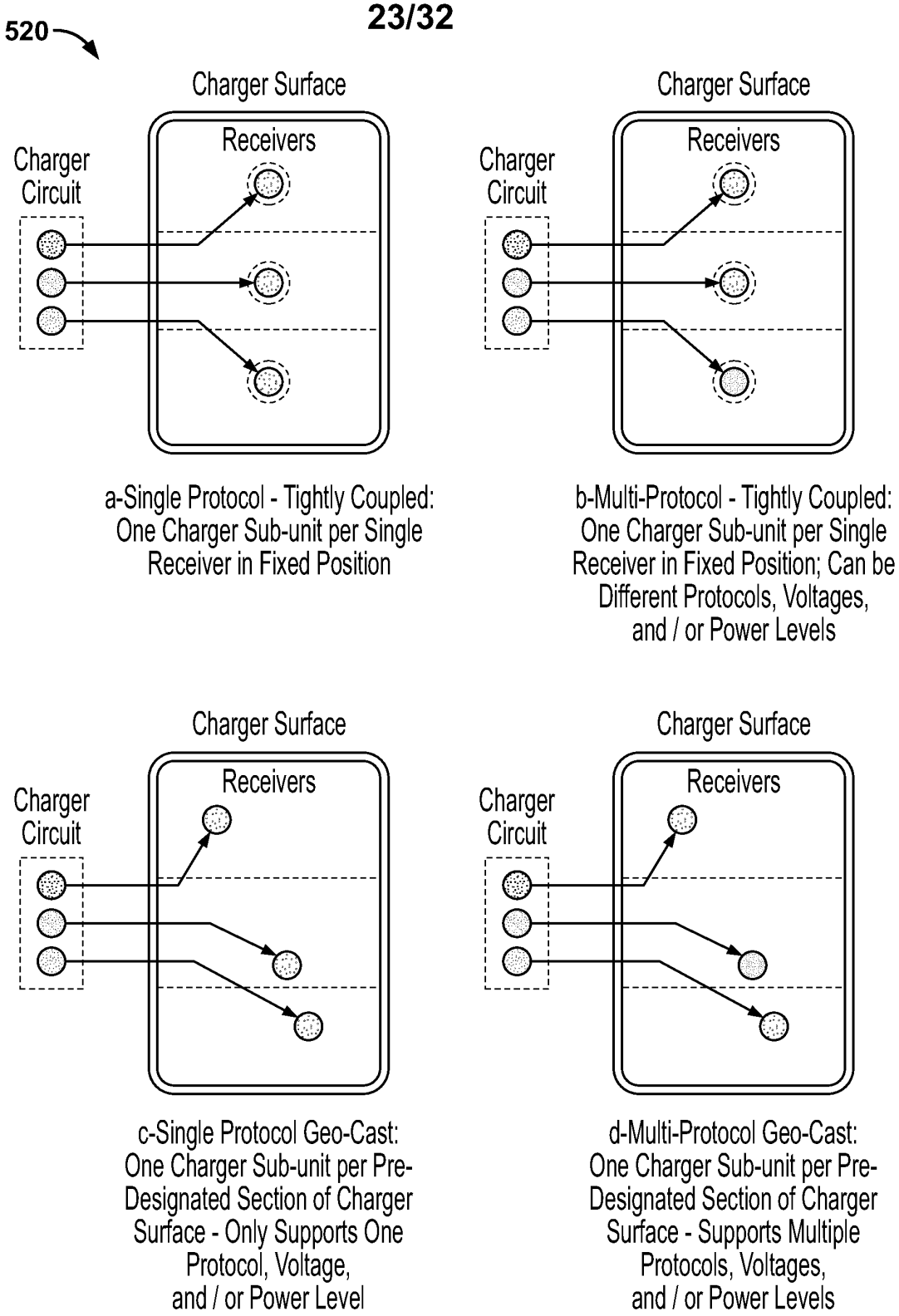

520
Charger Surface
Receivers
Charger Circuit
a-Single Protocol - Tightly Coupled: One Charger Sub-unit per Single Receiver in Fixed Position
Charger Surface
Receivers
Charger Circuit
b-Multi-Protocol - Tightly Coupled: One Charger Sub-unit per Single Receiver in Fixed Position; Can be Different Protocols, Voltages, and / or Power Levels
Charger Surface
Receivers
Charger Circuit
c-Single Protocol Geo-Cast: One Charger Sub-unit per Pre-Designated Section of Charger Surface - Only Supports One Protocol, Voltage, and / or Power Level
Charger Surface
Receivers
Charger Circuit
d-Multi-Protocol Geo-Cast: One Charger Sub-unit per Pre-Designated Section of Charger Surface - Supports Multiple Protocols, Voltages, and / or Power Levels

FIG. 39

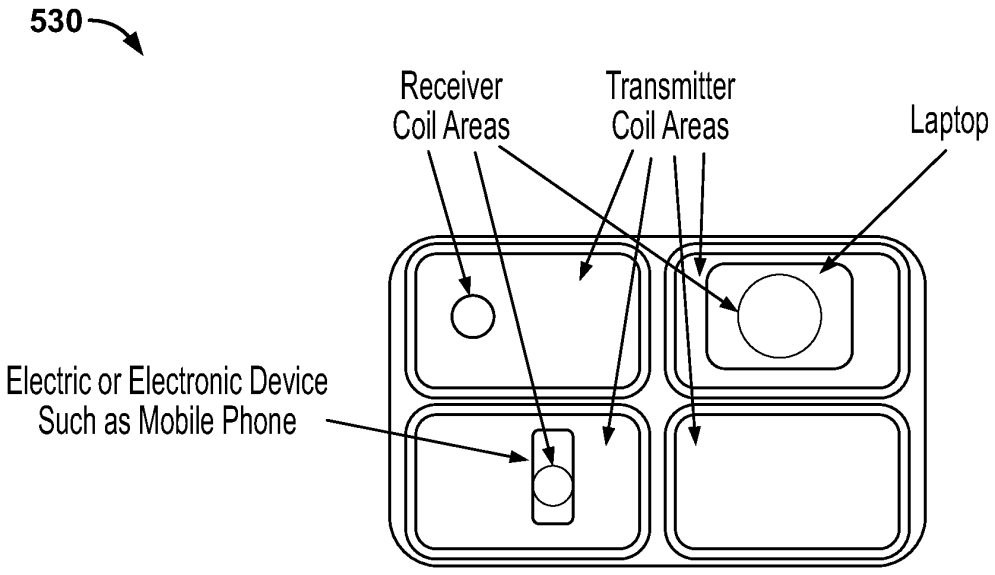

530
Receiver
Coil Areas
Transmitter
Coil Areas
Laptop
Electric or Electronic Device
Such as Mobile Phone

FIG. 40

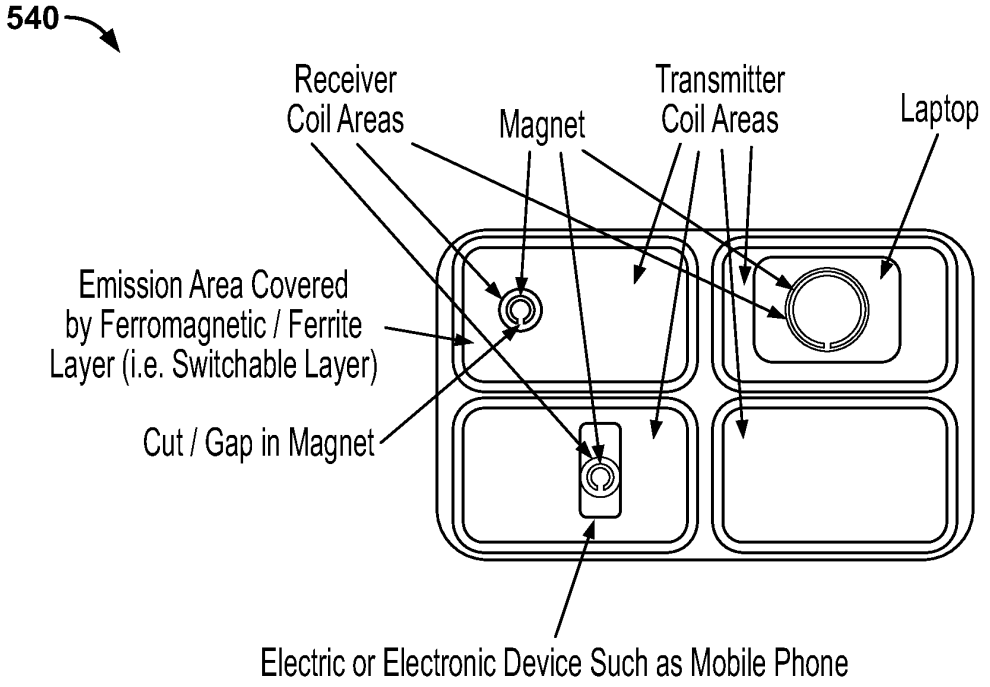

540
Receiver
Coil Areas
Magnet
Transmitter
Coil Areas
Laptop
Emission Area Covered
by Ferromagnetic / Ferrite
Layer (i.e. Switchable Layer)
Cut / Gap in Magnet
Electric or Electronic Device Such as Mobile Phone

FIG. 41

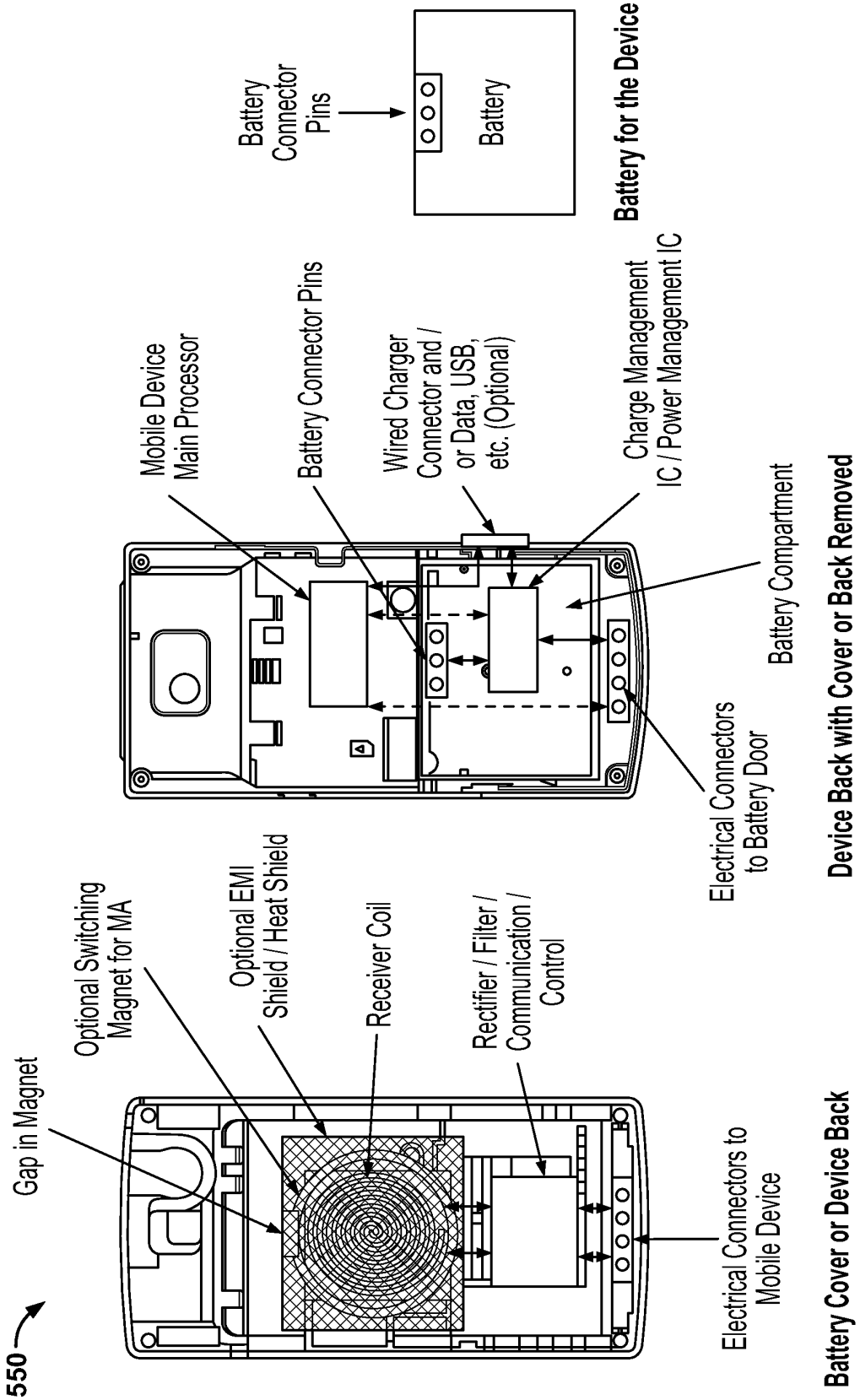

550
Gap in Magnet
Optional Switching Magnet for MA
Optional EMI Shield / Heat Shield
Receiver Coil
Rectifier / Filter / Communication / Control
Electrical Connectors to Mobile Device
Battery Cover or Device Back
Mobile Device Main Processor
Battery Connector Pins
Wired Charger Connector and / or Data, USB, etc. (Optional)
Charge Management IC / Power Management IC
Battery Compartment
Electrical Connectors to Battery Door
Device Back with Cover or Back Removed
Battery Connector Pins
Battery
Battery for the Device

FIG. 42

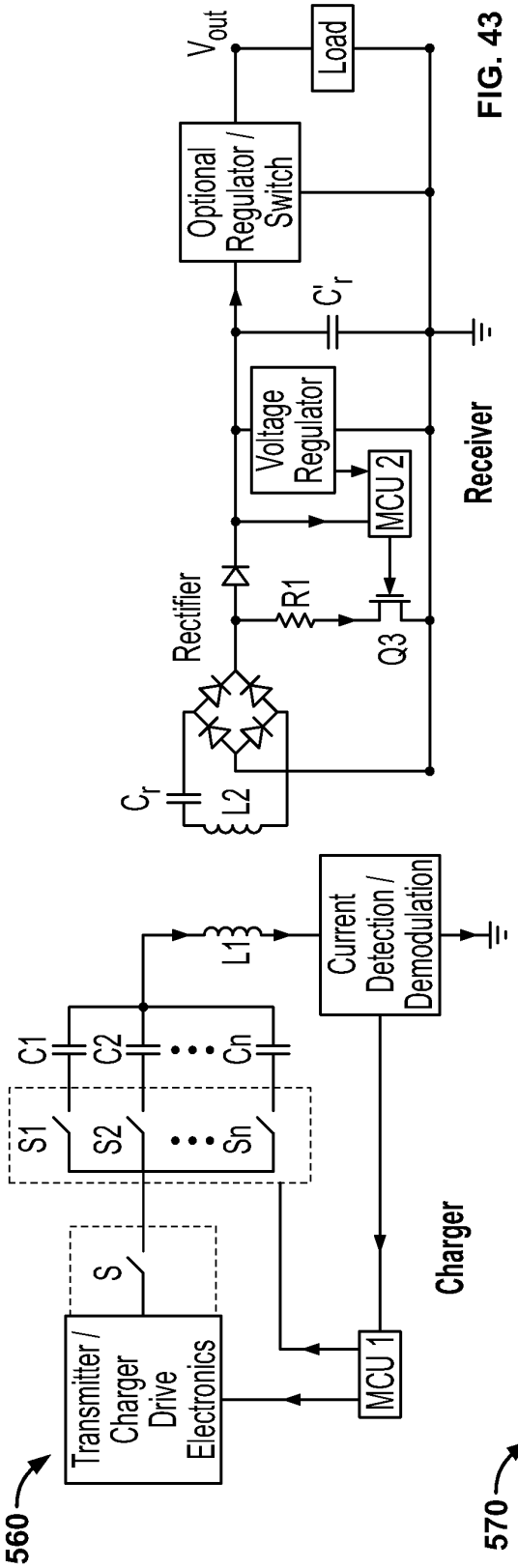

560
Transmitter / Charger Drive Electronics
S
S1
S2
Sn
C1
C2
Cn
L13
Current Detection / Demodulation
MCU 1
Charger
Rectifier
R1
Q3
Voltage Regulator
MCU 2
Receiver
Optional Regulator / Switch
Load
V_{out}
C'_r
C_r
L2

FIG. 43

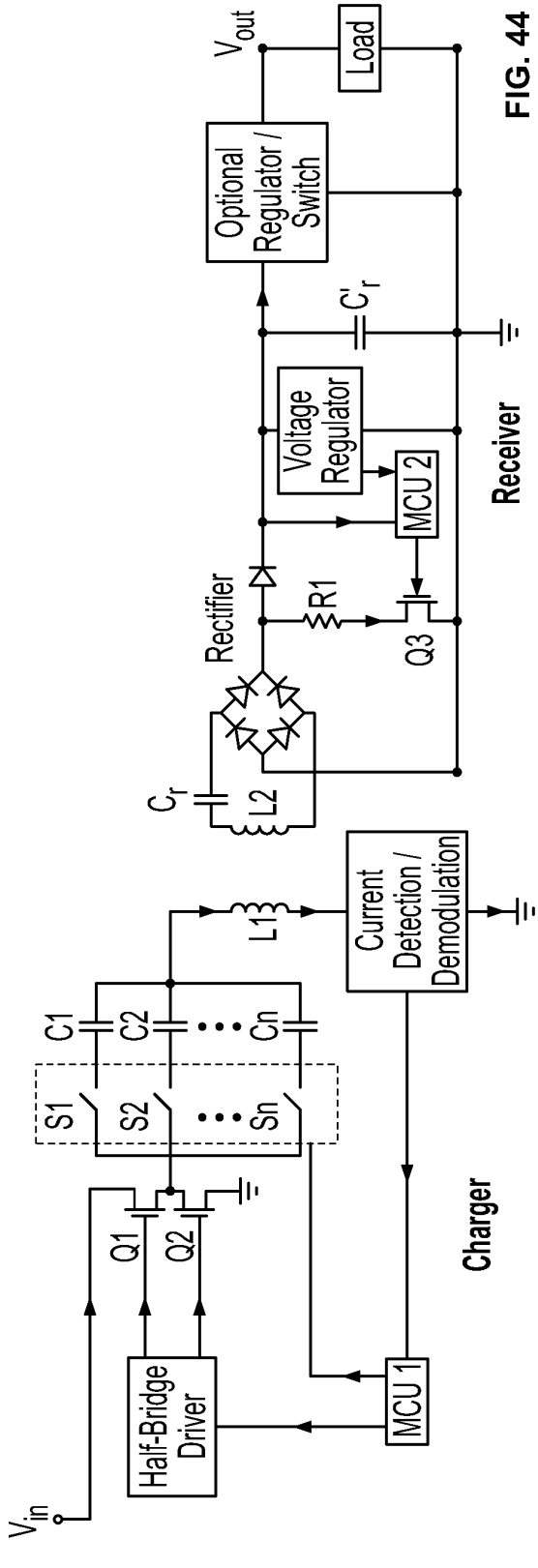

570
V_{in}
Half-Bridge Driver
Q1
Q2
S1
S2
Sn
C1
C2
Cn
L13
Current Detection / Demodulation
MCU 1
Charger
Rectifier
R1
Q3
Voltage Regulator
MCU 2
Receiver
Optional Regulator / Switch
Load
V_{out}
C'_r
C_r
L2

FIG. 44

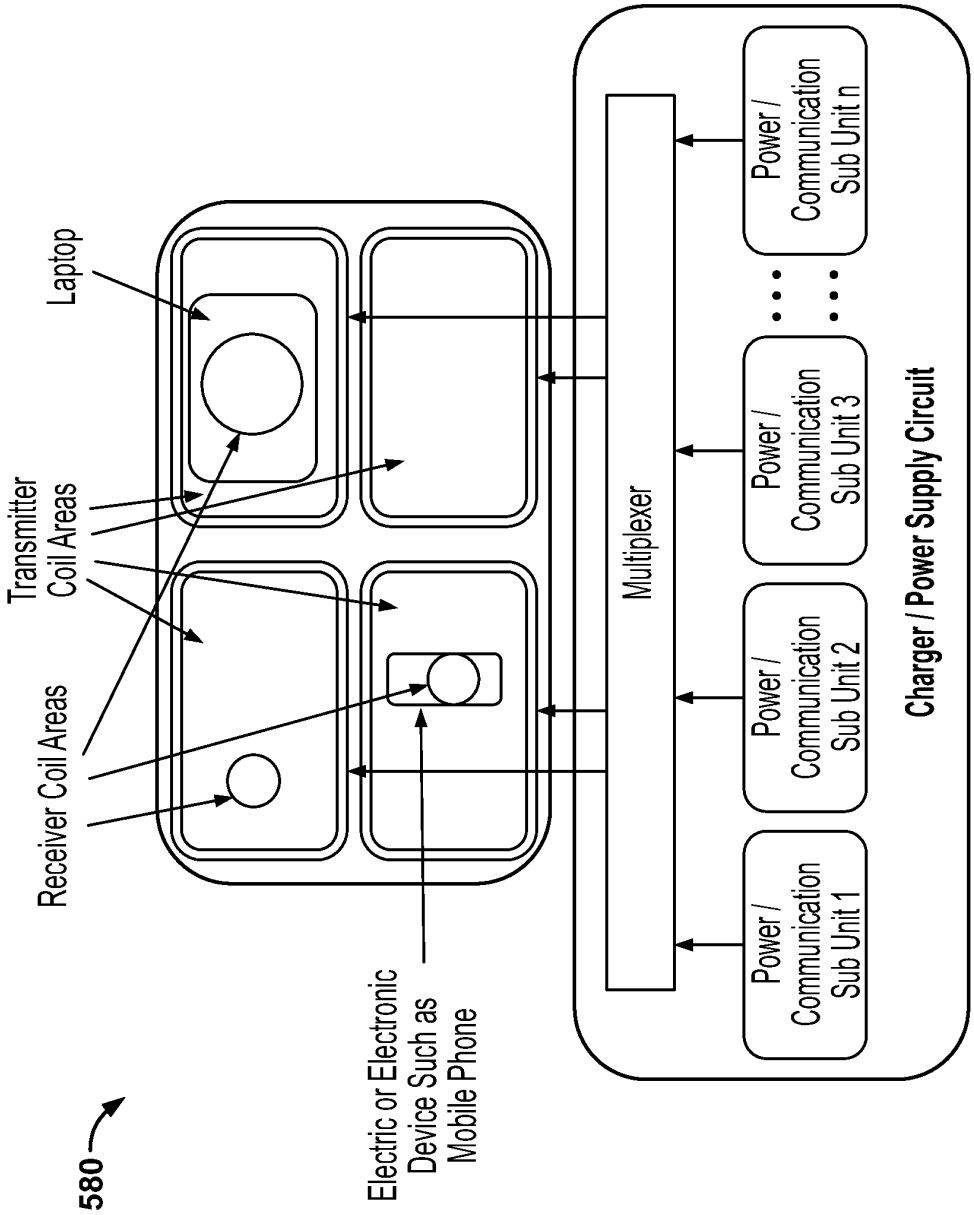

580
Laptop
Transmitter Coil Areas
Receiver Coil Areas
Electric or Electronic Device Such as Mobile Phone
Multiplexer
Power / Communication Sub Unit 1
Power / Communication Sub Unit 2
Power / Communication Sub Unit 3
Power / Communication Sub Unit n
Charger / Power Supply Circuit

FIG. 45

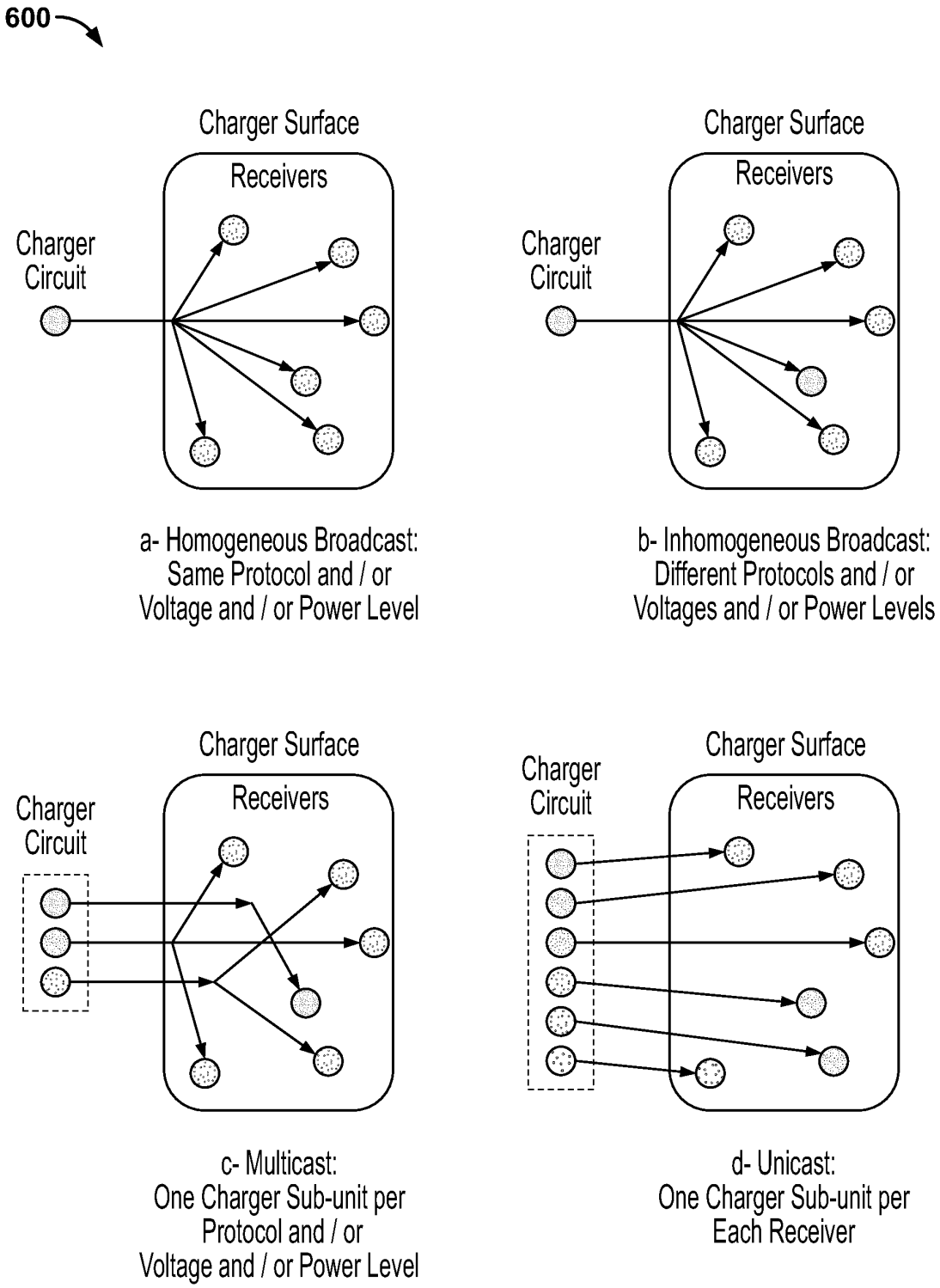

600
Charger Surface
Receivers
Charger Circuit
a- Homogeneous Broadcast: Same Protocol and / or Voltage and / or Power Level
Charger Surface
Receivers
Charger Circuit
b- Inhomogeneous Broadcast: Different Protocols and / or Voltages and / or Power Levels
Charger Surface
Receivers
Charger Circuit
c- Multicast: One Charger Sub-unit per Protocol and / or Voltage and / or Power Level
Charger Surface
Receivers
Charger Circuit
d- Unicast: One Charger Sub-unit per Each Receiver

FIG. 46

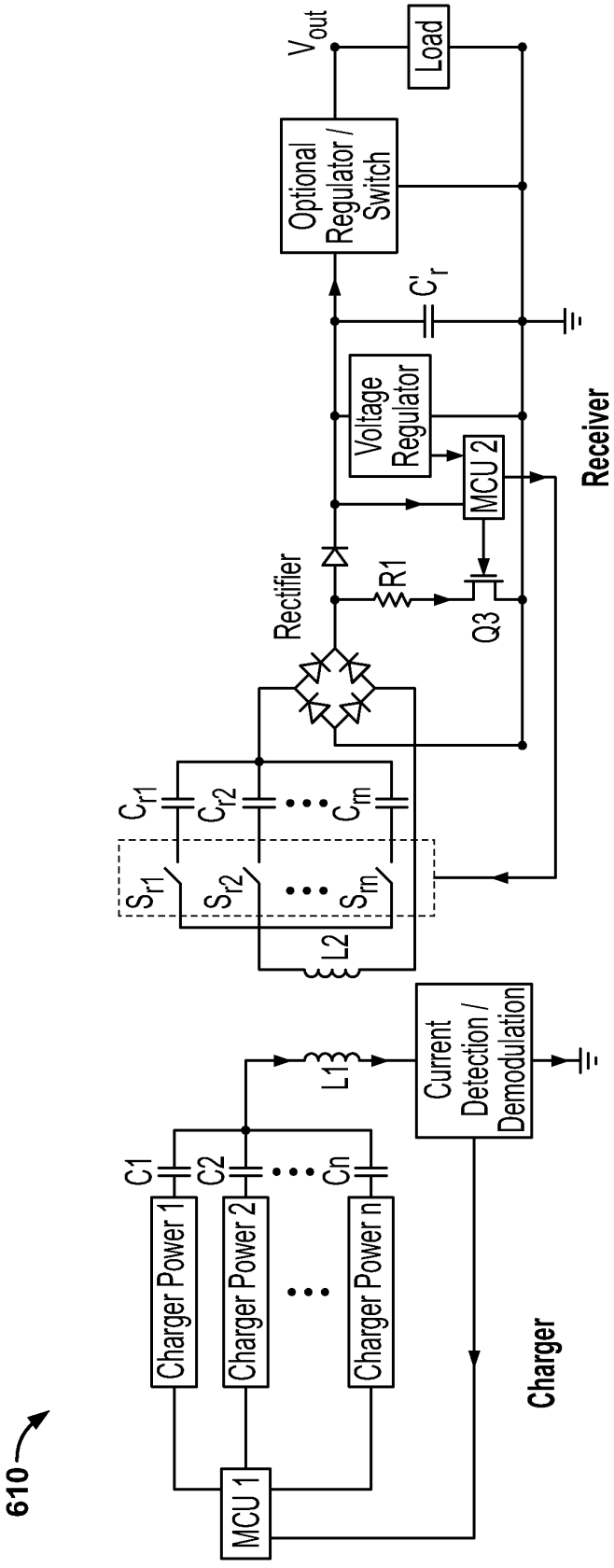

610
MCU 1
Charger Power 1
Charger Power 2
Charger Power n
C1
C2
Cn
L13
Current Detection / Demodulation
Charger
L2
Sr1
Sr2
Srm
Cr1
Cr2
Crm
Rectifier
R1
Q3
MCU 2
Voltage Regulator
C'r
Optional Regulator / Switch
Vout
Load
Receiver

FIG. 47

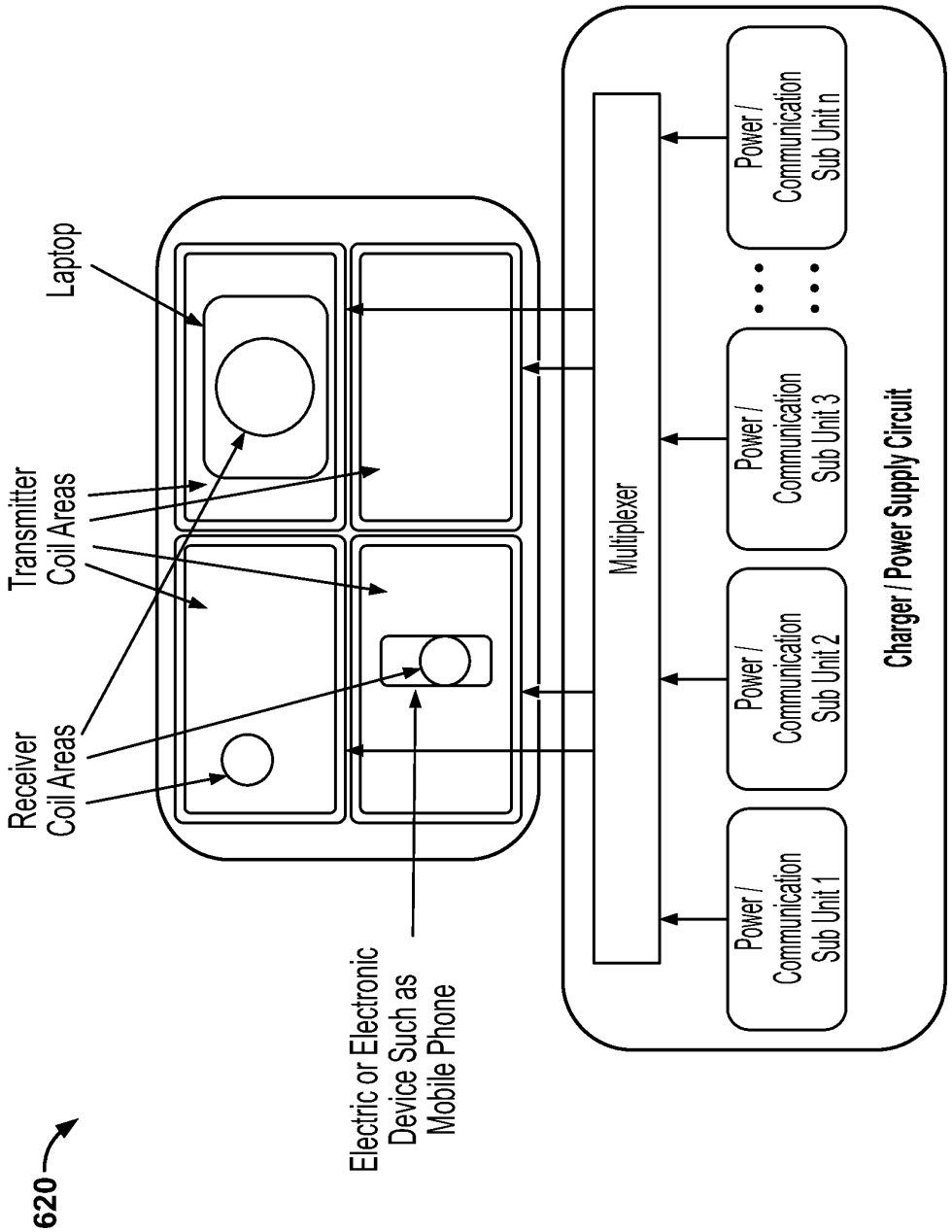

620
Laptop
Transmitter Coil Areas
Receiver Coil Areas
Electric or Electronic Device Such as Mobile Phone
Multiplexer
Power / Communication Sub Unit 1
Power / Communication Sub Unit 2
Power / Communication Sub Unit 3
Power / Communication Sub Unit n
Charger / Power Supply Circuit

FIG. 48

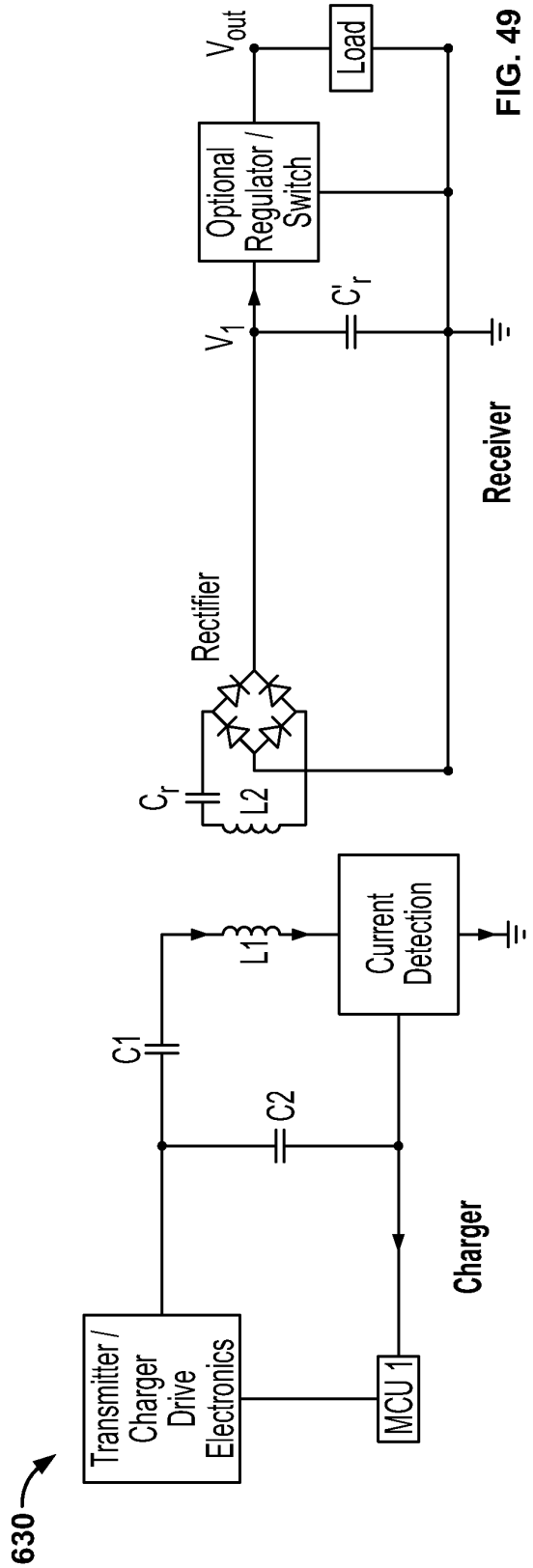

630
Transmitter / Charger Drive Electronics
MCU 1
C1
C2
L13
Current Detection
Charger
C_r
L2
Rectifier
V_1
C'_r
Optional Regulator / Switch
V_{out}
Load
Receiver

FIG. 49

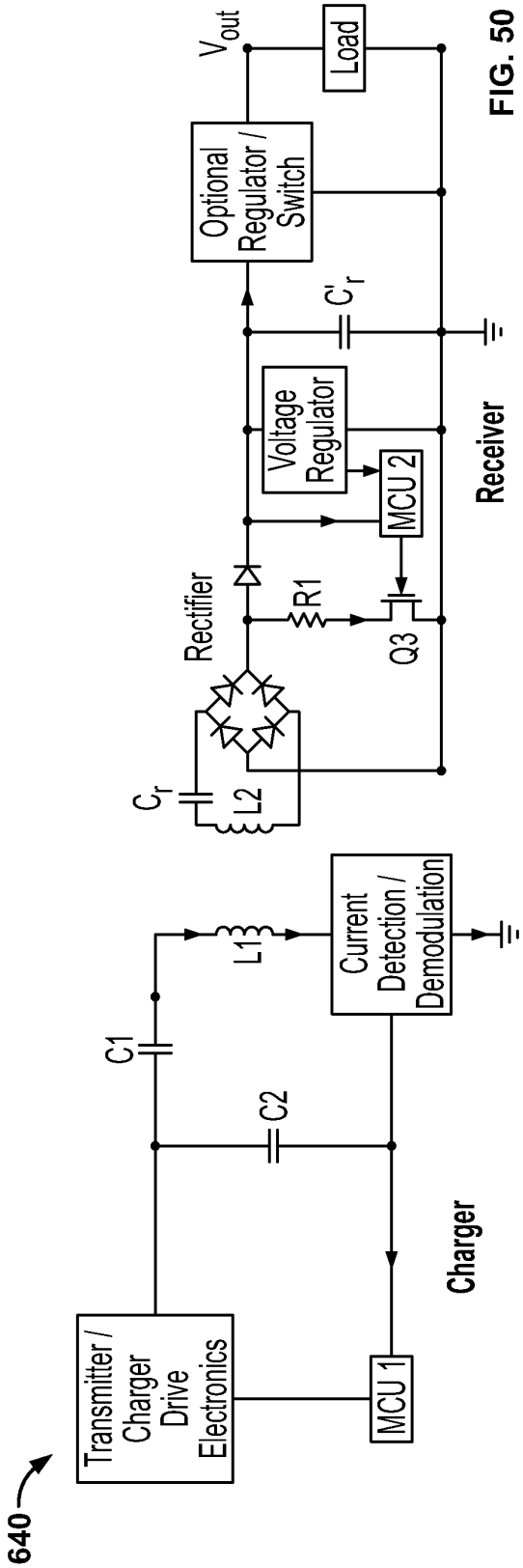

640
Transmitter / Charger Drive Electronics
MCU 1
C1
C2
L13
Current Detection / Demodulation
Charger
C_r
L2
Rectifier
R1
Q3
MCU 2
Voltage Regulator
C'_r
Optional Regulator / Switch
V_{out}
Load
Receiver

FIG. 50

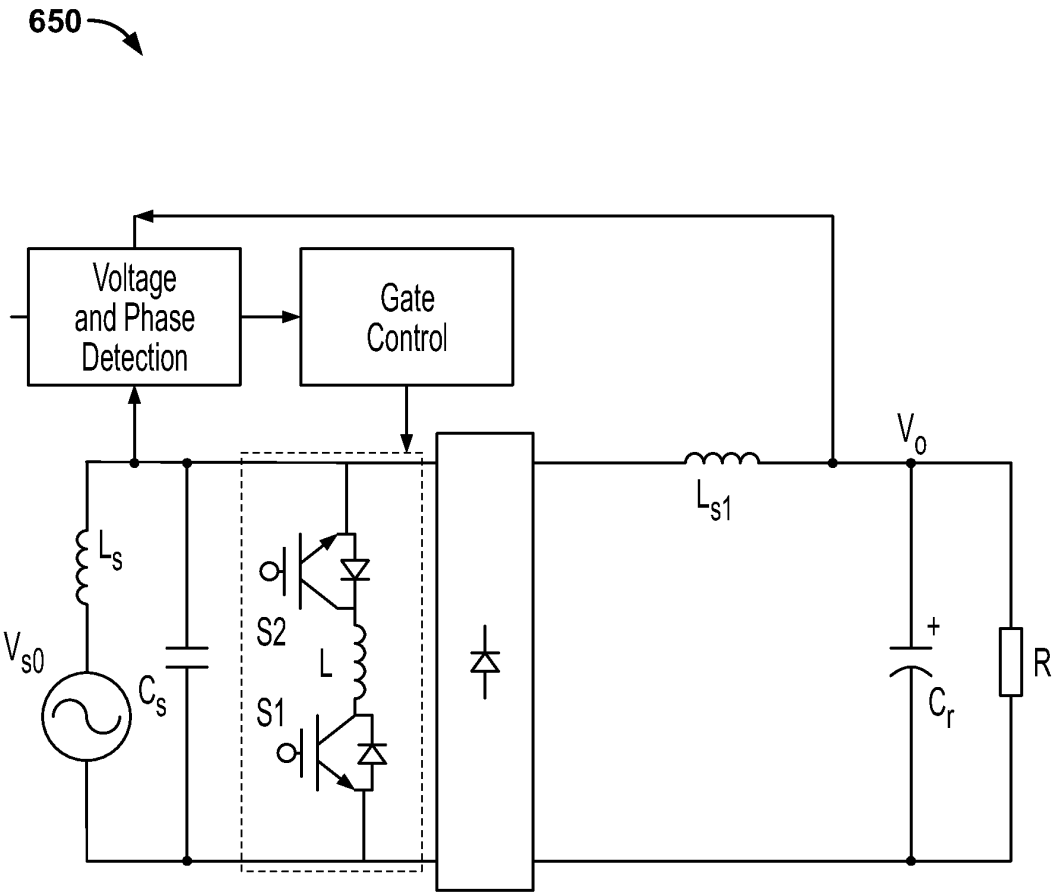

650
Voltage and Phase Detection
Gate Control
V_o
L_{s1}
L_s
V_{s0}
C_s
S2
L
S1
+
C_r
R

FIG. 51

Electronic Patent Application Fee Transmittal

Application Number:	13352096
Filing Date:	17-Jan-2012
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Karl Kenna/narissa besada
Attorney Docket Number:	AFPA-01032US0

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	380	380
Utility Search Fee	1111	1	620	620
Utility Examination Fee	1311	1	250	250
Pages:				
Claims:				
Claims in excess of 20	1202	19	60	1140
Miscellaneous-Filing:				
Late filing fee for oath or declaration	1051	1	130	130

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 2 months with $0 paid	1252	1	560	560
Miscellaneous:				
		Total in USD ($)		**3080**

Electronic Acknowledgement Receipt	
EFS ID:	12890188
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01032US0
Receipt Date:	30-MAY-2012
Filing Date:	17-JAN-2012
Time Stamp:	16:26:50
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$3080
RAM confirmation Number	3493
Deposit Account	061325
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	afpa_1032us0_Declaration_signed.pdf	836918 f428a15fd6e297fd6d54755337fd601a1c6aa1fc	no	3
Warnings:					
Information:					
2	Extension of Time	afpa_1032us0_PetitionExtensionTime.pdf	290667 efeb69111891ddc82894a0b84058b176478952ec	no	2
Warnings:					
Information:					
3	Drawings-only black and white line drawings	afpa_1032us0_replacement_figures.pdf	1686121 8ab4c7eaf75c95ee6d3867a9a6b219abb5dc570d	no	32
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	40470 a2233493a8f2c8d38262a61b208deebd5c2e5931	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2854176		

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<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/352,096	01/17/2012	2816	0.00	AFPA-01032US0	39	3

CONFIRMATION NO. 4453

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

FILING RECEIPT

OC000000052245327

Date Mailed: 01/30/2012

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Afshin Partovi, Sunnyvale, CA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/433,883 01/18/2011
and claims benefit of 61/546,316 10/12/2011
and claims benefit of 61/478,020 04/21/2011

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 01/27/2012

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/352,096**

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No

Title

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Preliminary Class

327

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/352,096

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	380
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	620
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	39 minus 20 =	* 19			OR	x 60 =	1140
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 250 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2390

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/352,096	01/17/2012	Afshin Partovi	AFPA-01032US0

CONFIRMATION NO. 4453

23910
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14TH FLOOR
SAN FRANCISCO, CA 94108

FORMALITIES LETTER

OC000000052245328

Date Mailed: 01/30/2012

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  *Applicant must submit $**380** to complete the basic filing fee for a non-small entity. If appropriate, applicant may make a written assertion of entitlement to small entity status and pay the small entity filing fee (37 CFR 1.27).*
- The oath or declaration is missing.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.
  Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.

The application is informal since it does not comply with the regulations for the reason(s) indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - Numbers, letters, and reference characters on the drawings must measure at least 0.32 cm (1/8 inch) in height. See Figure(s) 6-7, 12-13, 21, 23-24, 31 & 35.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Additional claim fees of $**1140** as a non-small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- A surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of $**130** for a non-small entity, must be submitted.

SUMMARY OF FEES DUE:

Total fee(s) required within **TWO MONTHS** from the date of this Notice is $**2520** for a non-small entity
- $**380** Statutory basic filing fee.
- $**130** Surcharge.
- The application search fee has not been paid. Applicant must submit $**620** to complete the search fee.
- The application examination fee has not been paid. Applicant must submit $**250** to complete the examination fee for a non-small entity.
- Total additional claim fee(s) for this application is $**1140**
  - $**1140** for **19** total claims over 20.

Replies should be mailed to:

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Commissioner for Patents
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Alexandria VA 22313-1450

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM

Inventor: Afshin Partovi

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Claim of Priority:

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application No. 61/433,883, titled "SYSTEM AND METHOD FOR MODULATING THE PHASE AND AMPLITUDE OF AN ELECTROMAGNETIC WAVE IN MULTIPLE DIMENSIONS", filed January 18, 2011; U.S. Provisional Patent Application No. 61/478,020, titled "SYSTEM AND METHOD FOR MODULATING THE PHASE AND AMPLITUDE OF AN ELECTROMAGNETIC WAVE IN MULTIPLE DIMENSIONS", filed April 21, 2011; and U.S. Provisional Patent Application No. 61/546,316, titled "SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM", filed October 12, 2011, each of which applications are incorporated by reference herein.

Field of Invention:

[0002] Embodiments of the invention are generally related to systems and methods for modifying the magnitude and/or phase of an electromagnetic field in one or multiple dimensions. Applications for use in charging or powering multiple devices with a wireless power charger system are also described.

Background:

[0003] Wireless technologies for powering and charging mobile and other electronic or electric devices, batteries and vehicles have been developed. These systems generally use a wireless charger or transmitter system, and a wireless receiver in combination, to provide a means for transfer of power across a distance. For safe and efficient operation of basic wireless charging systems, the two coil parts of the system are typically aligned and of comparable or

similar size. Such operation typically requires the user to place the device or battery to be charged in a specific location with respect to the charger. To enable better ease of use, it is desirable that the receiver can be placed on a larger surface area charger without the need for specific alignment of the position of the receiver. It is further desirable to be able to charge or power multiple devices of similar or different power and voltage requirements or operating with different wireless charging protocols on or near the same surface. These are the general areas that embodiments of the invention are intended to address.

Summary:

[0004] Described herein are systems and methods of modulating the phase and amplitude of an electromagnetic field in one or multiple (e.g. one, two or three) dimensions. Applications include beam shaping, beam forming, phase array radar, beam steering, etc. and inductive charging and power, and particularly usage in mobile, electronic, electric, lighting, or other devices, batteries, power tools, kitchen, industrial applications, vehicles, and other usages. Embodiments of the invention can also be applied generally to power supplies and other power sources and chargers, including systems and methods for improved ease of use and compatibility and transfer of wireless power to mobile, electronic, electric, lighting, or other devices, batteries, power tools, kitchen, military, industrial applications and/or vehicles.

Brief Description of the Figures:

[0005] **Figure 1** illustrates an exemplary charger and receiver, in accordance with an embodiment.

[0006] **Figure 2** illustrates an exemplary circuit, in accordance with an embodiment.

[0007] **Figure 3** illustrates another exemplary circuit, in accordance with an embodiment.

[0008] **Figure 4** illustrates another exemplary circuit, in accordance with an embodiment.

[0009] **Figure 5** illustrates another exemplary circuit, in accordance with an embodiment.

[0010] **Figure 6** illustrates another exemplary circuit, in accordance with an embodiment.

[0011] **Figure 7** illustrates another exemplary circuit, in accordance with an embodiment.

[0012] **Figure 8** illustrates a typical battery charge cycle, in accordance with an

embodiment.

[0013] **Figure 9** illustrates a typical wireless power system operation, in accordance with an embodiment.

[0014] **Figure 10** illustrates a communication process and regulation of power and/or other functions, in accordance with an embodiment.

[0015] **Figure 11** illustrates configurations for a tightly coupled power transfer system with individual transmitter coils of different size, in accordance with an embodiment.

[0016] **Figure 12** illustrates a coil, in accordance with an embodiment.

[0017] **Figure 13** illustrates a resulting calculated magnetic field, in accordance with an embodiment.

[0018] **Figure 14** illustrates the resonance in power transfer, in accordance with an embodiment.

[0019] **Figure 15** illustrates the magnetization curves of a number of Ferromagnetic materials, in accordance with an embodiment.

[0020] **Figure 16** illustrates the hysteresis curve for a hard ferromagnetic material such as steel, in accordance with an embodiment.

[0021] **Figure 17** illustrates the real and imaginary part of the permeability of a ferromagnetic material layer, in accordance with an embodiment.

[0022] **Figure 18** illustrates the magnetization curves of a high permeability proprietary soft magnetic ferrite material, in accordance with an embodiment.

[0023] **Figure 19** illustrates a large area transmitter coil covered by a ferromagnetic, ferrite, or other magnetic material, in accordance with an embodiment.

[0024] **Figure 20** illustrates the use of a ferrite magnetic material or switching layer above the coil to guide and shield the flux, in accordance with an embodiment.

[0025] **Figure 21** illustrates the use of Litz wire wrapped around the core to create a solenoid type receiver, in accordance with an embodiment.

[0026] **Figure 22** illustrates examples of magnets that can be used, in accordance with an embodiment.

[0027] **Figure 23** illustrates a magnetic aperture by incorporating a permanent and/or electromagnet into the receiver, in accordance with an embodiment.

[0028] **Figure 24** illustrates magnetization curves of a soft ferrite material are shown at different operating temperatures, in accordance with an embodiment.

[0029] **Figure 25** illustrates a magnetic aperture geometry for receivers of dissimilar size, in accordance with an embodiment.

[0030] **Figure 26** illustrates various multi-pole magnets, in accordance with an embodiment.

[0031] **Figure 27** illustrates various ring magnets, in accordance with an embodiment.

[0032] **Figure 28** illustrates examples of multi-pole ring or arc magnets with cuts or gaps in the circular pattern, in accordance with various embodiments, in accordance with an embodiment.

[0033] **Figure 29** illustrates a wire or cable available in a variety of gauges, in accordance with an embodiment.

[0034] **Figure 30** illustrates a saturable reactor or magnetic amplifier, in accordance with an embodiment.

[0035] **Figure 31** illustrates a configuration that includes a charger switching magnet, and optional charger and/or receiver shielding layers, in accordance with an embodiment.

[0036] **Figure 32** illustrates a system that uses two coils for the charger and two for the receiver, in accordance with an embodiment.

[0037] **Figure 33** illustrates a configuration where one or more repeaters are inserted between the charger and receiver resonant antennas, in accordance with an embodiment.

[0038] **Figure 34** illustrates a layer comprising a magnetic or ferrite or other material added to the charger to limit the emission from the charger into space, in accordance with an embodiment.

[0039] **Figure 35** illustrates the use of one or more repeater antennas and one or more magnetic / switching layers, in accordance with an embodiment.

[0040] **Figure 36** illustrates another use of one or more repeater antennas and one or more magnetic / switching layers, in accordance with an embodiment.

[0041] **Figure 37** illustrates a charger coil that is flat with a magnetic or switching layer formed in the shape of a cup, cup holder cylinder or other bowl, in accordance with an embodiment.

[0042] **Figure 38** illustrates how the charger coil can be wrapped around the vertical cylinder body while the inside of the cup uses the magnetic solid material, layer or laminated film, in accordance with an embodiment.

[0043] **Figure 39** illustrates architectures where the charger circuit comprises sub circuits or units whereby each sub-unit is responsible for powering or charging and/or communicating with one power receiver, in accordance with an embodiment.

[0044] **Figure 40** illustrates a geometry where multiple transmitter coils cover different areas of a multi-charger / power supply, in accordance with an embodiment.

[0045] **Figure 41** illustrates use of a magnetic layer and creation of magnetic coupling or a magnetic aperture, in accordance with an embodiment.

[0046] **Figure 42** illustrates a mobile device such as a mobile phone with a receiver coil and receiver circuit integrated into the back cover or battery door, in accordance with an embodiment.

[0047] **Figure 43** illustrates a circuit wherein the charger includes capacitors and switches, in accordance with an embodiment.

[0048] **Figure 44** illustrates a resonant converter architecture, in accordance with an embodiment.

[0049] **Figure 45** illustrates a geo-cast architecture, in accordance with an embodiment.

[0050] **Figure 46** illustrates architectures for full positioning freedom, in accordance with an embodiment.

[0051] **Figure 47** illustrates a multi-receiver system, in accordance with an embodiment.

[0052] **Figure 48** illustrates the use of multiple charger sections, in accordance with an embodiment.

[0053] **Figure 49** illustrates a simplified system for wireless transmission of power with constant output voltage, in accordance with an embodiment.

[0054] **Figure 50** illustrates a system that includes a feedback channel, in accordance with an embodiment.

[0055] **Figure 51** illustrates use of a variable inductor in parallel to the charger and/or receiver coil, in accordance with an embodiment.

Detailed Description:

[0056] With the proliferation of electrical and electronic devices and vehicles (which are considered examples of devices herein), simple and universal methods of providing power and or charging of these devices is becoming increasingly important.

[0057] The term device, product, or battery is used herein to include any electrical, electronic, mobile, lighting, or other product, batteries, power tools, industrial, kitchen, military or medical products and vehicles or movable machines such as robots whereby the product, part, or component is powered by electricity or an internal or external battery and/or can be powered or charged externally or internally by a generator or solar cell, fuel cell, hand or other mechanical crank or alike. A product or device can also include an attachable or integral skin, case, battery door or attachable or add-on or dongle type of receiver component to enable the user to power or charge the product or device.

[0058] In accordance with various embodiments, an induction power transmitter employs a magnetic induction coil(s) transmitting energy to a receiving coil(s) in a device or product, case, battery door, or attachable or add-on component including attachments such as a dongle or a battery inside or outside of device or attached to device through a connector and/or a wire, or stand-alone placed near the power transmitter platform. The receiver can be an otherwise incomplete device that receives power wirelessly and is intended for installation or attachment in or on the final product, battery or device to be powered or charged, or the receiver can be a complete device intended for connection to a device, product or battery directly by a wire or wirelessly.

[0059] As used herein, the term wireless power, charger, transmitter or inductive power and charger are used interchangeably. In accordance with an embodiment, the wireless charger may be a flat or curved surface or part that can provide energy wirelessly to a receiver. It can also be constructed of flexible materials and/or coils or even plastic electronics to enable mechanical flexibility and bending or folding to save space or for conformity to non-flat surfaces. The wireless charger may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle, truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary (non-rechargeable) or rechargeable battery, solar cell, fuel cell, mechanical (hand crank, wind source, etc.), nuclear source or other or another wireless charger or power supply or a combination thereof. In addition, the wireless charger may be powered by a part such as a rechargeable battery which is itself in turn recharged by another source such as an AC or DC power source, vehicle, boat or ship or airplane outlet or vehicle, boat or ship or airplane itself, solar cell, fuel cell, wind or mechanical (hand crank, wind, etc.) or nuclear source, etc. or a combination thereof. In addition, in cases where the wireless charger is powered by a rechargeable source such as a battery, the battery can also be itself in turn inductively charged by another wireless charger. The wireless charger may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, etc., airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, etc., cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, etc., industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, stereo systems, etc. The wireless charger may also have other functions built in or be constructed such that it is modular and

additional capabilities / functions can be added as needed.

[0060] Some of these capabilities / functions include an ability to provide higher power, charge more devices, exchange the top surface or exterior box or cosmetics, operate by internal power as described above through use of a battery and/or renewable source such as solar cells, communicate and/or store data from a device, provide communication between the device and other devices or the charger and/or a network, etc. An example is a basic wireless charger that has the ability to be extended to include a rechargeable battery pack to enable operation without external power. Another example may be a wireless charger containing or one or more speakers and/or microphone and Bluetooth, WiFi, etc. connectivity as a module that would enhance the basic charger to allow a mobile phone or music player being charged on the charger to play / stream music or sound or carry out a hands free conversation over the speakers and/or microphone wirelessly through a Bluetooth, WiFi, or other connection. Another example may be a charger product or computer or laptop, or display or TV etc. that also contains a disk drive, solid state memory or other storage device and when a device is placed on the charger, data connectivity through the charger, Bluetooth, NFC, Felica, WiFi, Zigbee, Wireless USB, etc. is also established for transfer, synchronizing or update of data or programs occurs to download / upload info, display or play music or video or synchronize data. One exemplary use may be a camera or phone charger whereby many other combinations of products and capabilities may be enabled in combination of charging and other functions. Examples of products or devices powered or charged by the induction transmitter and receiver include but are not limited to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered

devices or products. The receiver or the charger could also be incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device etc. to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle (such as, e.g. causing a display case or packaging to display promotional information or instructions, or to illuminate) and/or to use the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle, etc. to power or charge another device or component somewhere on or nearby. It is important to note that the product or device does not necessarily have to be portable and/or contain a battery to take advantage of induction or wireless power transfer. For example, a lighting fixture or a computer monitor that is typically powered by an AC outlet or a DC power supply may be placed on a table top and receive power wirelessly. The wireless receiver may be a flat or curved surface or part that can receive energy wirelessly from a charger. The receiver and/or the charger can also be constructed of flexible materials and/or coils or even plastic electronics to enable mechanical flexibility and bending or folding to save space or for conformity to non-flat surfaces.

[0061] In accordance with various embodiments, many of these devices contain internal batteries, and the device may or may not be operating during receipt of power. Depending on the degree of charge status of the battery or its presence and the system design, the applied power may provide power to the device, charge its battery or a combination of the above. The terms charging and/or power are used interchangeably herein to indicate that the received power can be used for either of these cases or a combination thereof. Unless specifically described, these terms are therefore used interchangeably. Also, unless specifically described herein, in accordance with various embodiments the terms charger power supply and transmitter are used interchangeably.

[0062] As shown in **Figure 1**, in accordance with an embodiment, a wireless charger or power system 100 comprises a first charger or transmitter part, and a second receiver part. The charger or transmitter can generate a repetitive power signal pattern (such as a sinusoid or square wave from 10's of Hz to several MHz or even higher, but typically in the 100 kHz to several MHz range) with its coil drive circuit and a coil or antenna for transmission of the power. The charger or transmitter typically also includes a communication and regulation / control system that detects a receiver and/or turns the applied power on or off and/or modify the amount of applied power by mechanisms such as changing the amplitude, frequency or duty cycle, etc. or a change in the resonant condition by varying the impedance (capacitance or inductance) of the charger or a combination thereof of the applied power signal to the coil or

antenna. In accordance with an embodiment, the charger can also be the whole or part of the electronics, coil, shield, or other part of the system required for transmitting power wirelessly. The electronics may comprise discrete components or microelectronics that when used together provide the wireless charger functionality, or comprise an Application Specific Integrate Circuit (ASIC) chip or chipset that is specifically designed to function as the whole or a substantial part of the electronics for wireless charger system.

[0063] The second part of the system is a receiver that includes a coil or antenna to receive power, a method for change of the received AC voltage to DC voltage, such as rectification and smoothing with one or more rectifiers or a bridge or synchronous rectifier, etc. and one or more capacitors. In cases where the voltage at the load does not need to be kept within a tight tolerance or can vary regardless of the load resistance or the resistance of the load is always constant, the rectified and smoothed output of the receiver can be directly connected to a load. Examples of this situation may be in lighting applications, applications where the load is a constant resistance such as a heater or resistor, etc. In these cases, the receiver system could be quite simple and inexpensive. In many other cases, the resistance or impedance of the load changes during operation. This includes cases where the receiver is connected to a device whose power needs may change during operation or when the receiver is used to charge a battery. In these cases, the output voltage may need to be regulated so that it stays within a range or tolerance during the variety of operating conditions. In these cases, the receiver may optionally include a regulator such as linear, buck, boost or buck boost, etc. regulator and/or switch for the output power. Additionally, the receiver may include a method for the receiver to communicate with the charger. The receiver may optionally include a reactive component (inductor or capacitor) to increase the resonance of the system and a switch to allow switching between a wired and wireless method of charging or powering the product or battery. The receiver may also include optional additional features such as including Near Field Communication, Bluetooth, WiFi, RFID or other communication and/or verification technology.

[0064] The charger or transmitter coil and the receiver coil can have any shape desired and may be constructed of PCB, wire, Litz wire, or a combination thereof. To reduce resistance, the coils can be constructed of multiple tracks or wires in the PCB and/or wire construction. For PCB construction, the multiple layers can be in different sides of a PCB and/or different layers and layered / designed appropriately to provide optimum field pattern, uniformity, inductance, and/or resistance or Quality factor (Q) for the coil. Various materials can be used for the coil conductor such as different metals and/or magnetic material or plastic conductors, etc. Typically, copper with low resistivity may be used. The design should also take into account the

skin effect of the material used at the frequency of operation to preferably provide low resistance.

[0065] The receiver can be an integral part of a device or battery as described above, or can be an otherwise incomplete device that receives power wirelessly and is intended for installation or attachment in or on the final product, battery or device to be powered or charged, or the receiver can be a complete device intended for connection to a device, product or battery directly by a wire or wirelessly. Examples include replaceable covers, skins, cases, doors, jackets, surfaces, etc for devices or batteries that would incorporate the receiver or part of the receiver and the received power would be directed to the device through connectors in or on the device or battery or the normal wired connector (or power jack) of the device or battery. The receiver may also be a part or device similar to a dongle that can receive power on or near the vicinity of a charger and direct the power to a device or battery to be charged or powered through a wire and/or appropriate connector. Such a receiver may also have a form factor that would allow it to be attached in an inconspicuous manner to the device such as a part that is attached to the outer surface at the bottom, front, side, or back side of a laptop, netbook, tablet, phone, game player, or other electronic device and route the received power to the input power connector or jack of the device. The connector of such a receiver may be designed such that it has a pass through or a separate connector integrated into it so that a wire cable for providing wired charging / power or communication can be connected to the connector without removal of the connector thus allowing the receiver and its connector to be permanently or semi-permanently be attached to the device throughout its operation and use. Many other variations of the receiver implementation are possible and these examples are not meant to be exhaustive. In accordance with an embodiment, the receiver can also be the whole or part of the electronics, coil, shield, or other part of the system required for receiving power wirelessly. The electronics may comprise discrete components or microcontrollers that when used together provide the wireless receiver functionality, or comprise an Application Specific Integrate Circuit (ASIC) chip or chipset that is specifically designed to function as the whole or a substantial part of the electronics for wireless receiver system.

[0066] Optional methods of communication between the charger and receiver can be provided through the same coils as used for transfer of power, through a separate coil, through an RF or optical link, through RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), etc. or through such protocols as defined by the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocol, or combination thereof.

[0067] In the case that communication is provided through the power transfer coil, one method for the communication is to modulate a load in the receiver to affect the voltage in the receiver coil and therefore create a modulation in the charger coil parameters that can be detected through monitoring of its voltage or current. Other methods can include frequency modulation by combining the received frequency with a local oscillator signal or inductive, capacitive, or resistive modulation of the output of the receiver coil.

[0068] The communicated information can be the output voltage, current, power, device or battery status, validation ID for receiver, end of charge or various charge status information, receiver battery, device, or coil temperature, and/or user data such as music, email, voice, photos or video, or other form of digital or analog data used in a device. It can also be a pattern or signal or change in the circuit conditions that is transmitted or occurs to simply notify the presence of the receiver nearby.

[0069] In accordance with an embodiment, the data communicated can be any one or more of the information detailed herein, or the difference between these values and the desired value or simple commands to increase or decrease power or simply one or more signals that would confirm presence of a receiver or a combination of the above. In addition, the receiver can include other elements such as a DC to DC converter or regulator such as a switching, buck, boost, buck / boost, or linear regulator. The receiver can also include a switch between the DC output of the receiver coil and the rectification and smoothing stage and its output or the output of the regulator stage to a device or battery or a device case or skin and in cases where the receiver is used to charge a battery or device, the receiver may also include a regulator, battery charger IC or circuitry and/or battery protection circuit and associated transistors, etc. The receiver may also include variable or switchable reactive components (capacitors and/or inductors) that would allow the receiver to change its resonant condition to affect the amount of power delivered to the device, load or battery. The receiver and/or charger and/or their coils can also include elements such as thermistors, magnetic shields or magnetic cores, magnetic sensors, and input voltage filters, etc. for safety and/or emission compliance reasons. The receiver may also be combined with other communication or storage functions such as NFC, WiFi, Bluetooth, etc. In addition, the charger and or receiver can include means to provide more precise alignment between the charger and receiver coils or antennas. These can include visual, physical, or magnetic means to assist the user in alignment of parts. To implement more positioning freedom of the receiver on the charger, the size of the coils can also be mismatched. For example, the charger can comprise a larger coil size and the receiver a smaller one or vice versa, so that the coils do not have to be precisely aligned for power transfer.

[0070] In simpler architectures, there may be minimal or no communication between the charger and receiver. For example, a charger can be designed to be in a standby power transmitting state, and any receiver in close proximity to it can receive power from the charger. The voltage, power, or current requirements of the device or battery connected to the receiver circuit can be unregulated, or regulated or controlled completely at the receiver or by the device attached to it. In this instance, no regulation or communication between the charger and receiver may be necessary. In a variation of this, the charger may be designed to be in a state where a receiver in close proximity would bring it into a state of power transmission. Examples of this would be a resonant system where inductive and/or capacitive components are used, so that when a receiver of appropriate design is in proximity to a charger, power is transmitted from the charger to a receiver; but without the presence of a receiver, minimal or no power is transmitted from the charger.

[0071] In a variation of the above, the charger can periodically be turned on to be driven with a periodic pattern (a ping process) and if a receiver in proximity begins to draw power from it, the charger can detect power being drawn from it and would stay in a transmitting state. If no power is drawn during the ping process, the charger can be turned off or placed in a stand-by or hibernation mode to conserve power and turned on and off again periodically to continue seeking a receiver.

[0072] In accordance with an embodiment, the power section (coil drive circuit and receiver power section) can be a resonant converter, resonant, full bridge, half bridge, E-class, zero voltage or current switching, flyback, or any other appropriate power supply topology. **Figure 2** shows a more detailed view of the wireless charger system 120 with a resonant converter geometry, wherein a pair of transistors Q1 and Q2 (such as FETs, MOSFETs, or other types of switch) are driven by a half-bridge driver IC and the voltage is applied to the coil L1 through one or more capacitors shown as C1. The receiver includes a coil and an optional capacitor (for added efficiency) shown as C2 that may be in series or in parallel with the receiver coil L2. The charger and/or receiver coils may also include impedance matching circuits and/or appropriate magnetic material layers behind (on the side opposite to the coil surfaces facing each other) them to increase their inductance and/or to shield the magnetic field leakage to surrounding area. The charger and/or receiver may also include impedance matching circuits to optimize / improve power transfer between the charger and receiver.

[0073] In many of the embodiments and figures described herein, the resonant capacitor C2 in the receiver is shown in a series architecture. This is intended only as a representative illustration, and this capacitor may be used in series or parallel with the receiver

coil. Similarly, the charger is generally shown in an architecture where the resonant capacitor is in series with the coil. System architectures with the capacitor C1 is in parallel with the charger coil are also possible.

[0074] In accordance with an embodiment, the charger also includes a circuit that measures the current through and/or voltage across the charger coil (in this case a current sensor is shown in the figure as an example). Various demodulation methods for detection of the communication signal on the charger current or voltage are available. This demodulation mechanism can be, for example, an AM or FM receiver (depending on whether amplitude or frequency modulation is employed in the receiver modulator) similar to a radio receiver tuned to the frequency of the communication or a heterodyne detector, etc.

[0075] In accordance with an embodiment, the microcontroller unit (MCU) in the charger (MCU1) is responsible for understanding the communication signal from the detection / demodulation circuit and, depending on the algorithm used, making appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output. In addition, MCU1 is responsible for processes such as periodic start of the charger to seek a receiver at the start of charge, keeping the charger on when a receiver is found and accepted as a valid receiver, continuing to apply power and making necessary adjustments, and/or monitoring temperature or other environmental factors, providing audio or visual indications to the user on the status of charging or power process, etc. or terminating charging or application of power due to end of charge or customer preference or over temperature, over current, over voltage, or some other fault condition or to launch or start another program or process. For example, the charger can be built into a car, and when a valid receiver and/or an NFC, RFID or other ID mechanism integrated into or on a mobile device, its case or skin, dongle or battery is found, the charger may activate some other functions such as Bluetooth connectivity to the device, displaying the device identity or its status or state of charge on a display, etc. More advanced functions can also be activated or enabled by this action. Examples include using the device as an identification mechanism for the user and setting the temperature of the car or the driver or passenger side to the user's optimum pre-programmed temperature, setting the mirrors and seats to the preferred setting, starting a radio station or music preferred by user, etc., as described in U.S. Patent Publication No. 20110050164, incorporated by reference herein. The charger may also include an RF signal amplifier / repeater so that placement of a mobile device such as a mobile phone, tablet, etc. would provide close coupling and/or turning on of the amplifier and its antenna so that a better signal reception for communication such as cell phone calls can be obtained. Such Signal Boosters

that include an antenna mounted on the outside of a car, a bi-directional signal amplifier and a repeater antenna inside a car are increasingly common. The actions launched or started by setting a device on a charger can also be different in different environments. Examples can include routing a mobile phone call or music or video from a smart phone to the speakers and microphones or video monitors or TV, computer, laptop, tablet, etc. in a car, home, office, etc. Other similar actions or different actions can be provided in other environments.

[0076] It may be useful in addition to the communication signal to detect the DC value of the current through the charger coil. For example, faults may be caused by insertion or presence of foreign objects such as metallic materials between the charger and receiver. These materials may be heated by the application of the power and can be detected through detection of the charger current or temperature or comparison of input voltage, current, or power to the charger and output voltage, current, or power from the receiver and concluding that the ratio is out of normal range and extra power loss due to unknown reasons is occurring. In these conditions or other situations such as abnormal charger and/or receiver heating, the charger may be programmed to declare a fault condition and shut down and/or alert the user or take other actions.

[0077] In accordance with an embodiment, once the charger MCU has received a signal and decoded it, it can take action to provide more or less power to the charger coil. This can be accomplished through known methods of adjusting the frequency, duty cycle or input voltage to the charger coil or a combination of these approaches. Depending on the system and the circuit used, the MCU can directly adjust the bridge driver or an additional circuit such as a frequency oscillator may be necessary to drive the bridge driver or the FETs.

[0078] A typical circuit for the receiver in accordance with an embodiment is also shown in **Figure 2**. In accordance with an embodiment, the receiver circuit can include a capacitor C2 in parallel or series with the receiver coil to produce a tuned receiver circuit. This circuit is known to increase the efficiency of a wireless power system. The rectified and smoothed (through a bridge rectifier and capacitors) output of the receiver coil and optional capacitor is either directly or through a switch or regulator applied to the output. A microcontroller is used to measure various values such as output voltage, current, temperature, state of charge, battery full status, end of charge, etc. and to report back to the charger to provide a closed loop system with the charger as described above. In the circuit shown in **Figure 2**, the receiver MCU communicates back to the charger by modulating the receiver load by rapidly closing and opening a switch in series with a modulation load at a pre-determined speed and coding pattern. This rapid load modulation technique at a frequency distinct from the power transfer frequency

can be easily detected by the charger. A capacitor and/or inductor can also be placed in parallel or in series with this load.

[0079] As an example, if one assumes that the maximum current output of the receiver is 1000 mA and the output voltage is 5 V for a maximum output of 5W; in this case, the minimum load resistance is 5 ohms. A modulation load resistor of several ohms (20, or 10 ohms or smaller) would be able to provide a large modulation depth signal on the receiver coil voltage. Choosing a 5 ohm resistor would modulate the output between a maximum current of 1 Amp or larger and a smaller value defined by the device load at the output. Such a large modulation can be easily detected at the charger coil current or voltage as described above. Other methods of communication through varying the reactive component of the impedance can also be used. The modulation scheme shown in Figure 2 is shown only as a representative method and is not meant to be exhaustive. As an example, the modulation can be achieved capacitively, by replacing the resistor with a capacitor. In this instance, the modulation by the switch in the receiver provides the advantage that by choosing the modulation frequency appropriately, it is possible to achieve modulation and signal communication with the charger coil and circuitry, with minimal power loss (compared to the resistive load modulation).

[0080] The receiver in Figure 2 also shows an optional DC regulator that is used to provide constant stable voltage to the receiver MCU. This voltage supply may be necessary to avoid drop out of the receiver MCU during startup conditions where the power is varying largely or during changes in output current and also to enable the MCU to have a stable voltage reference source so it can measure the output voltage accurately. Alternatively, a switch to connect or disconnect the load can be used or combined with the regulator. To avoid voltage overshoots during placement of a receiver on a charger or rapid changes in load condition, a voltage limiter circuit or elements like Zener diodes or regulators or other voltage limiters can also be included in the receiver.

[0081] In the above description, a uni-directional communication (from the receiver to the charger) is described. However, this communication can also be bi-directional, and data can be transferred from the charger to the receiver through modulation of the voltage or current in the charger coil and read back by the microcontroller in the receiver detecting a change in the voltage or current, etc.

[0082] In accordance with other embodiments, and other geometries where position independence on placement of the receiver on the charger surface is achieved by having multiple charger coils in an array or pattern, similar drive and communication circuits in the charger and receiver can be implemented. To detect the appropriate coil to activate in the

charger to achieve optimum power transfer to a receiver placed on the charger, the charger coils can be activated in a raster or zigzag fashion or other geometry and current drawn from a charger coil, strength of voltage, current, power or signal from the receiver or other methods can be used to determine the closest match between position of one or more of the charger coils and a receiver coil and the appropriate charger coil or coils can be activated and modulated to provide optimum power transfer to the receiver.

[0083] While a system for communication between the charger and receiver through the power transfer coil or antenna is described above, in accordance with an embodiment the communication can also be implemented through a separate coil, a radio frequency link (am or fm or other communication method), an optical communication system or a combination of the above. The communication in any of these methods can also be bi-directional rather than uni-directional as described above. As an example, **Figure 3** shows a system 130 in accordance with an embodiment, wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes. This system is similar to the system shown in Figure 2, except rather than load modulation being the method of communication, the MCU in the receiver transmits the necessary information over an RF communication path. A similar system with LED or laser transceivers or detectors and light sources can be implemented. Advantages of such system include that the power received is not modulated and therefore not wasted during communication and/or that no noise due to the modulation is added to the system.

[0084] One of the disadvantages of the circuit shown in Figure 2 is that, in the receiver circuit shown therein, the current path passes through 2 diodes and suffers 2 voltage drops resulting in large power dissipation and loss. For example, for Schottky diodes with forward voltage drop of 0.4 V, at a current output of 1 A, each diode would lose 0.4 W of power for a combined power loss of 0.8 W for the two in a bridge rectifier configuration. For a 5 V, 1 A output power (5W), this 0.8 W of power loss presents a significant amount of loss (16%) just due to the rectification system.

[0085] In accordance with an embodiment, an alternative is to use a center-tapped receiver 140 as shown in **Figure 4**, wherein during each cycle current passes only through one part of the coil and one diode in the receiver and therefore halves the rectification losses. Such a center tapped coil can be implemented in a wound-wire geometry with 2 sections of a wound wire or a printed circuit board coil or with a double or multi-sided sided PCB coil or a combination or even a stamped, etched or otherwise manufactured coil or winding.

[0086] In any of the systems described above, as shown in **Figure 5**, the charger and

receiver coils can be represented by their respective inductances 150 by themselves (L1 and L2) and the mutual inductance between them M which is dependent on the material between the two coils and their position with respect to each other in x, y, and z dimensions. The coupling coefficient between the coils k is given by:

$$k = M / (L1 * L2)^{1/2}$$

[0087] The coupling coefficient is a measure of how closely the 2 coils are coupled and may range from 0 (no coupling) to 1 (very tight coupling). In coils with small overlap, large gap between coils or dissimilar coils (in size, number of turns, coil winding or pattern overlap, etc.), this value can be smaller than 1.

[0088] **Figure 6** shows a wirelessly powered battery pack and receiver 160 in accordance with an embodiment. The components of a typical common battery pack (battery cell and protection circuit, etc.) used in a battery device used in applications such as mobile phone, etc. are shown inside the dashed lines. The components outside the dashed lines are additional components that are included to enable safe wireless and wired charging of a battery pack. A battery pack may have four or more external connector points that interface with a mobile device pins in a battery housing or with an external typical wired charger. In accordance with an embodiment 170, the battery cell is connected as shown in **Figure 7** to two of these connectors (shown in the figure as BATT+ and BATT-) through a protection circuit comprising a battery protection IC that protects a battery from over-current and under or over voltage. A typical IC can be Seiko 8241 IC that uses 2 external Field Effect Transistors (FETs) as shown in Figure 7 to prevent current going from or to the battery cell (on the left) from the external battery pack connectors if a fault condition based on over current, or battery cell over or under voltage is detected. This provides safety during charging or discharging of the battery. In addition, a battery pack can include a PTC conductive polymer passive fuse. These devices can sense and shut off current by heating a layer inside the PTC if the amount of current passing exceeds a threshold. The PTC device is reset once this current falls and the device cools.

[0089] In addition, in accordance with an embodiment, the battery pack can contain a thermistor, which the mobile device checks through one other connector on the battery pack to monitor the health of the pack, and in some embodiments an ID chip or microcontroller that the mobile device interrogates through another connector to confirm an original battery manufacturer or other information about the battery. Other connectors and functions can be included in a battery pack to provide accurate battery status and/or charging information to a

device being powered by a battery pack or a charger charging the battery pack.

[0090] In addition to the components described above, in accordance with an embodiment, the receiver circuit comprises a receiver coil that can be a wound wire and/or PCB coil as described above, optional electromagnetic shielding between the coil and the metal body of the battery, optional alignment assisting parts such as magnets, etc., a receiver communication circuit (such as the resistor and FET for load modulation shown in Figures 2 and 4), a wireless power receiver (such as rectifiers and capacitors as described above), and an optional Battery charger IC that has a pre-programmed battery charging algorithm. Each type of battery and chemistry requires a pre-determined optimized profile for charging of that battery type. A typical charge cycle 180 for a Lithium Ion (Li-Ion) is shown in **Figure 8**. Such a battery can be charged up to a value of 4.2 V at full capacity. The battery should be charged according to the guidelines of the manufacturer. For a battery of capacity C, the cell can typically be charged at the rate 1C. In Stage 1, the maximum available current is applied and the cell voltage increases until the cell voltage reaches the final value (4.2 V). In that case, the charger IC switches to Stage 2 where the charger IC switches to Constant Voltage charging where the cell voltage does not change but current is drawn from the source to further fill up the battery. This second Stage may take 1 or more hours and is necessary to fully charge the battery. Eventually, the battery will draw little (below a threshold) or no current. At this stage, the battery is full and the charger may discontinue charging. The charger IC can periodically seek the condition of the battery and top it off further if the battery has drained due to stand-by, etc.

[0091] In accordance with an embodiment, such multiple stages of battery charging can be implemented in firmware with the wireless power charger and receiver microcontrollers monitoring the battery cell voltage, current, etc. and working in tandem and to provide appropriate voltage, current, etc. for safe charging for any type of battery. In another approach as shown in Figure 6, a battery charger IC chip that has specialized battery charging circuitry and algorithm for a particular type of battery can be employed. These charger ICs (with or without fuel gauge capability to accurately measure battery status, etc.) are available for different battery chemistries and are included in most mobile devices with mobile batteries such as mobile phones. They can include such safety features as a temperature sensor, open circuit shut off, etc. and can provide other circuits or microcontrollers such useful information as end of charge signal, signaling for being in constant current or voltage (stage 1 or 2 above, etc.). In addition, some of these ICs allow the user to program and set the maximum output current to the battery cell with an external resistor across 2 pins of the IC.

[0092] In accordance with an embodiment, the wirelessly charged battery pack in

addition includes a micro-controller that coordinates and monitors various points and may also include thermal sensors on the wireless power coil, battery cell and/or other points in the battery pack. The microcontroller also may communicate to the charger and can also monitor communication from the charger (in case of bi-directional communication). Typical communication through load modulation is described above.

[0093] In accordance with an embodiment, another aspect of a wirelessly charged battery pack can be an optional external / internal switch. A battery pack can receive power and be charged wirelessly or through the connectors of a battery pack. For example, when such a battery pack is used in a mobile phone, the user may wish to place the phone on a wireless charger or plug the device in to a wired charger for charging or charge the device as well as synchronize or upload and/or download data or other information. In the second case, it may be important for the battery pack to recognize current incoming to the battery pack and to take some sort of action. This action can include, e.g. notifying the user, shutting off the wired charger by a switch or simply shutting down the charger IC and sending a signal back through the microcontroller and modulating the current back to the charger that a wired charger is present (in case priority is to be given to the wired charger) or conversely to provide priority to the wireless charger and shut off wired charger access to battery when the wireless charger is charging the battery. At either case, a protocol for dealing with presence of two chargers simultaneously should be pre-established and implemented in hardware and firmware.

[0094] As shown in Figure 6, the wireless charging of battery occurs with current flowing into the battery through the battery contacts from the mobile device. Typically, such current is provided by an external DC supply to the mobile device (such as an AC/DC adaptor for a mobile phone) and the actual charging is handled by a charger IC chip or power management IC inside the mobile device that in addition to charging the battery, measures the battery's state of charge, health, verifies battery authenticity, and displays charge status through LEDs, display, etc. to a user. It may be therefore be advantageous to include a current sense circuit at one of the battery pack contacts to measure and sense the direction of current flow into or out of the battery. In situations where the current is flowing inwards (i.e. the battery is being externally charged through a wired charging connection, and/or through a mobile device), the micro-controller can take the actions described above and shut off wireless charging or conversely, provide priority to wireless charging and if it is present, allow or disallow wired charging as the implementation requires.

[0095] In many applications, it is important to include a feature that can inform a mobile device user about the state of charge of a battery pack in the device. To enable an accurate

measurement of the remaining battery charge, several gas gauging techniques can be implemented, in general by incorporating a remaining charge IC or circuitry in the battery or in the device. In accordance with an embodiment, the mobile device can also include a Power Management Integrated Circuit (PMIC) or a fuel or battery gauge that communicates with the wirelessly chargeable battery and measures its degree of charge and display this status on the mobile device display or inform the user in other ways. In another embodiment, this information is transmitted to the charger and also displayed on the charger. In typical circumstances, a typical fuel gauge or PMIC may use battery voltage / impedance, etc. as well as measurement of the current and time for the current entering the mobile device (coulomb counting) to determine the status of the battery charge. However in a wirelessly charged system, this coulomb counting may have to be carried out in the battery rather than in the mobile device, and then communicated to the mobile device or the charger, since the charge is entering the battery directly through the onboard wireless power receiver and circuitry. The communication between the mobile device and the battery is through the connectors of the battery and may involve communication with an on-board microcontroller in the battery pack. In accordance with an embodiment, the wirelessly chargeable battery pack can include appropriate microcontroller and/or circuitry to communicate with the mobile device or wireless charger circuitry and update its state of charge, even though no current may be externally applied (through a wired power supply or charger) to the mobile device and the battery is charged wirelessly. In simpler fuel gauge techniques, the battery voltage, impedance, etc. can be used to determine battery charge status, and that in turn can be accomplished by performing appropriate measurements by the mobile device circuitry through battery connector points or by appropriate circuitry that may be incorporated in the wirelessly chargeable battery pack and/or in the mobile device or its PMIC or circuitry. Figure 6 shows an embodiment where a microcontroller or circuit inside the battery pack is included to accomplish the fuel gauge task and report the state of charge to the device. This circuitry can be the same, or different, from an ID chip used to identify the battery and can communicate through a common battery connector or a separate one.

[0096] In accordance with an embodiment, the firmware in the receiver micro-controller plays a key role in the operation of this battery pack. The micro-controller can measure voltages and currents, flags, and temperatures at appropriate locations for proper operation. In accordance with one embodiment, by way of example, the micro-controller can measure the value of V_{out} from the rectifier circuit and attempt to keep this constant throughout the charging cycle thereby providing a stable regulated DC supply to the charger IC chip. The microcontroller can report the value of this voltage or error from a desired voltage (for example

5V) or simply a code for more or less power back to the charger in a binary or multi-level coding scheme through a load modulation or other scheme (for example RF communication, NFC, Bluetooth, etc. as described earlier) back to the charger. The charger can then take action through adjustment of input voltage to the charger coil, adjustment of the frequency or duty cycle of the AC voltage applied to the charger coil to bring the V_{out} to within required voltage range or a combination of these actions or similar methods. The micro-controller throughout the charging process, in addition, may monitor the end of charge and/or other signals from charger and/or protection circuit and the current sense circuit (used to sense battery pack current direction and value) to take appropriate action. Li-Ion batteries for example need to be charged below a certain temperature for safety reasons. In accordance with an embodiment, it is therefore desirable to monitor the cell, wireless power receiver coil or other temperature and to take appropriate action, such as to terminate charging or lower charging current, etc. if a certain maximum temperature is exceeded.

[0097] It will be noted that during charging, as shown in Figure 8, the battery cell voltage increases from 3 V or lower, to 4.2 V, as it is charged. The V_{out} of the wireless power receiver is input to a charger IC and if this V_{out} is kept constant (for example 5V), a large voltage drop (up to 2 V or more) can occur across this IC especially during Stage 1 where maximum current is applied. With charging currents of up to 1 A, this may translate to up to 2 Watts of wasted power / heat across this IC that may contribute to battery heating. In accordance with an embodiment, it is therefore desirable to implement a strategy whereby the V_{out} into the charger IC tracks the battery voltage thereby creating a smaller voltage drop and therefore loss across the charger IC. This can provide a significant improvement in performance, since thermal performance of the battery pack is very important.

[0098] In accordance with an embodiment, the communication between the receiver and charger needs to follow a pre-determined protocol, baud rate, modulation depth, etc. and a pre-determined method for hand-shake, establishment of communication, and signaling, etc. as well as optionally methods for providing closed loop control and regulation of power, voltage, etc. in the receiver.

[0099] In accordance with an embodiment, a typical wireless power system operation 190 as further shown in **Figure 9** can be as follows: the charger periodically activates the charger coil driver and powers the charger coil with a drive signal of appropriate frequency. During this 'ping' process, if a receiver coil is placed on top or close to the charger coil, power is received through the receiver coil and the receiver circuit is energized. The receiver microcontroller is activated by the received power and begins to perform an initiation process

whereby the receiver ID, its presence, power or voltage requirements, receiver or battery temperature or state of charge and/or other information is sent back to the charger. If this information is verified and found to be valid, then the charger proceeds to provide continuous power to the receiver. The receiver can alternately send an end of charge, over-temperature, battery full, or other messages that will be handled appropriately by the charger and actions performed. The length of the ping process should be configured to be of sufficient length for the receiver to power up its microcontroller and to respond back and for the response to be received and understood. The length of time between the pings can be determined by the implementation designer. If the ping process is performed often, the stand-by power use of the charger is higher. Alternately, if the ping is performed infrequently, the system will have a delay before the charger discovers a receiver nearby. So in practice, a balance must be achieved.

[00100] Alternately, the ping operation can be initiated upon discovery of a nearby receiver by other means. This provides a very low stand-by power use by the charger and may be performed by including a magnet in the receiver and a magnet sensor in the charger or through optical, capacitive, weight, NFC or Bluetooth, RFID or other RF communication or other methods for detection. Alternatively, the system can be designed or implemented to be always ON (i.e. the charger coil is powered at an appropriate drive frequency) or pinged periodically and presence of the receiver coil brings the coil to resonance with the receiver coil and power transfer occurs. The receiver in this case may not even contain a microcontroller and act autonomously and may simply have a regulator in the receiver to provide regulated output power to a device, its skin, case, or battery. In those embodiments in which periodic pinging is performed, the presence of a receiver can be detected by measuring a higher degree of current flow or power transfer or other means and the charger can simply be kept on to continue transfer of power until either the power drawn falls below a certain level or an end of charge and/or no device present is detected. In another embodiment, the charger may be in an off or standby, or low or no power condition, until a receiver is detected by means of its presence through a magnetic, RF, optical, capacitive or other methods. For example, in accordance with an embodiment the receiver can contain an RFID chip and once it is present on or nearby the charge, the charger would turn on or begin pinging to detect a receiver.

[00101] In accordance with an embodiment, the protocol used for communication can be any of, e.g. common RZ, NRZ, Manchester code, etc. used for communication. An example of the communication process and regulation of power and/or other functions is shown in **Figure 10**. As described above, the charger can periodically start and apply a ping voltage 200 of pre-determined frequency and length to the charger coil (as shown in the lower illustration in Figure

10). The receiver is then activated, and may begin to send back communication signals as shown in top of Figure 10. The communication signal can include an optional preamble that is used to synchronize the detection circuit in the charger and prepare it for detection of communication. A communication containing a data packet may then follow, optionally followed by checksum and parity bits, etc. Similar processes are used in communication systems and similar techniques can be followed. In accordance with an embodiment, the actual data packet can include information such as an ID code for the receiver, received voltage, power, or current values, status of the battery, amount of power in the battery, battery or circuit temperature, end of charge or battery full signals, presence of external wired charger, or a number of the above. Also this packet may include the actual voltage, power, current, etc. value or the difference between the actual value and the desired value or some encoded value that will be useful for the charger to determine how best to regulate the output.

[00102] Alternatively, the communication signal can be a pre-determined pattern that is repetitive and simply lets the charger know that a receiver is present and/or that the receiver is a valid device within the power range of the charger, etc. Any combination of systems can be designed to provide the required performance.

[00103] In response to the receiver providing information regarding output power or voltage, etc. the charger can modify voltage, frequency, duty cycle of the charger coil signal or a combination of the above. The charger can also use other techniques to modify the power out of the charger coil and to adjust the received power. Alternatively the charger can simply continue to provide power to the receiver if an approved receiver is detected and continues to be present. The charger may also monitor the current into the charger coil and/or its temperature to ensure that no extra-ordinary fault conditions exist. One example of this type of fault may be if instead of a receiver, a metal object is placed on the charger.

[00104] In accordance with an embodiment, the charger can adjust one or more parameters to increase or decrease the power or voltage in the receiver, and then wait for the receiver to provide further information before changing a parameter again, or it can use more sophisticated Proportional Integral Derivative (PID) or other control mechanism for closing the loop with the receiver and achieving output power control. Alternatively, as described above, the charger can provide a constant output power, and the receiver can regulate the power through a regulator or a charger IC or a combination of these to provide the required power to a device or battery.

[00105] Various manufacturers may use different encodings, and also bit rates and protocols. The control process used by different manufacturers may also differ, further causing

interoperability problems between various chargers and receivers. A source of interoperability differences may be the size, shape, and number of turns used for the power transfer coils. Furthermore, depending on the input voltage used, the design of a wireless power system may step up or down the voltage in the receiver depending on the voltage required by a device by having appropriate number of turns in the charger and receiver coils. However, a receiver from one manufacturer may then not be able to operate on another manufacturer charger due to these differences in designs employed. It is therefore beneficial to provide a system that can operate with different receivers or chargers and can be universal.

[00106] The resonant frequency, F of any LC circuit is given by:

$$F = 1 \; / \; 2\pi\sqrt{LC}$$

[00107] Where L is the Inductance of the circuit or coil in Henries and C is the Capacitance in Farads. For the system shown in Figure 2, one may use the values of C1 and L1 in the above calculation for a free running charger and as a Receiver is brought close to this circuit, this value is changed by the mutual coupling of the coils involved. It must be noted that in case a ferrite shield layer is used behind a coil in the charger and/or receiver, the inductance of the coil is affected by the permeability of the shield and this modified permeability should be used in the above calculation. In accordance with an embodiment, to be able to detect and power / charge various receivers, the charger can be designed such that the initial ping signal is at such a frequency range to initially be able to power and activate the receiver circuitry in any receiver during the ping process. After this initial power up of the receiver, the charger communication circuit should be able to detect and understand the communication signal from the receiver. Many microcontrollers are able to communicate in multiple formats and may have different input pins that can be configured differently to simultaneously receive the communication signal and synchronize and understand the communication at different baud rates and protocols. In accordance with an embodiment, the charger firmware can then decide on which type of receiver is present and proceed to regulate or implement what is required (end of charge, shut-off, fault condition, etc.). Depending on the message received, the charger can then decide to change the charger driver voltage amplitude, frequency, or duty cycle, or a combination of these or other parameters to provide the appropriate regulated output.

[00108] In accordance with an embodiment, the charger's behavior can also take into account the difference in the coil geometry, turns ratio, etc. For example, a charger and receiver pair from one or more manufacturers may require operation of the charger drive voltage

at 150 kHz. However, if the same receiver is placed on a charger from another manufacturer or driven with different coil / input voltage combination, to achieve the same output power, the charger frequency may need to be 200 kHz. The charger program may detect the type of receiver placed on it and shift the frequency appropriately to achieve a baseline output power and continue regulating from there. In accordance with an embodiment, the charger can be implemented so that it is able to decode and implement multiple communication and regulation protocols and respond to them appropriately. This enables the charger to be provided as part of a multi-protocol system, and to operate with different types of receivers, technologies and manufacturers.

[00109] For receivers that contain an onboard regulator for the output power, stability of the input voltage to the regulator is not as critical since the regulator performs a smoothing function and keeps the output voltage at the desired level with any load changes. It is however, important not to exceed the maximum rated input voltage of the regulator or to drop below a level required so that the output voltage could no longer be maintained at the required value. However, in general, inclusion of a regulator and/or a charger IC chip (for batteries) reduces the power / voltage regulation requirements of the wireless power receiver portion of the circuit at the expense of the additional size and cost of this component. In accordance with some embodiments, simpler voltage limiting output stages such as Zener diodes or other voltage limiting or clamping ICs or circuits, can be used.

[00110] While the system above describes a system wherein the communication is primarily through the coil, as described earlier, communication can also be implemented through a separate coil, RF, optical system or a combination of the above. In such circumstances, a multi-protocol system can also be used to interoperate between systems with different communication and/or control protocols or even means of communication.

[00111] Electromagnetic Interference (EMI) is an important aspect of performance of any electronic device. Any device to be sold commercially requires adherence to regulation in different countries or regions in terms of radiated power from it. Any power supply (wired or wireless) that includes high frequency switching can produce both conducted and radiated electromagnetic interference (EMI) at levels that exceed the acceptable limits so extreme care must be taken to keep such emissions to a minimum.

[00112] For an inductive charger comprising a number of coils and electronics switches and control circuitry, the main sources of emission include:

- Any potential radiated noise from switching FETS, drivers, etc. or sense and control circuitry. This noise can be at higher frequency than the fundamental drive

frequency of the coils and can be emitted away from the charger because of the frequency. This noise can be minimized by optimizing the drive circuit to avoid sharp edges in the drive waveform and associated noise.

- Noise from copper traces with AC signals. This noise can also be at higher frequency and emit away from the charger. The length of these paths must be minimized.
- EM emission from the switched coil. For coils described here and driven in the 100's of kHz up to several MHz, the wavelength of the Electromagnetic (EM) field generated can be in the hundreds of meters. Given the small length of the coils windings (often 1 m or less), the coils used are not efficient far-field transmitters of the EM field and the generated EM field is in general highly contained near the coil surface. The magnetic flux pattern from a PCB coil is highly contained in the area of a coil and does not emit efficiently away from the coil.
- Care must be taken when designing the current paths, and in some embodiments shielding of the FETs or other ICs or electronics components may be necessary. In addition, switching the coils with waveforms that have higher frequency components, gives rise to noise at higher frequencies. In any of the above geometries described, incorporation of conductive layers and/or ferromagnetic layers in the system can shield the outside environment from any potential radiative fields. The conductive layers may be incorporated in the PCB to eliminate the need for additional separate shielding layers.

[00113] In any of the configurations described here, care must be taken when designing the current paths, and in some embodiments shielding of the FETs or other ICs or electronics components may be necessary. The shielding may be implemented by incorporation of ferrite or metal sheets or components or a combination thereof. Use of thin layers (typically several micrometers of less in thickness) of metal or other conductive paint, polymer, nano material, dielectric or alike that take advantage of frequency dependence of the skin effect to provide a frequency dependent shielding or attenuation have been described in other patent applications (for example, U.S. Patent Publication No. 2009/0096413, herein incorporated by reference) where a process for incorporating a thin layer of metal in the top layer or other areas of the charger have been described. Since the layer does not absorb incident EM fields at the frequency of operation of the device, they would pass through even on the top surface of the charger (facing the charger coil) but higher frequency components would be absorbed reducing

or eliminating the harmful effect of higher frequency components radiation to nearby devices, interference, or effects on living organisms or humans and meeting regulatory conditions for operation. It is therefore possible to incorporate the charger or receiver into parts or products where the charger and/or receiver coil is covered by a thin layer of conductive or conductive containing material or layer. Such conductive material may include metallic, magnetic, plastic electronic or other material or layers.

[00114] In many situations the frequency content of any EMI emissions from the wireless charger and receiver is important, and care must be taken that the fundamental frequency and its harmonics do not exceed required values and do not cause unnecessary interference with other electronic devices, vehicles or components nearby. In accordance with an embodiment, one method that can be used to reduce the peak value of such emissions is to intentionally introduce a controlled dither (variation) to the frequency of the operation of the charger. Such a dither would reduce the peak and spread the frequency content of the fundamental emission and its harmonic over a range of frequencies determined by the amount of the dither or shift introduced. Appropriate implementation of dither can reduce undesired interference issues at a given frequency to acceptable levels. However, the overall emitted power may not be reduced. To introduce a dither in any of the systems described here, the charger driver can be appropriately driven by the MCU to dither its operating frequency or this can be hard wired into the design. Introduction of dither would typically introduce a slow ripple to the output voltage from the receiver. However, this slow ripple can be kept to a minimum or a regulator or circuit can be incorporated into the receiver to reduce this ripple to an acceptable level or to eliminate it.

[00115] In accordance with an embodiment, the multi-protocol approaches described here are important for development of a universal system that can operate amongst multiple systems and provide user convenience.

[00116] In accordance with an embodiment, the systems described here may use discreet electronics components or some or all of the functions described above may be integrated into an Application Specific Integrated Circuit (ASIC) to achieve smaller footprint, better performance / noise, etc. and/or cost advantages. Such integration is common in the Electronics industry and can provide additional advantages here.

[00117] In many cases, for the systems described above, the transmitter and receiver coils may be of similar, although not necessarily same sizes and are generally aligned laterally to be able to transfer power efficiently. For coils of similar size, this would typically require the user to place the device and/or receiver close to alignment with respect to the transmitter coil.

For example, for a transmitter / receiver coil of 30 mm diameter, this would require lateral (x,y) positioning within 30 mm so there is some degree of overlap between the coils. In practice, a considerable degree of overlap is necessary to achieve high output powers and efficiencies. This may be achieved by providing mechanical or other mechanisms such as indentations, protrusions, walls, holders, fasteners, etc. to align the parts.

[00118] However for a universal charger / power supply to be useful for charging or powering a range of devices, a design able to accept any device and receiver is desirable. For this reason, in accordance with an embodiment, a flat or somewhat curved charger / power supply surface that can be used with any type of receiver may be used. To achieve alignment in this case, markings, small protrusions or indentations and/or audio and/or visual aids or similar methods can be used. Another method includes using magnets, or magnet(s) and magnetic or ferrite magnetic attractor material(s) that can be attracted to a magnet in the transmitter / charger and receiver. In these methods, typically a single charger / transmitter and receiver are in close proximity and aligned to each other.

[00119] However, for even greater ease of use, it may be desirable to be able to place the device to be charged / powered over a larger area, without requiring precise alignment of coils. There are several methods that have been previously used for this.

[00120] Several other methods that address the topic of position independence have been described previously. For example, as described in U.S. Patent Publication No. 20070182367 and U.S. Patent Publication No. 20090096413, both of which applications are herein incorporated by reference, an embodiment comprising multiple transmitter coils arranged in a two-dimensional array to cover and fill the transmitter surface is described. When a receiver is placed on the surface of such a coil array, the transmitter coil with the largest degree of overlap with the receiver is detected and activated to allow optimum power transmission and position independent operation. The detection mechanism can be through, e.g. detection of weight, capacitive, optical, mechanical, magnetic RFID, RF, or electrical sensing of the receiver. In accordance with an embodiment, the coils in the charger / power supply are sequentially powered (pinged) and the charger / power supply waits for any possibly receivers to be powered up and reply to the ping. If no reply is detected back within a time window, the next coil is activated, etc. until a reply is detected in which case the charger / power supply initiates power up of the appropriate transmitter coil(s) and proceeds to charge / power the receiver.

[00121] In another geometry, each transmitter (or charger) coil center includes a sensor inductor (for example, E. Waffenschmidt, and Toine Staring, 13th European Conference on Power Electronics and Applications, Barcelona, 2009. EPE '09. pp. 1 – 10). The receiver coil

includes a soft magnetic shield material that shifts the resonance frequency response of the system and can be sensed by a sensor in the transmitter to switch the appropriate coil on. The drawback of this system is that 3 layers of overlapping coils with a sensor and detection circuit at the center of each is required adding to the complexity and cost of the system. Other variations of the above or a combination of techniques can be used to detect the appropriate transmitter coil.

[00122] In accordance with other embodiments, described in U.S. Patent Publication No. 2007/0182367 and U.S. Patent Publication No. 2009/0096413, the charger / power supply may contain one or more transmitter coils that are suspended and free to move laterally in the x-y plane behind the top surface of the charger / power supply. When a receiver coil is placed on the charger / power supply, the closest transmitter coil would move laterally to position itself to be under and aligned with the receiver coil. One passive method of achieving this may be to use magnets or a combination of magnet(s) and attractor(s) (one or more attached to the transmitter coil or the movable charging component and one or more to the receiver coil or receiver) that would attract and passively align the two coils appropriately. In another embodiment, a system that detects the position of the receiver coil on the charger / power supply surface and uses this information to move the transmitter coil to the appropriate location actively using motors, piezo or other actuators, etc. is possible.

[00123] In general the systems above describe use coils that are of similar size / shape and in relatively close proximity to create a wireless power system.

[00124] As described above, the coupling coefficient k is an important factor in design of the wireless power system. In general, wireless power systems can be categorized into two types. One category which is called tightly coupled operates in a parameter space where the k value is typically 0.5 or larger. This type of system is characterized by coils that are typically similar in size and/or spatially close together in distance (z axis) and with good lateral (x,y) overlap. This so called tightly coupled system is typically associated with high power transfer efficiencies defined here as the ratio of output power from the receiver coil to input power to transmitter coil. The methods described above for position independent operation (array of transmitter coils and moving coils), typically may use tightly coupled coils.

[00125] In contrast, for coils of dissimilar size or design or larger transmitter to receiver distance or smaller lateral coil overlap, the system coupling coefficient is lower. Another important parameter, the quality factor of a transmitter (tx) and receiver (rx) coil is defined as:

$$Q_{tx} = 2 \pi f L_{tx} / R_{tx}$$

$$Q_{rx} = 2 \pi f L_{rx} / R_{rx}$$

where f is the frequency of operation, L_{tx} and L_{rx} the inductances of the transmitter and receiver coils and R_{tx} and R_{rx} their respective resistances. The system quality factor can be calculated as follows:

$$Q = (Q_{tx}. Q_{rx})^{1/2}$$

[00126] In general, the loosely coupled systems may have smaller power transfer efficiencies. However, it can be shown (see for example, E. Waffenschmidt, and Toine Staring, 13th European Conference on Power Electronics and Applications, Barcelona, 2009. EPE '09. pp. 1 – 10) that an increase of Q can compensate for smaller k values, and reasonable or similar power transfer efficiencies can be obtained. Such systems with dissimilar coil sizes and higher Q values are sometimes referred to as Resonant Coupled or Resonant systems. However, resonance is also often used in the case of similar-size coil systems. Others, (such as André Kurs, Aristeidis Karalis, Robert Moffatt, J. D. Joannopoulos, Peter Fisher, and Marin Soljac, Science, 317, P. 83-86, 2007; and http://newsroom.intel.com/docs/DOC-1119) have shown that with systems with k of <0.2 due to large distance between coils (up to 225 cm), sizeable reported power transfer efficiencies of 40% - 70% can be obtained. Other types of loosely coupled system appear to use mis-matched coils where the transmitter coil is much larger than the receiver coil (see for example, J. J. Casanova, Z.N. Low, J. Lin, and Ryan Tseng, in Proceedings of Radio Wireless Symposium, 2009, pp. 530-533 and J. J. Casanova, Z. N. Low, and J. Lin, IEEE Transactions on Circuits and Systems – II: Express Briefs, Vol. 56, No. 11, Nov. 2009, pp. 830-834 and a Fujitsu System described at http://www.fujitsu.com/global/news/ pr/archives/month/ 2010/20100913-02.html) .

[00127] Previous references (e.g., U.S. Patent Nos. 6,906,495, 7,239,110, 7,248,017, and 7,042,196) describe a loosely coupled system for charging multiple devices whereby a magnetic field parallel to the plane of the charger is used. In this case, the receiver contains a coil that is typically wrapped around a magnetic material such as a rectangular thin sheet and has an axis parallel to the plane of the charger. To allow the charger to operate with the receiver rotated to any angle, two sets of coils creating magnetic fields parallel to the plane of the charger at 90 degrees to each other and driven out of phase are used.

[00128] Such systems may have a larger transmitter coil and a smaller receiver coil and operate with a small k value (possibly between 0 and 0.5 depending on coil size mismatch and

gap between coils / offset of coils). Of course the opposite case of a small transmitter coil and larger receiver coil is also possible.

[00129] **Figure 11** shows configurations 220 for a tightly coupled power transfer system with 2 individual transmitter coils of different size powering a laptop and a phone (left) and a loosely coupled wireless power system with a large transmitter coil powering 2 smaller receiver coils in mobile phones (right).

[00130] An ideal system with largely mis-matched (i.e. dissimilar in size / shape) coils can potentially have several advantages:

1. Power can be transferred to the receiver coil placed anywhere on the transmitter coil.
2. Several receivers can be placed and powered on one transmitter allowing for simpler and lower cost of transmitter.
3. The system with higher Q can be designed so the gap between the transmitter and receiver coil can be larger than a tightly coupled system leading to design of systems with more design freedom. In practice, power transfer in distances of several cm or even higher have been demonstrated.
4. Power can be transferred to multiple receivers simultaneously. In addition, the receivers can potentially be of differing power rating or be in different stages of charging or require different power levels and/or voltages.

[00131] In order to achieve the above characteristics and to achieve high power transfer efficiency, the lower k value is compensated by using a higher Q through design of lower resistance coils, etc. The power transfer characteristics of these systems may differ from tightly coupled systems and other power drive geometries such as class E amplifier or Zero Voltage Switching (ZVS) or Zero Current Switching (ZCS) or other power transfer systems may operate more efficiently in these situations. In additions, impedance matching circuits at the charger / transmitter and/or receiver may be required to enable these systems to provide power over a range of load values and output current conditions. General operation of the systems can, however be quite similar to the tightly coupled systems and one or more capacitors in series or parallel with the transmitter and/or receiver coil is used to create a tuned circuit that may have a resonance for power transfer. Operating near this resonance point, efficient power transfer across from the transmitter to the receiver coil can be achieved. Depending on the size difference between the coils and operating points, efficiencies of over 50% up to near 80% have been reported.

[00132] To provide more uniform power transfer across a coil, methods to provide a more uniform magnetic field across a coil can be used. One method for achieving this uses a hybrid coil comprising a combination of a wire and PCB coils (see, for example, X. Liu and S. Y. R. Hui, "Optimal design of a hybrid winding structure for planar contactless battery charging platform," IEEE Transactions on Power Electronics, vol. 23, no. 1, pp. 455–463, 2008). In another method, the transmitter coil is constructed of Litz wire and has a pattern that is very wide between successive turns at the center and is more tightly wound as one gets closer to the edges (see, for example, J. J. Casanova, Z. N. Low, J. Lin, and R. Tseng, "Transmitting coil achieving uniform magnetic field distribution for planar wireless power transfer system," in Proceedings of the IEEE Radio and Wireless Symposium, pp. 530–533, January 2009). **Figure 12** shows a coil 230 demonstrated therein, while **Figure 13** shows the resulting calculated magnetic field 240. In a geometry described in U.S. Patent Publication No. 2008/0067874, also incorporated herein by reference, a planar spiral inductor coil is demonstrated, wherein the width of the inductor's trace becomes wider as the trace spirals toward the center of the coil to achieve a more uniform magnetic field allowing more positioning flexibility for a receiver across a transmitter surface. In yet other embodiments (F. Sato, et al., IEEE Digest of Intermag 1999, PP. GR09, 1999), the coil can be a meandering type of coil wherein the wire is stretched along X direction and then folds back and makes a back and forth pattern to cover the surface.

[00133] In accordance with an embodiment, the charger can operate continuously, and any receiver placed on or near its surface will bring it to resonance and will begin receiving power. The regulation of power to the output can be performed through a regulation stage at the receiver. Advantages of such a system include that multiple receivers with different power needs can be simultaneously powered in this way. The receivers may also have different output voltage characteristics. To achieve this, the number of turns on the receiver coil can be changed to achieve different receiver output voltages. Without any receivers nearby, such a charger would not be in resonance and would draw minimal power. At end of charge, the receiver can include a switch that will detect the minimal current draw by a device connected to the receiver, and disconnect the output altogether and/or disconnect the receiver coil so that the receiver is no longer drawing power. This will bring the charger out of resonance and minimal input current is drawn at this stage.

[00134] In accordance with another embodiment, the charger can periodically ping for receivers, and initiate and maintain power transfer if sufficient current draw from a receiver is detected. Otherwise, the charger can return to standby and continue pinging. Such a system would have even lower stand-by power usage.

[00135] In a more complex system, similar communication and control and/or receiver detection as described for the tightly coupled situation earlier can be applied for such loosely coupled systems. However, a wireless power system designed to power multiple receivers placed on a single transmitter (see, for example, "Qualcomm Universal Charging" available at http://www.qualcomm.com/common/documents/articles/eZone_052609.pdf) may need to regulate the power transfer and the voltage at each receiver differently depending on the status of the load / device that the power is being delivered to. In cases where multiple receivers are placed on one transmitter coil and it is desired to power / charge all devices, all receivers may try to communicate with the transmitter and the transmitter will need to distinguish between receivers and operate differently (e.g. at different power level, or switching frequency, etc.) with each one. Since the transmitter coil emits power to all the receivers, it may be difficult to regulate power delivered to each receiver differently. Therefore in a practical system, some degree of regulation of power to be delivered to a load or device may be performed in the receiver circuitry.

[00136] In another method of regulation, each receiver may time-share the transmitter power. Each receiver placed on a transmitter may synchronize and communicate with the transmitter and/or with other receivers through wireless RF communication or RFID or Near Field Communication, Bluetooth, WiFi, or communication through power transfer and/or separate coils or through optical or other methods. The transmitter may then power each receiver sequentially and deliver the appropriate power level through adjustment of the transmitter frequency, pulse width modulation, or adjustment of input voltage, or a combination of above methods. In order for this system to operate, it may be necessary for all or some of the receivers to disconnect from receipt of power during the time period when one receiver is receiving power. This can be accomplished by implementing and opening a switch in the path of the receiver coil circuit or disabling the receiver's output or its associated optional regulator or alike. In this way, only one receiver coil (or more depending on design and architecture) is at any given time magnetically coupled to the transmitter and receives power. After some period of time, that receiver may be disconnected by opening its appropriate switch and the next receiver powered, etc. Alternatively, one or more receivers may be powered at the same time. In this case, the receivers may need to share the available power so for example, while with one receiver 5 W of output power may be available, with 2 receivers, each can only output only 2.5 W, etc. This may be acceptable in many charging and/or power applications.

[00137] In any practical system, in addition to the power transfer and communication system, appropriate electromagnetic shielding of the transmitter and receiver is necessary and

may be similar or different to the tightly coupled systems.

[00138] The ratio of the size of the transmitter coil to the receiver coil may be decided depending on design considerations such as the desired number of receivers to be powered / charged at any given time, the degree of positioning freedom needed, the physical size of device being charged / powered, etc. In the case that the transmitter coil is designed to be of a size to accommodate one receiver at a time, the transmitter and receiver coils may be of similar size thereby bringing the loosely coupled system to the tightly coupled limit in this case.

[00139] While the loosely coupled system may have distinct advantages and in some ways may overcome the complexities of the multiple coil / moving coil systems employed in tightly coupled systems to achieve position independence, traditional systems suffer from several issues:

1. Since a large area transmitter coil and smaller receiver coil may be used, Electromagnetic emission in areas of the transmitter coil not covered by the receiver coil is present. This emission is in the near field and drops rapidly away from the coil. Nevertheless, it can have adverse effects on devices and/or people in the vicinity of the transmitter.
2. The receiver may be incorporated or attached to Electronic and electrical devices or batteries that often contain metallic components and/or circuits and/or parts / shells, etc. Such metallic sections that are not shielded may absorb the emitted EM field from the transmitter and create destructive and undesirable eddy currents and/or heating in these parts.
3. The Electromagnetic field emitted may also affect the operation of the device being powered or charged or even nearby devices that are not on the transmitter / charger. Such interference with device operation / reception or a drop in sensitivity of a radio transmitter / receiver (desense) is quite important in design of mobile or electronic devices such as mobile phones or communication devices. To avoid this effect, the portions of the device being charged or powered that may be exposed to the Electromagnetic (EM) field with the exception of the receiver coil area may need to be shielded causing severe restrictions on the device design and affecting operation of other antennas or wireless components in the device.
4. In many situations, an after-market or optional receiver such as a case, skin, carrier, battery or attachment with a receiver built in is desired to enable a mobile or electronic / electric device to be powered or charged wirelessly. To shield the entire device from EM radiation at locations beside the receiver coil, such an after-market or

optional receiver will require shielding in all other locations of the device thereby severely limiting the design and choices in after-market products possible. For example, a battery with a built in receiver circuit and shielding may not be sufficient to protect a mobile device to be charged wirelessly. For example, in the case of a mobile phone, such a battery would cover only a small area of a mobile phone's back's surface area leaving the rest of the phone exposed to EM radiation which could have serious effects on its performance and operation. Furthermore, the shielding may affect the performance of the device and its multiple wireless components.

5. Metallic objects such as keys or coins or electronic devices or cameras that contain metal backs or circuits containing metals or other metal that are placed on a charger / transmitter may affect the operation of the transmitter and draw power from it due to eddy currents. This may result in excessive heating of such objects that is highly undesirable.

6. The EM field emitted from the transmitter further may be sufficiently physically close to a user as to be affecting and incident on the user. Such exposure to EM radiation may result in unwanted or unacceptable levels of exposure.

7. Many regulatory guidelines regarding the safe exposure limits for human and electrical / electronic device operation exists and awareness and concern regarding this issue is increasing. Any unnecessary exposure from an uncovered and operating area of a transmitter is highly undesirable.

8. A substantial amount of power from the transmitter may be lost from the area that is not physically covered by the receiver leading to lower efficiencies and wastage of power.

9. To capture the most amount of power and to achieve higher efficiencies, the receiver coil area must be maximized. This often leads to a larger receiver coil area than tightly coupled implementations.

[00140] It is therefore desired to benefit from the advantages of a loosely coupled system while minimizing or avoiding problems related to it.

[00141] In accordance with various embodiments described herein, through appropriate design of the system, and use of two novel techniques referred to herein as Magnetic Aperture (MA) and Magnetic Coupling (MC) respectively, the benefits of the use of a mismatched (in size) coil system can be retained, while overcoming the problems and issues raised above, leading to ideal systems for wireless power transfer.

[00142] As described above, a position independent system may be implemented by use of a large area transmitter coil upon which a smaller receiver coil may be placed on a variety or any location and receive power. Typically, a system such as shown in Figure 2 includes capacitors in series and/or parallel with the transmitter and/or receiver coils to provide a resonant circuit that shows strong power transfer characteristics at particular frequencies. (See for example S.Y. Hui, H.S.H Chung, and S.C. Tang, IEEE Transactions on Power Electronics, Vol. 14, pp.422-430 (1999), which shows an analysis method for such a system). Using values of L1 = 46 μH for the transmitter coil and L2 = 4 μH for the receiver (based on a 16 cm x 18 cm 13-turn transmitter coil and a 4 cm x 5 cm, 6-turn receiver coil (J. Casanova, Z.N. Low, and J. Lin, IEEE Trans. On Circuits and Systems – II, Express Briefs, Vol. 56, pp. 830-834 (2009)), and using 12 nF for the receiver capacitance, the impedance to the input supply of the transmitter can be calculated as shown in **Figure 14**, clearly showing the resonance in power transfer 250.

[00143] In practice, a transmitter operating on or near resonance frequency does not draw much power until a receiver of appropriate inductance and capacitance is nearby thereby shifting its operating point and bringing it into resonance at which point, significant power can be drawn from the transmitter supply and enabling large power transfer and high power transfer efficiencies. However, as described above, a large area transmitter typically would also then emit power into areas not covered by the receiver coil, which could cause EMI and accompanying health issues.

[00144] In accordance with various embodiments, the techniques described herein allow operation of a position-independent power transfer system, while reducing or eliminating undesirable radiation from other areas of the transmitter coil. To achieve this, it is necessary to achieve the seemingly mutually exclusive conditions of low-to-no emission from a transmitter coil, with high-efficiency and position-independence operation at positions with the presence of the receiver coil. Ideally, this system is passive in that no complicated detection of receiver location and switching and control of the power transfer is necessary.

[00145] In accordance with an embodiment, a large transmitter coil and smaller receiver coil or coils similar to a loosely coupled system are used. However, to reduce or eliminate radiation from the transmitter coil, the transmitter coil is covered with a thin soft magnetic layer.

[00146] **Figure 15** shows the magnetization curves 260 of a number of Ferromagnetic materials. They include 1.Sheet steel, 2.Silicon steel, 3.Cast steel, 4.Tungsten steel, 5.Magnet steel, 6.Cast iron, 7.Nickel, 8.Cobalt, and 9.Magnetite. In the linear regime of operation, the magnetic field strength H is related to the magnetic flux density B through the permeability of the material μ:

$$\overline{B} = \mu \overline{H} + \overline{M}$$

where M is the magnetization of a material. It must be noted that B, H, and M are vectors and μ is a scalar in isotropic materials and a tensor in anisotropic ones. In anisotropic materials, it is therefore possible to affect the magnetic flux in one direction with a magnetic field applied in another direction. The permeability of Ferromagnetic materials is the slope of the curves shown in Figure 15 and is not constant, but depends on H. In Ferromagnetic or Ferrite materials as shown in Figure 15, the permeability increases with H to a maximum, then as it approaches saturation it decreases by orders of magnitude toward one, the value of permeability in vacuum or air. Briefly, the mechanism for this nonlinearity or saturation is as follows: for a magnetic material consisting of domains, with increasing external magnetic field, the domains align with the direction of the field (for an isotropic material) and create a large magnetic flux density proportional to the permeability times the external magnetic field. As these domains continue to align, beyond a certain value of magnetic field, the domains are all practically aligned and no further increase in alignment is possible reducing the permeability of the material by orders of magnitude closer to values in vacuum or air.

[00147] Different materials have different saturation levels. For example, high permeability iron alloys used in transformers reach magnetic saturation at 1.6 - 2.2 Tesla (T), whereas ferromagnets saturate at 0.2 - 0.5 T. One of the Metglass amorphous alloys saturates at 1.25 T. The magnetic field (H) required to reach saturation can vary from 100 A/m or lower to 1000's of A/m. Many materials that are typically used in transformer cores include materials described above, soft iron, Silicon steel, laminated materials (to reduce eddy currents), Silicon alloyed materials, Carbonyl iron, Ferrites, Vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, and many other materials in solid or flexible polymer or other matrix that are used in transformers, shielding, or power transfer applications. Some of these materials may be appropriate for applications in various embodiments described herein.

[00148] **Figure 16** shows the hysteresis curve 270 for a hard ferromagnetic material such as steel. As the magnetic field is increased, the magnetic flux saturates at some point, therefore no longer following the linear relation above. If the field is then reduced and removed, in some media, some value of B called the remanence (Br) remains, giving rise to a magnetized behavior. By applying an opposite field, the curve can be followed to a region where B is reduced to zero. The level of H at this point is called the coercivity of the material.

[00149] Many magnetic shield layers comprise a soft magnetic material made of high

permeability ferromagnets or metal alloys such as large crystalline grain structure Permalloy and Mu-metal, or with nanocrystalline grain structure Ferromagnetic metal coatings. These materials do not block the magnetic field, as with electric shielding, but instead draw the field into themselves, providing a path for the magnetic field lines around the shielded volume. The effectiveness of this type of shielding decreases with the decrease of material's permeability, which generally drops off at both very low magnetic field strengths, and also at high field strengths where the material becomes saturated as described above. The permeability of a material is in general a complex number:

$$\mu = \mu' + j\mu''$$

where μ' and μ'' are the real and imaginary parts of the permeability providing the storage and loss component of the permeability respectively. **Figure 17** shows the real and imaginary part of the permeability of a ferromagnetic material layer 280.

[00150] **Figure 18** shows the Magnetization curves 290 of a high permeability (real permeability ~ 3300) proprietary soft magnetic ferrite material at 25 ºC and 100 ºC temperature. Increase of temperature results in a reduction in the Saturation Flux density. But at either temperature, saturation of the flux density B with increasing H is clearly observed. A distinct reduction in the slope of B-H curve (i.e. material permeability) is observed at around 100 A/m and the reduction of the permeability increases with H increase until the material permeability approaches 1 at several hundred A/m. This particular material is MnZn based and retains high permeability at up to 1 MHz of applied field frequency but loses its permeability at higher frequencies. Materials for operation at other frequency ranges also exist. In general, MnZn based materials may be used at lower frequency range while NiZn material is used more at higher frequencies up to several hundred MHz. It is possible with appropriate material engineering and composition to optimize material parameters to obtain the desired real and imaginary permeabilities at any operating frequency and to also achieve the saturation magnetic field and behavior desired.

Magnetic Coupling (MC) Geometry

[00151] In accordance with various embodiments, a method can be provided for shielding / reducing the EM field emitted from the transmitter coil, while at the same time providing a path for transfer of power from this field to a receiver coil placed arbitrarily on the surface of the transmitter. To achieve this, in accordance with an embodiment 300 shown in **Figure 19**, a

large area transmitter coil (of wire, Litz wire, or PCB type, or a combination thereof) is covered by a ferromagnetic, ferrite, or other magnetic material or layer that acts to guide, confine, and shield any field, due to its high permeability. Choosing the thickness of the material and its permeability and saturation properties, the magnetic material can reduce or shield the field in the area above the charger / transmitter coil so that it is reduced by 2 orders of magnitude or less compared to an otherwise similar geometry without the magnetic layer. Bringing a receiver coil with appropriate resonant capacitor in series or parallel to the receiver coil, the field penetrating the magnetic layer can be collected, and localized power transfer wherever the receiver coil is placed can be achieved.

[00152] To test this geometry, a charger coil similar to shown in Figure 12 with a size of 18 cm x 18 cm consisting of Litz wire was created and covered with a 0.5 mm thick sheet of material with properties shown in Figure 17. A circular receiver coil of 7 turns with radius 2 cm was placed on top of the charger surface / magnetic layer. This Magnetic Coupling (MC) geometry 320 is shown in **Figure 20**. The receiver circuit comprises a parallel resonant capacitor, followed by a bridge rectifier and smoothing capacitor. Significant power transfer was achieved with receiver coil at distances of several mm to 2-3 cm from the charger surface. The power transfer and efficiency increased with introduction of a 0.5 mm thick ferrite magnetic material or layer above the coil to guide and shield the flux as shown in Figure 20. The resonance of the charger / receiver circuit in this case is important for operation of the MC configuration. The leakage field from the surface of the charger can be reduced by using thicker or higher permeability magnetic layer. Choosing the appropriate magnetic layer and receiver shield / guide layer permeabilities and thicknesses is important to provide a low reluctance path for the magnetic flux to allow higher power transfer and efficiencies while achieving sufficient field shielding at other locations of the charger. The inventors have found that power transfer of over 10 W at the output and DC- out to DC- in power transfer efficiencies of over 50% can be achieved in this MC configuration with several mm to 2-3 cm of charger / receiver coil distance. Moving the MA receiver coil (with switching magnet) laterally across the surface of the transmitter coil confirms that high power transfer and high efficiencies can be obtained across the transmitter surface. The amount and efficiency of the power transfer showed very good uniformity. The emission from other locations of the charger, where the receiver was not present, were monitored by a probe and shown to be lower by 2 orders of magnitude or more compared to similar locations in a magnetic resonant charger with no magnetic layer. Due to the high permeability of the ferrite layer, this fringing (leaking) field dies away rapidly from the top surface and should not cause significant EMI issues away from the charger. No interference

effect with magnetic or non-magnetic metal sheets or ferrites placed on the charger surface were observed, showing that the magnitude of the leakage field from the surface is small and only couples well to the receiver due to the resonant conditions produced by the receiver LC circuit. Also as expected, multiple receivers could be charged / powered simultaneously in this MC geometry.

[00153] In accordance with an embodiment in the MC geometry, the reluctance of the flux path in the receiver can be lowered by including high permeability material in the core of the receiver ring coil (similar to a solenoid) or a T-shape core or alike. Many geometries are possible and these are only given here as examples. Additionally, while Litz wire receiver coil was used. PCB coils and/or a combination of Litz wire and PCB coil can be used.

[00154] In accordance with an embodiment, to reduce the reluctance of the path, the receiver coil can be created by using a flux guide material (such as ferrite with permeability greater than 1) with an axis perpendicular (or an angle sufficient to catch the substantially perpendicular flux from the charger) to the surface of the charger. As shown 330 in **Figure 21**, Litz wire can be wrapped around the core to create a solenoid type receiver with a relatively small cross section (2 mm x 10 or 20 mm) substantially parallel to the surface of the charger. In one example, the length of the solenoid height (along the direction perpendicular to the surface of the charger) was varied from 10 to 20 mm but could be shorter. Typical number of turns on the receiver coil was 7 turns. Substantial power transfer (over 20 W) was received at resonance with the receiver coil bottom on or within several cm of the surface of the charger. Rotating the angle of the solenoid with respect to the perpendicular direction to the surface to the charger produced large power transfers confirming that as long as some component of the charger flux is along the axis of the coil, efficient power transfer can be obtained. Minimal leakage power from other areas of the charger surface was observed and position free and multiple receiver operation could be obtained as expected. As shown in Figure 21, optionally, an additional shield / guide layer on the top of the receiver and on the bottom of the charger can also be added. Such a solenoid with a magnetic flux guide can be constructed to also have a larger area parallel to the surface of the charger approximating the embodiment in Figure 20 but with a flux guide layer in the middle of the coil. In this case, the height (along the length perpendicular to the surface of the charger) can be quite short (1-2 mm or less). Use of the flux guide and a smaller cross section parallel to the surface of the charger as shown in Figure 21 may also be important for applications where small areas for the sections of receiver in the plane of the charger are available. Examples may be devices such as phones, etc. or batteries that are longer in 1 or 2 dimensions and would be stood substantially on their ends or sides to receiver

power wirelessly.

[00155] In accordance with another embodiment, the charger / transmitter also includes magnetic flux guide layer / shield at the bottom of the charger as shown in Figure 20 and 21 so that emissions from the bottom of the charger / transmitter are reduced. In yet another embodiment, metal layers are also included on the top of the receiver shield and/or the bottom of the charger / transmitter shield to provide further shielding from the magnetic field.

[00156] It must be noted that for a transmitter coil of geometry in Figure 12 with several A of current in the coil (currents used here), the incident magnetic field is estimated to be in the 100 A/m^2 to several 100 A/m^2 range (see Figure 13). Care must be taken so that the magnetic material is chosen such that magnetic saturation does not occur. However, in the region of power transfer between the charger and the transmitter coil the magnetic field is enhanced by the resonance and the Quality Factor (Q) of the system and a much larger magnetic field may be present. In these tests, the Q of the system was about 30. Thus it may be possible that in the power transfer location under the receiver coil, the magnetic layer can experience saturation and reduction of permeability to provide a more efficient path for the flux from the charger coil to transmit to the receiver coil above and increased power transfer and efficiencies. By choosing magnetic layers with appropriate saturation field values, this effect can be used to benefit as described above.

Magnetic Aperture (MA) Geometry

[00157] In accordance with another embodiment and geometry, one can create a Magnetic Aperture (MA) in a magnetic shield or ferromagnetic layer at any desired location, so that the magnetic field confined in such a layer at that location is efficiently coupled to a receiver coil and can provide power transfer to such a receiver. At any other location on the transmitter coil, the confinement of the field prevents or reduces unnecessary radiation, thereby providing low EMI and adverse health and interference effects.

[00158] Several methods to enable local change (switching) of the characteristics of the ferromagnetic material in the MA geometry are described herein. In accordance with an embodiment, the local characteristics of the ferromagnetic, ferrite, or other magnetic material or layer are altered by saturating the layer through application of a DC and/or AC magnetic field such as through a permanent magnet or electromagnet, etc. For example, a magnet or electromagnet can be incorporated behind, in front, around or at the center of the receiver coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnet layer locally on or near where the receiver coil is placed.

[00159] Examples of magnets that can be used include, e.g. one or more disc, square, rectangular, oval, curved, ring (340 in **Figure 22**), or any other shape of magnet and combination thereof and with appropriate magnetization orientation and strength that can provide sufficient DC or AC magnetic field to shift the operating position of the magnetization curve (as shown in Figure 15 or 18), so that the combination of the transmitter coil, the affected ferromagnet layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

[00160] As shown in **Figure 23**, in accordance with an embodiment 350 of MA, by incorporating a permanent (and/or electromagnet) into the receiver in front, and/or behind and/ or at the level of the receiver coil (on the outside and/or inside of the coil) , and bringing the receiver close to the charger surface, at this point, a local 'magnetic aperture' is opened up in the ferromagnetic, ferrite, or other magnetic material or layer, allowing the transmitter coil's electromagnetic field to be transmitted through this local aperture without affecting any areas nearby. In this manner, by reducing the permeability of the ferromagnet layer locally through saturation or reduction with the DC and/or AC field or other means, one can establish at what location the power and energy coupling occurs while keeping the field confined in other areas. The magnetic or ferrite material layer is here therefore also alternatively called a switching layer. This layer acts as both a reservoir and/or guide layer of AC magnetic flux (for power transfer) and a switching layer. This embodiment can be used to meet the goal of simultaneously transferring power efficiently to a receiver at any desired location while keeping the field from emitting at other locations and causing problems. At the same time, since the magnetic field created from the entire surface of the charger coil is directed or guided towards the magnetic aperture created, this provides an effect analogous to funneling the power to this magnetic aperture area and an efficient method for transfer of power to an arbitrarily positioned receiver is achieved. In Figure 23, typically, the receiver may also include an outer surface or case. Such a surface or case would be typically located between the receiver coil and the charger surface parts as shown in **Figure 24**.

[00161] Figure 24 provides an illustrative method of understanding the behavior 360 of the system. Magnetization curves of a soft ferrite material are shown at different operating temperatures. The AC magnetic field generated by the wireless charger / power supply coil is also shown in two regions of operation (shielded region and the magnetic aperture region). Most of the surface area of the ferrite layer has no receiver on it and operates in the shielded region with high permeability guiding and shielding the AC magnetic field generated by the charger / power supply coil in the transmitter from the outside. In the magnetic aperture region

(where the receiver and the switching magnet is), the DC (and/or AC) magnet acts as a bias to move the operating point from around the vertical axis where the material has high permeability and confines and guides the magnetic field to a region where the material is saturated and has a low permeability creating a magnetic aperture for coupling to a receiver coil nearby causing efficient power transfer. The magnetic field required for saturating the switching material (the magnetic switching field) can be easily created by many types of commonly available magnets that can generate up to several 100's of A/m or more of magnetic field easily saturating many ferrite materials.

[00162] As can be seen above, this approach utilizes the physics underlying the nonlinear behavior of ferrite material to act as an active switch to provide power transfer only in desired locations. Permeability is an inherent material property of a magnetic material and the response time of the material is only limited by domain movements and can be in nano seconds or faster depending on the material. It is therefore one of the advantages of this system that the device responds almost instantaneously, and, if a receiver is moved on the surface, a new aperture is created and shielding is restored at all other locations almost instantaneously. In comparison, any other wireless charger system such as coil arrays, moving coils, etc. has a slow response to such movement due to time lag related to mechanical movement of coil and/or electronic detection and reconfiguration of an electronic system. Furthermore, multiple receivers (with switching magnets) can be placed on or near the charger surface to create multiple magnetic apertures for coupling of power to multiple receivers while maintaining shielding and low electromagnetic emission at all other locations providing a simple to use, efficient multi-charger system.

[00163] In accordance with an embodiment, to provide shielding from the magnetic field at locations below the transmitter coil (the side opposite to the charging / power side of the transmitter) and above the receiver coil (on the side of the coil that may be in close contact with a device, battery, or electrical part being powered or charged wirelessly), further shielding layers such as ferromagnet and/or metallic layers can also optionally be added below the transmitter coil and/or above the receiver coil as necessary. Furthermore, these layers can be integrated into the coil design (such as metal shield layers integrated into a PCB multi-layer design that includes a PCB coil). The choice of material and thickness, etc. can be chosen such that even though a magnet in the receiver may be used to saturate (switch) the top layer of the transmitter (the switching layer), the permeability of the shield layers would not be affected. For example, the switchable layer in the charger can comprise material with low saturation field values while the other shield layers in the charger and/or receiver have higher saturation field values.

Examples of materials to use for these shields may be sheets or other shapes of material such as ferrites, nano materials, powder iron (Hydrogen Reduced Iron), Carbonyl Iron, Vitreous Metal (amorphous), soft Iron, laminated Silicon Steel, Steel, etc. or other material used in transformer core applications where high permeability and saturation flux densities as well as low eddy current heating due to conductivity at frequency of operation is required. Lamination has also been used in many applications of transformers to reduce eddy current heating. It must be noted that to avoid saturating the ferrite shield from the switching magnet in the receiver, the shield can also be multi-layer or other structures can be used. For example in an embodiment, a thin high saturation flux density layer (of for example powdered Iron or steel) can be placed behind the switching magnet (as shown in Figure 23) to shield from the switching magnet field with another optional ferrite layer of other characteristics such as higher permeability or operation at the AC magnetic field frequency above that. Thus the high saturation flux density layer will shield the high permeability layer from the saturating effects of the magnet and allow it to guide and shield the AC magnetic field effectively.

[00164] In another embodiment, the high saturation shield layer is formed or manufactured to have a shape and dimensions to fit the magnet's switching magnetic field pattern to shield the field from it and allow the AC power magnetic field from the charger that is coming through the created magnetic aperture to extend upwards (in Figure 23) to another shield or ferrite layer with different characteristics. For example in the geometry of Figure 23, if a ring type of switching magnet is used, the high saturation shield material may be ring shaped with appropriate dimensions and placed behind (atop in Figure 23) of the magnet to shunt or reduce the field from the magnet and a sheet of ferrite is placed on top of the high saturation shield layer to guide and shield the AC magnetic power transfer flux coming through the center of the coil as shown in Figure 23. Many combinations of the above techniques and materials can be combined in the receiver and charger to best optimize performance and these embodiments are only given as examples.

[00165] To test the above embodiment, a transmitter coil with Litz wire with dimensions of 10 cm x 10 cm was constructed. The coil was constructed similar to earlier work (J. J. Casanova, Z.N. Low, J. Lin, and Ryan Tseng, in Proceedings of Radio Wireless Symposium, 2009, pp. 530-533 and J. J. Casanova, Z. N. Low, and J. Lin, IEEE Transactions on Circuits and Systems – II: Express Briefs, Vol. 56, No. 11, Nov. 2009, pp. 830-834). The receiver comprised a Litz wire coil of 35 mm radius and 10 turns and the received power was connected to a rectifier and capacitor circuit to provide a DC output. The transmitter coil was then driven with a resonant converter circuit similar to Figure 2 and the frequency of the system was adjusted for

test purposes. It is important to realize that different power delivery mechanisms and receiver systems as well as different shape, geometry, winding, and construction of coils such as wire, Litz wire, or a combination can be used, and this setup is used only as an example.

[00166] To test the transmission capability of the loosely coupled system itself first, a resonant converter wireless charger drive circuit was powered from a DC supply at 20 V input voltage and the receiver coil was placed on the transmitter with a coil to coil vertical (z-direction) gap of 5 mm. Power level in excess of 20 W with a DC output to DC input power overall system efficiency of over 70% could be achieved. When moving the receiver coil power laterally, power transfer was observed across the surface of the charger. However the amount and efficiency of the power transfer at a fixed drive frequency was not uniform. Placing a metal object, such as a metal disk, on the transmitter surface at a location laterally away from the receiver coil confirms that strong magnetic field emissions exist on the entire surface of the transmitter coil as expected since the coin heats up within seconds to very high temperatures confirming heating by eddy currents. Placement of larger metal sheets would shift the resonance frequency significantly and if brought back to resonance would heat up the sheet through eddy Currents. Similarly, a receiver circuit connected to some Light Emitting Diodes (LEDs) shows significant power being emitted from all areas of the transmitter coil as expected.

[00167] Next, a sheet of Hitachi material MS-F comprising 18 μm of FineMET® FT-3M material on an adhesive tape substrate was used as a ferromagnet / ferrite material (switchable layer) and placed on the entire top of the transmitter coil surface. This material has a saturation flux density of 1.23 T. Placing a receiver coil 5 mm away from the transmitter coil and the switchable layer and adjusting the transmitter frequency, no power was transferred to the receiver at any frequency. Next, a Nd rare-earth ring magnet (of material N45H) of inner diameter of 32 mm and outer diameter of 36 mm and 2.5 mm thickness and magnetized along its axis (with North and South pole on top and bottom of the ring) was placed behind in the center of the receiver coil. The ring magnet as shown in Figure 22 includes a cut or gap in its circumference. This cut or gap is optional and can be manufactured during casting of the magnet to avoid or reduce generation of any eddy currents from stray magnetic fields in the receiver in magnetic material that is electrically conductive (such as Nd rare-earth magnets) during operation in the wireless power system. By breaking the circular pattern of the ring, any potentially generated currents would not be able to circulate and heat the magnet.

[00168] The overall geometry 370 of the MA for operation with the switchable layer and the receiver and magnet is shown in **Figure 25** for two receivers of dissimilar size and possibly power ratings and/or voltage outputs. Figure 25 shows a simplified side view of a wireless

power system in accordance with an embodiment, showing a charger (transmitter) and receiver coil, switching layer, and switching magnet. In this instance, a ring switching magnet is shown and the coils are described as circular ring coils for simplicity. However, in accordance with other embodiments, other geometries and designs can be used to achieve similar results. For example, as described above, the coil can be configured to achieve a more uniform field pattern and/or the magnet can be of a different shape and magnetization orientation. In addition, the magnet can be placed in front of, behind, or on the same plane as the coil and/or the coils can be made of wires, PCB, free standing metal parts or a combination thereof or other geometries and materials.

[00169] The magnetic flux densities and the magnetic field orientation are also shown in **Figure 23**. The magnetic flux flows or is guided in the switching layer and is funneled or directed to the receiver location by the presence of the receiver magnet. The arrows for the AC magnetic flux density lines are shown to guide the reader in the direction of the energy flow rather than show the vector direction since this field is AC and changes direction in every half cycle.

[00170] In an isotropic material, the switching magnetic field (from the switching or permanent magnet or electromagnet shown here) should have a component in an orientation along the direction of the AC (wireless power transfer) magnetic field to saturate the permeability in that orientation and affect its behavior. However in an anisotropic material, different orientations of switching magnetic field can affect the permeability along the plane of the ferrite layer affecting the AC magnetic power transfer field, giving rise to interesting combinations of switching layer materials and magnet designs to achieve enhanced performance.

[00171] In the embodiment shown in Figure 23, and using a ring magnet as the switching magnet, due to overlap of the radial orientation of the magnetic field from the ring magnet magnetized axially (North and South poles along its axis which is perpendicular to the plane of the charger surface), the DC switching magnetic field is parallel to the x-y plane under the ring magnet and more vertical in the center of the ring magnet so it is oriented to efficiently direct the AC wireless power magnetic field in the region towards the created aperture for power transfer. However, alternate geometries such as an arc, radially magnetized ring, cylinder, or multi-pole magnets can be used to provide optimal power coupling. A multi-pole magnet can provide a tighter external magnetic field pattern and may reduce any potential unwanted effect of magnet on nearby devices / materials while providing sufficient magnetic field to saturate the switching layer. In addition, use of appropriately designed magnets and/or anisotropic or multi-layer

switching layers can result in enhanced switching performance and coupling of power with minimal switching magnet strength.

[00172] In accordance with another embodiment, multi-pole magnets that have strong magnetic field strengths near the surface of the magnet with rapidly decreasing magnetic field strength away from the surface can be used. Some examples of multi-pole magnets are shown 380 in **Figure 26**. Such magnets can provide magnetic aperture switching nearby, while maintaining weak magnetic field strengths farther away, thereby minimizing the effect on other materials, devices, etc. This feature may be especially important for use with devices such as GPS or compasses that use the weak magnetic field of the earth to detect the device orientation.

[00173] In accordance with one embodiment that uses a ring magnet as shown 390 in **Figure 27**, the magnet can be magnetized radially or along its axis, but can comprise multiple alternating poles. Some examples of ring multi-pole magnets magnetized axially (perpendicular to the plane here) (a) and radially in the plane (b) and along directions shown by arrows in (c), (d), and (e). Different magnetic flux lines can be obtained (shown in (c), (d), and (e)) can be obtained depending on the orientation and number of poles and can be optimized to provide an ideal magnetic aperture and coupling between the flux lines of the charger coil and receiver coil providing optimum efficiency. As an example, the magnet shown in Figure 27(e) which consists of multiple sections poled in a particular geometry as shown provides uniform in plane magnetic flux lines in the center of the magnet to create a uniform magnetic aperture in the Figure 23 geometry while producing minimal fields outside the magnet. The geometries shown here are not meant to be exhaustive but show that many possibilities for design and optimization of the magnets exist and can provide optimum coupling in the smallest possible area.

[00174] In accordance with an embodiment, in addition to reduce or eliminate eddy currents, a cut or gap in the circumference of a ring, square, or other type of magnet can be introduced to prevent circular current from flowing due to the alternating magnetic field. **Figure 28** shows two examples 400 of multi-pole ring or arc magnets with cuts or gaps in the circular pattern, in accordance with various embodiments.

[00175] While the magnetic field necessary to saturate the switching layer can be engineered to be switched with low magnetic strength magnets that in general would not pose any problems to the device or any objects nearby, in accordance with another embodiment, to reduce or eliminate any potential effect of the switching magnet's magnetic field on the device's performance, its compass or GPS or on nearby devices or objects, magnetic shielding material such as shown on the top and bottom in Figure 23 can be incorporated in the receiver behind

the magnet (top of Figure 23).

[00176] In addition, the device, case, skin, battery door or battery incorporating the receiver and the switching magnet may incorporate a component that would shunt the switching magnet's magnetic flux and shield it from penetrating out from the surface of the device, skin, battery door, or battery. An example would be a cover manufactured from sheet of ferrite, magnetic material, magnetic steel, Alnico, Permalloy, etc. or a combination thereof that would be normally placed or attached, slid on or held on the outside area of the magnet (lower part of the receiver in Figure 23) while the device is being used normally. This cover could be slid open, removed or detached to expose the magnet before placement of the device, case, skin, battery door or battery, etc. on or near the charger surface to commence charging. The cover can also simultaneously have a shielding layer sheet that normally would shield the switching magnet from the interior of the device and would also be slid aside to allow normal operation of the receiver without these high permeability magnetic flux shunt layers. Alternatively, the switching magnetic field can be generated by an electromagnet in the receiver by passing a DC or AC or a combination of currents through an electromagnet. This may be activated mechanically by the user or through a detection mechanism that detects approach of a wireless charger through various RFID, NFC, Bluetooth, Felica, WiFi, optical, or other RF or wireless detection, and applies the appropriate power to the electromagnet in preparation for receiver to be placed on the wireless charger. Alternatively, the switching magnetic field may also be created by a combination of a permanent and electromagnet fields. Alternatively the cover layer described above for a permanent magnet can be automatically slid open, removed, opened, etc. when a charger is detected nearby through RFID, NFC, Bluetooth, Felica, WiFi, or other RF, wireless, or optical or magnetic detection mechanisms.

[00177] In accordance with an embodiment, to bring the system to resonance, the frequency of the applied power to the charger coil can be adjusted to observe power transfer through the switchable MA layer. Experimentally, with a single magnet for switching no power transfer was observed. Doubling the magnet strength by double stacking the magnets provided sufficient magnetic field strength to saturate the switchable layer and adjusting the frequency, large amounts of power were transmitted through the opened aperture. Over 10 W of power and efficiencies in excess of up to 50 % were achieved. To achieve optimum power transfer, it is necessary to move the magnets some distance (e.g. about 25 mm vertically in the z-direction) away from the transmitter surface. This may be due to the magnet size (diameter) being much smaller than the receiver coil and to saturate the switchable layer with sufficient size to optimally couple power to the receiver coil, it was necessary to move the magnets away to allow their

fringing fields to be larger in area than the size of the magnets itself and thereby open an optimally sized aperture for power transfer. In accordance with other embodiments, a larger diameter magnet that is matched with the receiver coil size can be used and can be at the same plane as the receiver coil (inside, outside or behind the receiver coil).

[00178] In accordance with an embodiment, the magnetic flux density of each magnet was estimated to be around 1.3 T by the manufacturer. In practice, it was observed that doubling up the magnets by stacking on top of each other and moving the magnets away to optimally match the aperture size to the receiver coil was optimal for power transfer. This is understandable in view of the fact that while the single magnet should have sufficient magnetic field to saturate the layer close to its surface, the resulting aperture when the magnet is on the plane of the receiver coil and close to the transmitter coil and switchable layer (5 mm distance between magnet and the switchable layer) is comparable in size to the magnet and smaller than the 40 x 50 mm size of the receiver coil. To achieve the best coupling, the magnet had to be further away (25 mm between magnet and transmitter switchable layer) in this example and therefore 2 magnets were required to provide sufficient flux density in this example. Even with the magnet co-planar with the receiver coil, doubling the magnets was necessary to provide sufficient fringing fields to open a sufficiently dimensionally large aperture for efficient power transfer.

[00179] In accordance with an embodiment, changing the receiver coil size so that it is comparable to the switching magnet diameter provides more efficient coupling, with output to input power efficiencies of 50% to over 70%, and output power levels of over 25 W achieved with even a single magnet due to better switching magnet field overlap with the receiver coil.

[00180] In accordance with an embodiment, due to the circular symmetry of the geometry used, the receiver can be rotated in the plane without any change in the received power or system efficiency. Rotation of the receiver out of the plane also demonstrated sizeable power transfer.

[00181] To test emission levels from other areas of the transmitter, the test with metallic object was repeated by placing a metallic object at a location close to the receiver coil on top of the transmitter surface. No change in power coupled to the receiver and no appreciable heating was detected. Similarly, when the magnets were removed from the center of the receiver coil, the power transfer stopped and the transmitter only drew very minimal current (less than 100 m A). While with the magnets at the center of the receiver coil, the transmitter drew 1 A or more of current. This is a very dramatic and large confirmation of the principle described here.

[00182] As a further test, the magnet and receiver were placed on a location on the

transmitter coil (covered with a switching layer on top of it). Large current draw from the transmitter power supply can be observed at an adjusted resonant frequency. This is due to the power being emitted through the generated magnetic aperture (MA) into the receiver. Next, another receiver coil without a magnet was placed on the transmitter at a location near the first receiver and magnet. No discernible power transfer was detected in this MC geometry. This is presumably due to the fact that the 2 locations have different inductance values and resonate at different frequencies. However, it may be possible to have both types of receivers operate on a single type of charger if the resonant conditions of the 2 different receivers are moved to be at the same frequency. This may be achieved by adjusting the resonant conditions of the 2 receivers by adjusting their LC circuit with adjusting the resonant cap (or a parallel or in series adjustable inductor) in the receiver. Moving the MA receiver coil (with switching magnet) laterally across the surface of the transmitter coil confirms that high power transfer and high efficiencies can be obtained across the transmitter surface. The amount and efficiency of the power transfer showed very good uniformity.

[00183] To confirm that the effect observed is due to the magnetic field and not the presence of the ferrite material in the magnets, the ring magnets were replaced with a ring constructed of the same material as the ring but not magnetized. No power transfer was observed with such a set up.

[00184] As a further confirmation, the receiver coil was placed on the transmitter coil and switchable layer but the magnet was removed. Next the magnets were brought close to the transmitter coil from below (the side opposite to the receiver coil). At about 25 mm distance to the switchable layer, with the magnets aligned with the lateral location of the receiver coil, strong power transfer and high power transfer efficiency was observed. Moving the magnets laterally away from lateral alignment with the receiver coil, the aperture closed and no power was transferred further confirming the effect as being due to the field.

[00185] As a final confirmation, with the receiver coil and the ring magnets placed on the transmitter coil and transmitter frequency optimized for high power transfer, a single ring magnet was brought to lateral alignment from below the transmitter coil with the top magnets. With the magnetic poles oriented so that the fields from the below magnet was opposing the magnetic field from the magnet above, lower amounts of power transfer were achieved. Demonstrating that the net magnetic field value was reduced by half and therefore the aperture was partially closed. Doubling the magnet below the transmitter coil, with the 2 magnetic fields from the magnets above and below the transmitter coil and the switchable layer cancelling each other out, the aperture could be closed and no power transfer was observed. Flipping the polarity of

the magnets below the transmitter coil so that the fields from magnets above and below would add up on the plane of the ferromagnetic layer, the power transfer would resume.

[00186] The multiple tests above appear to confirm that the principle of operation is the saturation of the ferromagnetic switchable layer, and this combination of materials and geometry performs as planned. Namely, safe (low or no EM emission from the surface of the charger / transmitter) and efficient power transmission to a receiver placed at any location on the transmitter coil can be achieved with minimal side effect and residual emission.

[00187] The embodiments for MC and MA configuration discussed above are not meant to be exhaustive and many variations and/or combinations of the configurations are possible. Overall, the transferred powers and the efficiencies observed from the MA configuration were larger than the MC configuration. However, by modeling and judicious design of geometry and materials, similar performances may be possible. The communication and control of these system can be similar to the tightly coupled systems described earlier providing regulation and control between transmitter and receiver. Alternately, the system can be designed with no regulation at the charger, and all the regulation instead at the receiver, or any combination of architectures as described earlier for loosely-coupled or tightly-coupled wireless power transfer systems above. The wireless power transmission systems and methods described herein have ideal characteristics for this application. By using the magnetic coupling (MC) or magnetic aperture (MA) technique, all the advantages of a loosely coupled system can be retained while achieving high efficiency, high power transfer efficiency, low EMI, and low or no interaction with nearby metallic objects of a tightly coupled system providing an ideal solution.

[00188] In practice, with the thin layer of the Hitachi switchable material used, some heating of the switchable layer was observed. This can be due to the material being lossy (high imaginary permeability) and/or being extremely thin. Use of ferrites with minimal or no loss at the frequency of interest would improve this effect. Also, as noted above and shown in Figure 15, ferrite material would have significantly lower saturation flux densities (0.2-0.5 T) compared to the thin sheet of the FineMET® material used. Thus, smaller magnetic flux densities (smaller or weaker magnets) can be used for switching.

[00189] Next to test MA configuration further, an 18 x 18 cm transmitter coil of the shape similar to Figure 12 was constructed and 60 x 60 x 0.5 mm plates of a MnZn Ferrite material were placed side by side in a tile manner to cover the transmitter coil surface as the switchable material while the same tests above were performed. This material has a low loss up to about 100 kHz and a real permeability of about 2000 up to 100 kHz. Similar switching results were obtained with a receiver of about 35 mm diameter and a single ring switching magnet

magnetized along axis as described earlier (Figure 22). However, with such thicker and lower loss material, no switching layer heating was observed. Adding a resonant capacitor in parallel to the coil in the receiver of appropriate value, power transfer of up to 30 W into one coil and DC-out to DC- in total power transfer efficiencies of over 70% were observed. Many ferrite materials with differing magnetic properties exist and optimizing the various fundamental properties and dimensions of the switchable layer or layers can be performed with more detailed modeling. In general, Furthermore, it is found that with appropriate design and selection of coils, switching magnet size, shape and strength and switching layer, the receiver coil can be placed several mm to several cm over the charger surface and receive power efficiently through a locally opened magnetic aperture. So the operation is not limited to the receiver being in direct or close contact with the charger surface.

[00190] In accordance with an embodiment, it may be advantageous to construct the charger / transmitter coil from ferromagnetic material with appropriate property so that the coil acts as both the magnetic field generator and the magnetic shield for MA and MC geometry. This may eliminate the need to have an additional magnetic or ferrite layer on the top surface of the charger / transmitter. Alternately, to retain desirable high conductivity and Q of the transmitter and/or receiver coils and to achieve the switching effect, a metallic coil of PCB and/or wire may be coated or covered with a switching magnet material such as ferromagnet. **Figure 29** shows a commercially available wire or cable 410 available in a variety of gauges with these characteristics. Section 1 in Figure 29 consists of multiple strands of copper or other conductor wire which may also be individually coated or insulated to avoid conduction between the strands (similar to Litz wire) to avoid skin effects. Section 2 is an overcoat or layer of ferrite or other magnetic material. Section 3 is an optional outer coating or insulation. The ferrite layer or coating can be achieved by dipping into a slurry, sputtering, e-beam, etc. as appropriate.

[00191] Similarly, a magnetic or ferrite layer made of material with low saturation magnetic field values can be used above the transmitter coil (for example as switching layer in MA or even MC geometry) while a material with higher saturation magnetic field value can be used below the transmitter coil and above the receiver coil for shielding purposes. For example, Nickel, cobalt, Mn, Zn, Fe, etc. or alloys of such material (see Figure 15 or 17) with low saturation magnetic field values may be used as the top layer of the charger / transmitter while Sheet Steel or FineMET® or other shield material with high saturation magnetic field values would be used for shielding. For either material, care must be taken to use material that reduces or eliminates eddy currents through geometry or doping of the material to provide high resistivity. By using a low saturation magnetic field material, a smaller and/or weaker switching

permanent magnet and/or electromagnet induced field may be used for switching the switchable layer in the MA geometry. Thus, the shields would not be saturated by the magnet used for switching and would remain effective in shielding unwanted stray magnetic fields from affecting nearby devices, materials, or living tissue. In such a case, the total system would be completely shielded and safe. Power would at the same time transferred efficiently between the transmitter and receiver from the created magnetic aperture at one or more locations desired by user where receivers are placed.

[00192] Another type of material that responds strongly to an applied magnetic field is a class of material known as ferrofluids which are colloidal suspensions of ferromagnetic particles or nano materials in a carrier fluid. In an embodiment the magnetic layer covering the charger coil in the systems described here may be a layer of ferrofluid material sandwiched between two barrier layers. With the application of an appropriate switching magnet of the receiver or a local increase in the AC magnetic field, the ferrofluid would be attracted and aligned appropriately to provide a local magnetic variation in the magnetic layer covering the charger coil and allow better coupling between the charger and receiver coil. Thus a similar behavior to using Ferrites for magnetic layer may be obtained.

[00193] The tests above with magnets placed above and below the switching layer in the MA configuration also show that novel methods of switching the layer can be employed. Since the layer responds to the net total magnetic field, a bias magnetic field can be designed to be incident on the layer and by including a weak additional magnet into the receiver, the total magnetic field with the receiver present can then be designed to exceed the saturation level to switch the layer locally. For example, a bias magnet material or electromagnet in the charger / transmitter can provide a uniform or local magnetic field to bring the DC or average AC level close to saturation and a smaller magnet material or electromagnet in the receiver can be used to exceed the required saturation level locally to open an aperture for power transfer. The bias magnet material can be a sheet of permanent magnet (perhaps even flexible plastic magnets readily available) and/or an electromagnet that would provide the DC bias.

[00194] In accordance with any of the embodiments described here, many types of magnets may be used to create the switching field in the MA configuration. They include metallic, alloy, rare earth, ceramic, ferrite, nano material, Alnico, composite or other material used to manufacture magnets.

[00195] In addition, it must be noted that when power is being transferred through the magnetic aperture, an AC magnetic field due to the inductive field is present. This field may be quite large in a resonant geometry with a high Q where the power resonating between the coils

is larger than the transferred power by a factor of Q (quality factor).

[00196] In accordance with an embodiment, it may be possible to open a magnetic aperture with a DC or AC magnetic field from a permanent magnet or electromagnet from the receiver or a bias DC or AC magnetic field plus a magnet and/or electromagnet from the transmitter / charger and start the power transfer through an aperture. Once power transfer is achieved through such an aperture, the saturating magnetic field may be removed or reduced and if the average value of the AC magnetic field is sufficiently high to saturate the layer, power transfer will continue. It must be noted that once an aperture is opened, due to resonance and local change of the permeability, the magnetic field at this location is much higher than neighboring areas and with proper design and choice of materials and fields, Q, etc, this aperture may be designed to remain open while the rest of the ferromagnetic layer would remain in a high permeability state and continue to provide shielding at other locations and limit radiation from these locations as desired. Such a latching behavior was observed experimentally with another type of thin layer ferromagnetic material with lower saturation flux density. In addition, the possibility of opening the magnetic aperture through power AC magnetic field alone without the need for any DC or AC switching magnetic field was discussed in the MC section earlier.

[00197] In yet another embodiment, the transmitter periodically or continually applies a DC or AC magnetic field generated by a coil (the same or different from the power transmitter coil) and sufficient magnetic field to bias the switching layer near or above its saturation value. The presence of the receiver coil with or without additional magnetic field from a permanent magnet or electromagnetic near the transmitter at a location on the surface may then be sufficient to bring the system to resonance, open the aperture and start power transfer as described above. Once power transfer starts, then the bias field may be removed or lowered to save energy. The locations on the switchable layer of transmitter away from the receiver will remain at high permeability and therefore confine the magnetic field and would not emit power.

[00198] Such an application of a magnetic field to bring the total magnetic field close to or above the saturation level can be achieved by pulsing a magnetic field from an electromagnet such as the transmitter coil and/or a separate electromagnet or coil and may be at the same time that the ping process described earlier occurs. Basically, through application of a magnetic field created by this bias electromagnet (can be the same as power transmitter coil or separate), the switchable layer is brought close to or over the saturation level. Then the power transmitter coil provides an additional AC magnetic field that may be detected through an opened magnetic aperture by any receiver coil present to start communication. Once this response is detected by

the charger / transmitter, then continuous power is transmitted from the charger / transmitter and the regulation / control loop is established and power is transmitted until the receiver sends an end of charge signal or is removed so no feedback signal is detected at the charger / transmitter. As described above, during the transfer of power, the bias magnetic field to the switchable layer may or may not be applied depending on the design and principle of operation.

[00199] In yet another embodiment, the receiver can contain a permanent magnet and/or electromagnet (which in some instances can be the same coil as for the receiver coil for power transfer) that is pulsed or turned on to apply a bias field to the switchable layer to saturate it to open the aperture and start power transfer. As described above, it may be possible to turn this bias off or remove the permanent magnet once the power transfer has started without affecting operation.

[00200] In many applications, it may be advantageous to control the amount of power output to or from a receiver circuit. In one embodiment where the output voltage of the receiver coil to an output device or battery needs to be regulated (or adjusted) with respect to changes in the load impedance, an output regulator stage can be used at the output of the receiver circuit or the input of the device or battery can be used. However, in another embodiment, it may be beneficial to take advantage of the properties of the magnetic aperture to control the power, voltage, or current delivered to the regulator. This may be achieved in any of the methods described above by controlling the amount of the current to a magnetizing magnet in the receiver so that by judiciously adjusting the degree of saturation of the switching magnetic material, the amount of coupling to the receiver coil is adjusted and a constant or desired output voltage to the output device or battery is provided. In this way, the nonlinearity of the performance of the magnetic material is used to control the amount of the coupling to each receiver actively.

[00201] It must be noted that as described earlier the permeability is a tensor and the permeability of the material to magnetic field in one orientation may be affected by a magnetic field in another orientation in anisotropic material. So, novel single or multi-layer material and field geometries may be employed to take advantage of the magnetic aperture concept. Furthermore, modeling of the AC magnetic field of the wireless charger and the switching magnetic field and the nonlinear behavior of the ferrite layer can provide further optimization in performance and choice of materials and geometries.

[00202] It may be further possible or desirable to switch the magnetic aperture on and keep it open in a certain location of the switchable layer. An example would be a charger / power supply layer where an aperture in a particular area for power coupling is opened and kept

open without continued presence of an AC or DC switching magnetic field until the user desires to close this aperture. For these cases, it may be desirable to use a hard magnetic switching layer such as shown in Figure 16 where the magnetic state of a region is changed by applying a sufficiently large magnetic field to switch the magnetic domains in that area and change the permeability permanently to a state that allows transfer of power through the aperture due to the created remanence field continuing to saturate the material until reset by an opposing field of value equal to the coercivity of the material or heating of the material over its curie temperature. An application of this may be for example a charger / power supply table or surface or device of large area where at will, by application of a high magnetic field through the switching layer with a permanent or electromagnet or a combination thereof, a region is modified and serves essentially as a power outlet for inductive power until the user chooses to close it by application of a reverse field or heating. This would allow intriguing possibilities in essentially creating a semi-permanent (reversible) power socket or outlet at any location by using a magnet of proper strength and geometry to essentially punch a permanent aperture at that location to allow coupling to the power available in the wireless charger surface. Once the magnetic aperture is created, placement of a device even without a magnet at that location would provide power to the device. The aperture can be closed at will with a reversed and sufficient magnitude field or local heating of the region.

[00203] An analogy for the above method of regulation and control of the amount of the power transferred can be seen in a product called the Saturable Reactor or Magnetic Amplifier (shown 430 in **Figure 30**) where the amount of an AC current flowing through a lamp (L) from an AC source (G) is controlled by the inductor T made of a ferrite core such as iron that is saturable. Another winding of the coil nearby is connected to a battery (B) or a DC power source and the current through the winding (i.e. the magnetic field and flux density incident on the core) are varied through a variable resistor (R) to change the permeability of the iron core or saturate it to modify the inductance value along the current path to the lamp (see Wikipedia entry for Saturable Reactor). While this is a very different application of modifying the permeability of a material with application of a magnetic field, it shows that the basic concept is solid and can be used in products.

[00204] In yet another embodiment, it may be advantageous to have a system geometry whereby the relative sizes of the charger and receiver coils are reversed so that the charger coil is smaller than the receiver coil and/or the charger incorporates the switching permanent and/or electromagnet for safety or other reasons. For example in case a wireless charger for an automobile, bus, robot or other product is developed such that in the case of an automobile as

an example, a driver may park a car over an area on the road or garage floor to receiver charge, it may be undesirable or impossible for the automobile (the receiver) to include a small coil and switching magnet that would open a magnetic aperture on a larger charger surface to allow efficient coupling. In such cases, it may be possible to design a large receiver coil and a magnetic switching layer placed below the coil (i.e. between the coil and the road) such that the switching layer would cover or exceed the area of the receiver coil. A smaller coil in or near the ground / road / floor and an in the case of MA configuration, appropriate permanent or electromagnet of appropriate size placed in the charger (on the ground or floor) and would open a magnetic aperture in the switching layer of the receiver (in the car) to allow optimum coupling of the charger and receiver coil when the automobile receiver coil and its switching layer is placed on the charger coil. In this configuration 440 shown in **Figure 31**, the charger switching magnet and optional charger and/or receiver shielding layers are shown. In addition, the receiver may include a surface or outer layer, skin, body, etc. that may be located between the ferrite, magnetic material or switching layer and the charger surface. It must be noted that any embodiments described in this document may be combined with the geometry of Figure 31 to be used for cases where larger receiver coils and smaller charger coils may be used.

[00205] In a Magnetic Coupling (MC) embodiment of this geometry, the switching magnet and the optional switching magnet shown in Figure 30 would not be required.

[00206] In yet another embodiment to allow for charging an automobile or other vehicle or movable system such as a robot, etc., the coil on the stationary part (the road or the floor) or alternately the moving part (car, robot, etc.), can be made to be much longer and/or wider than the other coil to avoid the need for precise alignment. For example a charger coil on a floor or road can be in a rectangular or oval shape while the receiver coil in a car is circular and placed at any location at the bottom center line of the car. In this way, the driver does not have to precisely align the coils in the front and back direction to use the charger. Similarly, different cars with the receiver coils placed at different locations in the car can use the same charger.

[00207] Another method for achieving the goal of modifying the permeability of the switchable layer locally is to use the Curie temperature property of a ferromagnet to alter its properties. Curie temperature or point is the temperature at which a ferromagnetic or a ferrimagnetic material becomes paramagnetic upon heating. An iron magnet for example will lose its magnetism if heated above the Curie temperature and the effect is reversible. In optical recording, a laser light is focused on a data track to be written and the local temperature is raised over the Curie temperature. At the same time, a nearby coil will create an alternating magnetic field that mimics the data to be recorded. As the location under the laser beam is

heated, the data is erased and the magnetization is changed to the direction dictated by the applied external magnetic field. Once the laser beam is passed and the material cools, that modified location of material is fixed and the up / down magnetization is frozen into the material to be stored and/or read back through magneto optic detection of polarization change of an incident optical beam when the track is read back.

[00208] Nickel (Curie Temperature of 358 ºC) and Iron (Curie Temperature of 770 ºC) or alloys of these materials are often used for this type of recording application. Lower Curie temperature ferromagnetic material can also be designed. As an example, the ferrite material used with high efficiency in the MA section above has a Curie temperature of 200 ºC, Similarly, in the wireless power case described above, in one embodiment, the receiver may locally heat a switchable layer optically or through resistive heating or a combination of the above to locally modify the permeability and affect the amount of power transfer by opening a magnetic aperture while leaving the rest of the area of a switchable layer unmodified to shield the transmitter coil magnetically and reduce or eliminate emission.

[00209] Use of the Curie temperature effect and the magnetic saturation may be combined or used individually to design an optimized system as described above and to achieve best performance.

[00210] In another implementation for use in other applications, a ferromagnetic layer that has an EM field incident on it, may be modified in a one or 2 dimensional manner as desired by placing pixels or arrays of electromagnets such as printed or assembled coils or alike along the front and/or back or inside such a material. This may be combined with field from one or more permanent magnets to bias the operation near the saturation level. By locally activating the electromagnets, the local permeability may be modified affecting the phase and amplitude transmission and/or reflection properties of the EM wave at that location.

[00211] While the above descriptions relate to modifying the amount and location of power transmitted from a 2 dimensional wireless power system, the concept can be used for modulating the transmitted and/or reflected amplitude and/or phase of any electromagnetic and/or magnetic wave by using a ferromagnetic layer. In a general sense, the description above is for the first time describing the concept of locally modifying the shielding and/or magnetic properties of a magnetic or ferromagnetic layer by application of one or more or a combination of permanent and/or electromagnets and/or temperature to modify the magnitude and/or phase of the reflected and/or transmitted electromagnetic or magnetic field at any location in the 2 dimensional space while passing through or reflecting from such a layer. Beyond wireless power, this may have applications in shielding or modulating the amplitude

and/or phase of a 2 dimensional electromagnetic or magnetic wave spatially. Applications may include phased array radar, beam steering, EM cloaking, beam forming and shaping, etc.

[00212] One advantage of use of a magnetic aperture (MC) or magnetic coupling (MC) in a wireless power transmission system is that the amount of power transferred and characteristics of the system may be determined by the size of the receiver coil and associated magnetic including magnet if any. So using a large transmitter coil, a designer may have flexibility in powering a variety of receivers and associated devices / power levels with the same transmitter coil. For example, a large receiver coil and associated possible magnet or electromagnet or heater (for curie temperature operation), may be used for providing relatively large power and to charge or power a laptop, power tool, or lamp, etc. while a smaller coil and magnet (in case of MA) may be used to power or charge a mobile phone or Bluetooth headset. Such flexibility is very advantageous in many applications.

[00213] In a loosely coupled system, two or more receivers may be placed on and powered or charged from one transmitter coil simultaneously due to the size mismatch. The inventors have tested placement of two or more receivers on the both types of charger surface (MC and MA) described here, and shown that in either configuration multiple receivers can be powered simultaneously while detecting no or low emission from any other area on the surface. This allows for the development of charger systems where multiple (2 or more) receivers can be powered or charged simultaneously. In accordance with various embodiments described here, the receivers can provide different power levels and/or voltages to different products or parts or be operating with different protocols or operating frequencies. The sizes of the receiver coil, number of turns of the receiver coil, the regulation mechanism and overall system design can also be optimized to address a particular design requirement. This allows for the development of power surfaces with little or no power dissipation or emission (since the system is not in resonance and in low current draw state without a receiver). The same surface can also power or charge multiple devices including lamps, kitchen appliances, laptops, keyboards, computer mice, mobile phones, power tools, batteries, etc. as needed by simple placement on or near the surface. Experimentally, the inventors have found that, depending on the degree of resonance that can be adjusted by adjusting the Q of the system, the receiver can also be some distance (up to several cm) from the charger surface and receive power. This also allows placement of the charger pad under a table or surface if necessary. In such a system, depending on configuration, power transferred to each receiver may or may not be individually adjusted since any adjustment would affect operation and power received at all receivers. Methods for adjustment of power to each receiver may include serially or alternate powering of each receiver

whereby the receiver disconnects its coil for a period allowing only one or a number of receivers to receive power or regulation of power at the receiver or a combination of the above. In this Time Division Multiplexed (TDM) arrangement, each receiver is powered for a period of time by having its receiver coil connected to the receiver circuit and output load, before disconnecting that receiver and moving on to the next receiver. The advantage of this system is that during each power delivery time slot to each receiver, a one to one power delivery and communication connection can be established and the output voltage, current, and/or power can be controlled by the charger / power supply through communication and feedback during this period before moving on to the next receiver, etc. The disadvantage of this architecture is that each receiver only receives power during some period of time instead of continuously. Such a condition may not be acceptable for some applications. In general, it would be desirable for the time slots for powering each receiver to be short enough so that the receiver or charging circuit in the device or battery does not notice the connection and disconnection of received power.

[00214] Another problem that has been noted in use of wireless power systems for charging and powering of devices or batteries has been that in case a metal object is placed between the receiver coil and the charger coil, the AC charging magnetic field may cause unwanted heating and safety issues. It is therefore desirable to detect such a presence and take corrective action. Corrective action may include termination of charging, reduction of power, notifying the user by an error message or a combination thereof. Several methods for detection of such foreign metal objects are possible. In a simple method, a thermal detector or thermistor in the charger and/or receiver detects an abnormal temperature rise in the charger or receiver coil area and corrective action is taken. Another method may be to measure or estimate the power delivered to a device or battery at any given moment and comparing it to the delivered power to the charger / transmitter, ensure that safe operation is being conducted. This can for example be done by the receiver reporting the power delivered values to the charger and the charger comparing it to the power or current it is delivering to the charger coil and taking corrective action if anomalies are observed. However, an advantage of the magnetic aperture system described here is that the magnetic aperture created depends on the application and sensing of the magnetic switching AC or DC field from the receiver to saturate the magnetic layer. Presence of metals in between the charger and receiver coils, may reduce or eliminate the magnetic aperture and therefore automatically reduce or shut off the power transfer. The degree of this effect would depend on the type, composition, and size of the metal object involved but with appropriate design of the charger and receiver coil, the switching magnet and the switching material would enable design of products that may inherently be safer

in this respect. In addition, this technique may be combined with the other techniques described above to provide further safety. In practice, the inventors have tested this by placing a large magnetic metal sheet of Stainless Steel in between the charger surface and a receiver coil and its switching magnet. While the amount and efficiency of the power transfer was affected, wireless power transfer continued without or with minimal eddy current heating of the sheet. This occurs because the Stainless Steel shields the magnetic switching layer in the charger from the switching magnetic field of the ring magnet in the receiver. Thus the magnetic aperture is only partially (area wise) opened only in the areas of overlap of the receiver coil and the charger surface where the metal sheet is not. In this way, power transfer can continue in this area and since the other parts of the metal sheet are on top of the magnetic layer that is not opened, it does not receive any power from the charger and thus no or minimal eddy current and heating is generated. A ring magnet was used in this case but the results are not limited to this geometry and are general with respect to a variety of magnets and geometries. Similar results may be obtained in the MC configuration.

[00215] In some applications, it may be desirable to be able to charge wireless power receivers at a distance from the charger surface or electronics. Examples for consumer application include a wireless charger that is mounted or attached under a desk or table to charge devices placed on top. Another case may be charging of a battery powered, electric automobile or vehicle. Depending on the charger and receiver coil size and operating frequency, Q of the cavity, etc. the operating distance varies. The inventors have found that in a 'traditional' loosely coupled system (i.e. without the magnetic layer) such as described above (with 18 x 18 cm charger coil and 35 mm diameter receiver coil) coils can be separated to distances of several cm while significant power is transmitted. The inventors have obtained power transfer of over 20 W into a single coil at up to distances of 3 or 4 cm. However the system efficiency may be reduced to 50% or lower for these distances. These gaps are sufficient for most of the consumer electronics applications envisioned.

[00216] Similarly with a magnetic layer system in MC or MA configuration as described above, the distance between the receiver and the charger can be increased while continuing to receive power. However, two parameters have to be kept in mind. One is the Q of the resonator and/or the distance where the electromagnetic field exists away from the charger surface (which is governed by the frequency of operation, coil size, magnetic material properties, pattern, etc.) and the other is the field pattern from the switching permanent or electromagnet that is required to open the magnetic aperture in the MA configuration. This switching field should be of sufficient dimension, direction, and shape to effectively affect the

switching magnetic layer and modify the properties to open an aperture and allow efficient coupling. It was experimentally observed that in a system similar to the loosely coupled system described in the last paragraph but with a switching layer covering the charger coil and a ring magnet similar to Figure 22 in the receiver, efficient (up to ~50% efficiency) power transfer at up to about 2 cm vertical coil to coil gap can be obtained. Somewhat less efficiency but larger operating distances can be obtained in the MC geometry without the switching magnet and with a different and appropriate receiver coil. It must be noted that even with a large gap between the charger and the receiver, the areas around the receiver do not contain significant Electromagnetic emission as tested by placing metal parts in this area and not observing much change in power transferred or pulled from the DC supply providing power to the charger. The reason for the presence of the coupling is the enhancement achieved by the resonant circuit (in the MC configuration) combined by the open aperture created in the MA configuration. As the gap is increased from around 2 cm, power transfer drops rapidly in the MA configuration. This may be due to the field of the switching magnet reducing and not opening the magnetic aperture completely. Proper optimization of the design and type of magnet, coils, switching layer or use of multiple layer switching layers could significantly improve this.

[00217] To enable the system to operate at larger gaps, several embodiments are possible. In one embodiment, the magnetic layer (ferrite or other material) is separated from the charger coil such that a gap between the charger coil and the switching layer exists. This gap can be several centimeters. Since the magnetic or switching layer (in the MA configuration) is a high permeability material, it is quite an effective material to draw the emitted magnetic field from the charger coil into itself. Therefore, even at large distances, the layer acts as a boost / repeater, or flux reservoir layer and good coupling into this layer exists. This power can be coupled into a receiver placed on or at a distance from this layer. In the MA configuration, when a receiver with a switching magnet is placed on or over the top surface of this layer, the magnet would switch the switching layer and receive power efficiently. Therefore, large gaps between the charger coil and a receiver can be obtained. Experimentally, a planar magnetic layer of ferrite material described above was placed at a distance of 3 cm away from the top surface of a charger coil of 18 x 18 cm as described above. An MA receiver (as described above) placed on the magnetic layer or within 2 cm of the layer would receive powers in excess of 20 W at efficiencies comparable to the case with the magnetic layer adjacent to the charger coil. In this case the magnetic layer essentially acts as a reservoir of AC power magnetic field away from the charger that is available for the receiver to tap into at a magnetic aperture location to draw power from. Similar results can be obtained in the MC geometry with the appropriate receiver

and no switching magnet. Such embodiments are attractive in the case of a desk charger where the charger coil and the associated electronics can be placed or attached to the underside of a table or desk top or the console of a car and the size and bulk of this part is hidden while a thin magnetic layer (can be a thin solid, flexible ferromagnetic, ferrite or other material) is placed on top of the desk or away from the charger coil to indicate the region of operation or carry a logo or be decorative or interchangeable, etc. This repeater layer can be a 0.5 mm or thinner layer and can be flexible or curved etc. as necessary and while being decorative or used to notify the user about where to place a device for charging / power, can serve the important shielding, guiding, and/or switching functions. Any of the materials described earlier can be used for this. Optionally, the charger coil and/or electronics can also have a shield on the opposite side to prevent emissions from the opposite side of the charger. The thin shield / repeater layer on top of the desk / table / console can also provide additional functionality or information to the user. For example the layer can be combined with a wireless power and/or data receiver and/or electronics and display relevant information to the user. Examples include start of charge, status of devices being charged, errors, etc. through use of displays, LEDs, electroluminescent displays, parts, etc. Such a display or layer may be as thin as 0.5 mm or thinner and can provide a multitude of functions.

[00218] In another embodiment, a wireless charger / power supply can be placed under a table top and a display or tablet built in or attached to the top and powered from below. The display and/or tablet can also include a portion or surface for charging or powering other devices on it or separate from it. The tablet alternatively may display the charger status or information about devices being charged / powered.

[00219] In yet another embodiment, a wireless charger surface with or without a magnetic top layer (i.e. MC, MA, tightly or loosely coupled or any other configuration) may be covered totally or partially with an electroluminescent (EL) and/or LCD or other display. These structures comprise several layers that may be constructed of metal and/or semiconductor and/or plastic and/or glass but may be as thin as 0.1 mm to several mm. Even though the structures would contain metal layers for applying a field for the device to operate, these layers are extremely thin (several nm to microns) and allow the magnetic field of a charger to pass through. It has been found that the surface of a MA or MC or tightly or loosely coupled charger can be totally or partially covered by an operating EL display while the charger operates normally with no significant reduction in power transferred or efficiency. It is also possible to construct the charger and/or receiver into or on an electronic display or screen. The charger and/or receiver coil and circuits may even be constructed of printed circuit or plastic material used to

manufacture the display to save processing steps and complexity.

[00220] In accordance with an embodiment, the charger is a stand-alone device / pad or other shape combining a display and charging functionality. The display can provide information useful for the user of the charger or can be a fully functional display for information such as a tablet, netbook or computer or table top computer display. For example a tablet may incorporate a wireless charger on its top display surface. By placing a mobile phone or camera on the display of the tablet, charging may commence and additionally, other functions may start. For example data, images, music, etc. may be transferred from one to another.

[00221] In the case of a desk wireless charger described above where the charger circuit is placed under the desk and a magnetic layer is placed on top as a magnetic boost or reservoir plus shield layer, it may be beneficial to provide LEDs, a charge indicator or other information to the user. In this case, according to an embodiment, all or a portion of the boost / magnetic layer is covered or integrated with an EL, LED or other layer and powered by the applied power from below and a small circuit to provide indicator LEDs, charge percentage, or other info or a full feature display to the user. As an option, in public area uses or kiosks, advertisement or other info can be provided to the user while devices are charged or powered on or near the display. The display and the charger layer can each be less than 0.5 mm thick or similar and can also be flexible or rollable and/or laminated or itself hermetic / impervious to environments and also allow accommodating a contour or curve or be rolled and unrolled like a placemat. Many applications and embodiments of this are possible and the possibility of a wirelessly powered display and/or charger can be used in many applications.

[00222] In various other applications, including U.S. Patent Application No's 12/400,703, 12/2102,00, 11/408,793, 11/654,883, 12/543,235, 12/250,015, 12/211,706, 12/427,318, 12/756,755, 12/618,555, 12/510,123, 12/323,479, 12/479,581, 12/505,353, 12/351,845, 12/189,720, 12/394,033, 12/547,200, 12/040,783; and U.S. Patent Nos. 7,741,734 and 7,825,543, wireless power systems for operation with large distance between the charger and receiver have been described. These systems generally operate as loosely coupled systems but have also been called magnetic resonant systems. However, the inventors recognize and have described the safety and regulatory issues arising from the large electromagnetic emissions present in such systems. Meeting regulatory and human safety standards are challenging and may be only achieved for limited power outputs and in certain frequencies of operation intended for unrestricted power output. Some of the embodiments of the systems described here attempt to overcome such restrictions by limiting or eliminating the Electromagnetic emission and exposure from wireless power systems by use of a magnetic

aperture.

[00223] To achieve the large operating distance possible by systems using loosely coupled or magnetic resonance technology whereby the coupling coefficient is small, previous investigators have found it necessary or preferable to operate the systems at high Q values often exceeding 100 or 1000. To overcome parasitic losses in a coil and driver system, previous investigators have also found it preferable to utilize 2 coils for the charger and 2 for the receiver. This system 450 is shown in **Figure 32.** The charger / driver electronics in the first coil is powered by the transmitter / charger drive electronics and produces an electromagnetic wave that couples to a charger resonant antenna placed nearby through a coil L1. This antenna is the one that actually transmits power over a distance and comprises an LC circuit formed by a low resistance wire or coil loop (L_c) and a capacitor (C_c). Due to high Q's encountered, the voltages generated may exceed 1000's of V so appropriate high voltage capacitors may be needed. The receiver (used in or on or attached to a mobile or electronic device or battery) comprises a receiver resonant coil (L_r) and a capacitor (C_r). The receiver resonant antenna may have similar construction and/or Q or more typically be of smaller dimensions and/or Q of the charger. The wireless power is transmitted over a distance between the 2 resonant antennas described. This received power is then in turn coupled to a receiver circuit through a coil L2. The power is then rectified and smoothed and connected to a load. An optional regulator or power switch may also be included in the receiver. This description describes a simplified system with no communication and/or microcontroller control. In practice, these elements may be needed as described in earlier systems.

[00224] In loosely coupled systems as described here, it may be possible to increase the distance between the charger and receiver coils additionally by adding passive resonant antenna elements to act as repeaters. This configuration 460 is shown in **Figure 33** where one or more repeaters are inserted between the charger and receiver resonant antennas.

[00225] While some of the systems described here use 2 coils for the charger and 2 for the receiver, systems with single charger coil and single receiver coil or 2 coils on either charger or receiver are also possible for loosely coupled / magnetic resonance systems as described in earlier sections. In general, due to potentially lower Q factors, these may operate at lower charger / receiver distances. The descriptions here are attempting to capture the various systems possible in the most general sense and are not meant to limit the description of the embodiments possible.

[00226] One of the key observations in this system is that the magnetic field generated between the 2 resonant antennas (or resonant antennas and repeater antennas) is quite large

and enhanced owing to the resonance and the high Q used. This would in many cases cause unnecessary emissions, human exposure, and/or eddy current heating and interaction with metals nearby.

[00227] In accordance with an embodiment and building on the concepts of MC and MA configurations described above and shown 470 in **Figure 34**, a layer comprising magnetic or ferrite or other material is added to the charger to limit the emission from the charger into space. The receiver may contain a permanent magnet or electromagnet (in the MA configuration) to locally modify the switching layer and create a magnetic aperture for localized and efficient transfer of power to the receiver. The efficiency of such a system would exceed the regular loosely coupled system due to the elimination or reduction of loss of power to surrounding areas and the extraneous unwanted electromagnetic emissions would be greatly reduced as described earlier. It must be kept in mind that a variety of materials, parameters, and geometries for the magnetic / switching layer, magnet, coil, rectification, regulation, or additional elements for communication, control, detection of foreign objects, thermistors, etc. are possible as described here and Figure 34 is greatly simplified to more clearly illustrate the basic elements of the system. It must also be noted that as described earlier, the magnetic / switching layer may be placed at a distance from the charger resonant coil and similarly the receiver magnet may be at a distance from the magnetic / switching layer and/or the receiver resonant coil. In addition, as described earlier, the magnetic / switching layer may in effect act as a reservoir of power due to its high permeability and draw the power away from the charger coil in a similar manner as a resonant antenna or a repeater antenna. Thus several geometries with a large gap between the charger coil L1 and the charger resonant antenna with the magnetic / switching layer close to the charger resonant antenna or closer gap between the charger coil L1 and the charger resonant antenna and a larger gap between the charger resonant antenna and the magnetic / switching layer or a combination of the above is possible to create a larger gap between the charger and the charger surface or the receiver. Similarly many variations in placement of the receiver switching magnet or electromagnet exist. In addition, one or more magnetic / switching layers and optionally (in case of use of MA) magnets may be placed at one or more locations of a system such as shown in Figure 34 to funnel or better control the direction and flow of the power as shown in **Figure 35** to increase efficiency and reduce unwanted emissions.

[00228] In the geometry 480, 490 of Figure 35 and **Figure 36** respectively, one or more repeater antennas and one or more magnetic / switching layers and optionally (in case of use of MA) magnets and/or electromagnets are used to extend the range between the charger and

receiver while controlling the emissions. It must be noted that as described above, magnetic / switching layers and/or repeaters and/or resonant antennas may be used in a number of combinations and placements to extend the range as appropriate for any application.

[00229] As an example of the embodiments described above, a charger may be placed below a table or console and the resonant coil and a magnetic / switching layer placed on top of a table in a thin layer to be close to receivers embedded or attached to devices and/or batteries. In another geometry, the charger and the charger resonant coil may be under a table or a long distance away and a repeater can be placed below or on top of table with a magnetic / switching layer directly or with some distance on top of it to for the device to be placed on top of. Many different geometries are possible with the combination of approaches described here to provide efficient power transfer to one or more receivers while keeping extraneous unwanted emissions to a low level.

[00230] It must be noted that in these embodiments a larger charger resonant coil and smaller receiver coils is described. However, as described earlier, the opposite may be preferable in some situations and the magnetic / switching layer may be placed closer to the receiver and any used switching magnet may be close or part of the charger.

[00231] In addition, while the MA or MC configuration and use of a possible switching magnet is described here, any of the combinations of heat, dc, and or AC magnetic fields and/or use of hard magnets or self switching due to high AC magnetic fields, etc. can be used to achieve desired performance and characteristics. In addition, any magnet if used can have a varierty of shapes and geometries as described earlier.

[00232] Many of these combinations of technologies may be advantageous to systems where high power and large charger / receiver gaps are desired such as charging electric vehicles, etc.

[00233] In accordance with an embodiment, the charger coil and/or the magnetic / switching layer is curved or folded to form a non planar or enclosed surface. Examples include a charger bowl or cup where mobile devices can be placed to be charged. Such a cup may be advantageous in an automobile cup holder as an example to allow the user to place a phone into the cup for charging. The charger coil can be constructed from Litz wire and/or flexible PCB material to cover the entire or a portion of the surface of the cup. This can be covered by an appropriate magnetic / switching layer and when a mobile device or receiver with the appropriate magnet (in case of MA configuration) is placed inside the cup, it can switch the appropriate location on the cup to allow flow of power and charging of the device without affecting nearby parts or extraneous emissions. In an MC configuration, no switching magnet

would be necessary.

[00234] As an alternative, the charger coil may be flat and the magnetic or switching layer is formed in the shape of a cup, cup holder cylinder or other bowl, etc. or laminated with solid or flexible material such as flexible magnetic material or ferrite as shown 500 in **Figure 37**. For example, in an embodiment such as shown in Figure 37, the wireless charger may be in the shape of a cup for placement of mobile devices inside to receive charge / power. The charger can be powered with the charger circuit integrated into the cup or cup holder or inductively through integration of a receiver and charger drive circuit into the cup or cup holder or directly simply by having the charger circuit and coil at the bottom as shown in Figure 37. When inductively powered, the bottom of the cup or cup holder may be from the same magnetic material or other material to guide the flux to the walls and may even contain a repeater antenna as described earlier to allow large gap between the charger and the cup. The charger coil may be at the bottom or at a distance from the cup and flat or curved and the flux is guided up the sides with a ferrite material shaped like a cylinder or coated or laminated with flexible ferrite or other magnetic layer to allow a device with appropriate receiver and/or switching magnet (in the case of MA configuration) to be charged when placed inside. Additional shielding material may be placed on the outer surface of the charger to shield the charger radiation externally. Many other shapes and configurations are possible with the technology described here.

[00235] Alternately, as described above and shown 510 in **Figure 38**, the charger coil can also be wrapped around the vertical cylinder body while the inside of the cup uses the magnetic solid material, layer or laminated film. The charger coil is only partially shown. The coil would wrap around the entire or the desired active part of the surface of the cylinder or cup or cup holder and comprise one or more coils. Many geometries of coil and construction by wire, PCB, Litz wire or a combination are possible. In this case as described above, the charger coil may be powered directly by a charger circuit powered by wired power or a charger circuit that is itself powered inductively whereby a wireless receiver is integrated into the cup or cup holder and is powered by a wireless charger base. The ability to separate the charger cup / cup holder from the charger body / surface (base) as shown in Figure 37 may be advantageous and provide flexibility in some circumstances.

[00236] In all of the embodiments described here, the electronics in the charger and receiver may be implemented using discreet electronics components or Application Specific Integrated Circuits (ASICs) that would combine a variety of the functions and electronics components into one or several components and enable further integration and reduction in cost and footprint.

[00237] Overall, many geometries or architectures for wireless power systems are possible. In network systems and internet, terminology for the methods for transfer of information from a source to one or many different recipients has been developed. A similar terminology is used here to consider powering one or multiple receivers. For cases where the receiver must be placed on or near a fixed position, systems such as tightly coupled systems are used. The architectures below can use loosely, or tightly coupled systems or use a ferromagnetic layer and creation of a magnetic aperture as described above or a combination of the above to achieve positioning freedom. This description is thus more general and attempts to illustrate the different control and communication methods that can be used. In one view, the wireless power system can be described as a power transmission system (wireless charger and receiver circuitry) and systems for control, regulation, safety and other features necessary.

[00238] Having dealt extensively above with the power transmission system and methods of power delivery in tightly, loosely, and magnetic coupling and magnetic aperture systems, methods will be described herein for the control, regulation, and safety of the system (control system). To implement the systems with desired characteristics, a close interaction and appropriate design between the power transmission system design and the control system design is necessary.

[00239] **Figure 39** shows several possible architectures 520 where the charger circuit comprises sub circuits or units whereby each sub-unit is responsible for powering or charging and/or communicating with one power receiver. The arrows in Figure 39 show the direction of the power transfer to the device to be charged. However, the direction for the communication and/or control can be in the same direction, the opposite direction, or bidirectional or no communication and/or control between the charger and receiver may exist. In addition, the communication and/or control can be through the coils, by load modulation, separate communication coil or coils, RF or optical path, etc. or a combination of such methods. As described above, existing protocols such as Bluetooth, WiFi, NFC, RFID, Zigbee, WiGig, Wireless USB, or protocols such as that provided by the Wireless Power Consortium (WPC), developed for wireless power, or a combination of the above and/or new protocols or proprietary communication mechanisms can be used. As described above, it is also possible to develop systems whereby there is no communication between the charger and receiver and any regulation or end of charge termination and/or shut off due to unexpected events occurs in the receiver.

[00240] A simple example of such one to one architectures is a multi-charger tightly coupled system where multiple identical or similar charger circuits are replicated several times

in a charger and connected to similar coils to allow powering or charging several receivers simultaneously and mostly independently. a) In this architecture, a charger can only support one protocol and the Charger circuit is composed of multiple sub-units where each sub-unit powers and/or communicates with one receiver. The charger coil or active area is defined and in tightly coupled systems each receiver coil must be placed on or near a charger coil to receive power / charge. Little positioning flexibility exists. An example of such architecture is a multi-charger tightly coupled system where multiple identical or similar charger circuits are replicated several times in a charger part or product and connected to similar coils to allow powering or charging several receivers simultaneously and mostly independently. b) In this architecture, the positioning freedom is limited as in a) but the system is designed with its hardware and/or firmware so that each charging location is capable of operating in one or more communication and/or power protocols, providing different voltages, and/or power levels and thus providing more flexibility. Some of the ways to achieve this multi-protocol flexibility or achieving different voltages and/or power levels are described earlier. c) In this architecture, the charger surface may be divided into sections where a receiver can be placed anywhere or with a larger degree of positioning freedom and be powered or charged. This architecture only supports one protocol, voltage and/or power level in each of the charger sections. An example may be a magnetic resonant (loosely coupled) or magnetic aperture or a combination of these systems where the charger comprises several similar coils and/or driver and/or communication circuits and they operate mostly independently to power or charge multiple devices simultaneously. Alternately, each region may provide positioning freedom with tightly coupled technologies such as coil arrays or a moving coil as described earlier. d) This architecture is similar to (c) but it may support multiple protocols, voltages and/or power levels in each of the charger sections. This can be achieved by some of the techniques described earlier.

[00241] As an example of Figure 39(d), a power transmitter / charger / power supply may comprise a number of transmitter coils and associated control and communication circuits operating in tandem or independently. The charger / power supply / transmitter surface may thus be divided (and identified to the user) to contain independent sections so that the user may place one receiver on or near each section of the charger / power supply / transmitter to be powered and/or regulated by its associated electronics. Each section may operate as a position independent charger / power supply through use of the techniques and geometries described here so that the user may place the receiver in any position on the charger / power supply / transmitter for operation. Another device to be powered and/or charged may be placed in another section and similarly operate in a position independent manner in that section.

[00242] **Figure 40** shows a geometry 530 where multiple transmitter coils cover different areas of a multi-charger / power supply. Within each section, devices with different power rating and/or coil size and/or using the same or different protocols may receive the appropriate voltage and power required. Loosely coupled systems or tightly coupled position free systems within each section can be used to achieve positioning freedom. Although support of multiple protocols or power or voltage levels would require that any system employed in each section be flexible and adaptable in these regards.

[00243] Alternatively or in addition, as shown 540 in **Figure 41**, as described earlier, use of a magnetic layer and creation of magnetic coupling or a magnetic aperture for coupling of power to receivers can provide benefits in efficiency, positioning flexibility and/or lower unwanted electromagnetic emission. Each section has an independent power driver and/or communication sub unit system to operate with the receiver nearby. In this way, control and regulation of individual devices and position independence can both be achieved. However, in protocols whereby the receiver signals to the charger about amount of power to send and takes control of the operation of the charger, placement of more than one device in each section may not be permitted since the regulation and control system operates by communication between the receiver and charger in each section and adjustment of the power / operation in that section. In practice, this may not be a significant disadvantage to the user.

[00244] One of the interesting aspects of the architecture in Figures 40 or 41 is that even if position free technologies such as loosely coupled chargers or magnetic coupling or magnetic aperture are used in the charger, it may be designed to be backwardly compatible with tightly coupled receivers and/or protocols. As described earlier, tightly coupled systems such as those that use the Wireless Power System (WPC) protocols, are in general designed to have communication between one charger sub unit and a single receiver system and in their basic form designed to establish this through communication through the coil although other methods and paths of communication can also be supported by the architecture in Figure 40 or 41. By appropriate design of the charger or transmitter coil, the value of the resonant capacitor, the communication system in the charger, etc. a position free charger that can detect and power receivers designed for tightly coupled systems can be designed. To achieve this, the resonant conditions of the position free system may need to be tuned to the right frequency of operation and the right protocol used to understand and act on the communication messages from the receiver. An advantage of this type of approach may be that by using a larger coil and more flexibility, multiple output powers or voltage levels may be supported in different types of receivers thus obviating the need for multiple coils or circuits in the charger to power different

types of receivers. Additionally, different communication or power protocols may also be supported to provide more flexibility.

[00245] **Figure 42** shows a mobile device 550 such as a mobile phone with a receiver coil and receiver circuit integrated into the back cover or battery door. The receiver circuit including rectifier, control, communication, etc. may be placed on this door and the power connection to the device made through pins or alike to the rest of the device. The main device may also contain a charger IC and or means of allowing wired power / charging for the device and an automatic or user controlled method for switching between wired and wireless charging. To use the wireless power receiver on a position free charger system using magnetic aperture, a switching magnet is also required to locally saturate the ferromagnetic switching layer. This is shown as a ring magnet with a cut (for reducing or eliminating eddy currents) here but can have different shapes and size as described earlier. Similar components may also be used in after – market or optional device cases, battery doors, skins or batteries to allow a non-wireless chargeable device to be enabled for wireless charging. In such cases, battery door or skins or batteries, the receiver coil and the circuitry may be included in the case, battery door, skin, or battery and connected to the device power input through the power connector of the device or pre-existing power connections on the back or side of the device, etc. Alternatively, the coil and the receiver may be integrated into the original or after-market battery of the device and directly charge the battery. In these cases, the receiver may also contain battery charging ICs and protection and or thermal circuits and circuits for detection of wired charging current into the battery and battery ID or other circuitry. In the MA configuration, for the receiver with a position free charger as described earlier with a switching layer, a method for switching the layer is needed. This can be a magnet, electromagnet, or a combination thereof as described above that are added or adhered to the front, back or around the receiver coil during manufacture or afterwards by the user or the product manufacturer or seller to create the appropriate magnetic aperture on the charger switching layer when the receiver is placed on the charger. For example, for a phone case or skin where the coil is in the case, the magnet may also be integrated inside the case by the manufacturer. In addition, the inventors have found that tightly coupled receivers such as those integrated into after-market cases or skins to work with tightly coupled protocols such as the wireless power consortium (WPC) can operate on position free magnetic aperture charger surfaces if one or more magnets of appropriate polarity, size, strength and material can be attached to the outside surface of the case facing the charger thus enabling a standard tightly coupled receiver to also operate on a position free charger surface providing a high degree of flexibility. It must be noted that such a receiver will continue to work

on the original tightly coupled (fixed position) charger for which it was designed for since the attachment of the magnet to the outside has no effect on its performance.

[00246] In one example, the inventors attached an axially magnetized 1.5mm thick Nd ring magnet similar to Figure 22, aligned to be centered around the coil in the protective case. to the outside of a Wireless Power Consortium (WPC)-compatible device (such as that commercially sold by, e.g. Energizer for use with, e.g. Apple iPhones and other mobile devices), and tested this tightly coupled receiver on a position free magnetic aperture system with 18 x 18 cm surface area comprising a coil with pattern similar to Figure 12 and covered by a layer of 0.5 thick MnZn material of appropriate permeability and switching magnetic field value. Operating the charger at the appropriate frequency of around 175 kHz, the charger can power the receiver and communication and regulation of power through the coil (through the opened magnetic aperture) can be achieved allowing position free, regulated power charging. The charger can fully implement the appropriate protocol and operate similar to a fixed position charger while retaining the flexibility in placement of the receiver. In addition, the receiver and case continue to function normally when used with a standard WPC-compatible charger. Since WPC-compatible systems contain an alignment disk magnet of pre-determined size, shape, and strength at the center of the charger coil (and a magnetic attractor at the center of the receiver coil for alignment), care must be taken in the polarity of the ring magnet attached to the case so that the case receiver would continue to align and center on the charger and not repel each other. Since a ring magnet of larger diameter is used here, addition of this magnet in fact enhances and adds in the centering by providing further tactile feedback and pull force to the user when the receiver is placed on or near the charger magnet of a smaller diameter in the charger thus enhancing the centering process with the standard WPC-compatible charger. On a position-free charger with a switching layer, the polarity (N-S orientation) of the magnet is not important for the switching layer since it responds to the magnitude of the total field (DC / AC switching magnetic field + AC wireless power magnetic field) so the choice of polarity is not important. This however, does become important if a bias DC magnetic field by a permanent or electromagnet is added to the charger as described earlier to lower the receiver magnetic field necessary to switch the layer.

[00247] Similarly, a magnet or magnets can be attached or added to the inside, backside or on the top surface of the cases, battery doors, skins, devices, batteries or back sides or batteries at the right location with respect to the receiver coil to enable a regular tightly coupled receiver to operate in a position free magnetic aperture system as well.

[00248] In accordance with an embodiment, such an addition or attachment can therefore

be used to enhance the usefulness of wireless power receivers integrated into various products such as cases, skins, devices, doors, back plates, or batteries by adding or attaching one or more appropriate magnets of the appropriate size, strength, and shape to enable the receiver to operate with a position free magnetic aperture charger. This may take the shape of a thin, light weight sticker or adhesive part or logo that is adhered by the user or in the manufacturing process to the right location on or in the case, skin, battery door, back plate, or battery to enable this additional functionality. Considering that the magnet may be a very thin and/or flexible magnet, this can be also made to be quite inconspicuous and to add very little to the thickness of the device and/or receiver. As described earlier, a variety of types of magnets and even multi-pole magnets may be used. In conditions such as charging inside automobiles, airplanes or other vehicles, trains or boats where the receiver experiences rapid motions, acceleration or deceleration, the combination of the magnet and the ferrite switching layer provides an additional benefit that the attraction between the magnet and the layer provides a magnetic attraction that can keep the device from unnecessary slipping during motion and this may be quite advantageous.

[00249] In any of the examples given above, the ring magnet and its variations including the gap are described only by way of example. In accordance with other embodiments, it is also possible to achieve the same or a similar effect with use of any appropriate one or several permanent magnets or electromagnets of arc, disc, cylinder, square, rectangular, triangular, oval, or ring, etc. shape, magnetization orientation and magnetic flux density pattern. As described above, it is important to optimize the type and structure of the material and the DC switching magnetic field appropriately to achieve optimum saturation. The use of anisotropic or multi-layer switching layer also provides further flexibility and design possibilities. Since a particular type of magnet and field strength may be required to open the aperture (in conjunction with the magnetic layer), it is therefore unlikely that a casual or accidental placement of a magnet by a user will open this aperture. Furthermore, if such an aperture is opened, the system with receiver communication and/or feedback can be designed to require a communication signal to verify presence of a receiver and continue providing power. Therefore, the systems described here can be implemented in an extremely robust and safe manner.

[00250] For ease of illustration, the switching layer was described above as one layer in many of the above descriptions. In accordance with various embodiments, such as for manufacturing and/or performance reasons, it may be desirable for the switching layer to be actually made of multiple active layers. For example, the FineMET® sheet material may comprise one, two or more layers of active Ferromagnetic material sandwiched between

adhesive or backing layers. This is done to accommodate the thin nature of the basic manufactured layer while providing sufficient performance and overall active layer thickness. In general, the multiple layers of the switching layer (sheet or material) of soft and/or hard magnetic material may be similar or different to improve performance and characteristics. Interesting and useful effects may be achieved by using exchange coupling between the layers as used in magnetic recording layers.

[00251] It is also possible to operate a receiver designed for tightly coupled operation in a Magnetic Coupling configuration as described earlier. Since tightly coupled systems contain resonant circuits in the receiver, by appropriate design of the charger and the magnetic layer, position free operation of the tightly coupled receiver such as a WPC receiver on an MC charger is possible.

[00252] An additional observation is that in the MA configuration, with a receiver containing an appropriate magnet placed on the charger surface, the magnetic aperture is opened as described above. The inventors have experimentally observed that a second receiver (with or without magnet) placed on top of the first receiver at distances of an inch or more apart from the first receiver coil also receives substantial amount of power if no or minimal shielding is incorporated behind the first receiver's coil. In accordance with an embodiment, the amount of power received is larger than received by a receiver coil placed at such a distance from the charger surface when a magnet placed near the surface opens an aperture. This is an indication that, in accordance with some embodiments, the coil and/or circuit from the first receiver (close to the charger surface) acts as a resonant repeater as described earlier and the second receiver coil (from the receiver not requiring a magnet farther away and above the first receiver) can be designed to interact and resonate to extend the power to larger distances from the surface. This important and useful effect demonstrates that, in accordance with various embodiments, multiple receivers can be stacked (possibly to several receivers and many inches high) from the charger surface and all the receivers may be powered and or charged simultaneously. It also demonstrates that once a magnetic aperture is opened, the power from the aperture can be effectively guided or extended far above the charger surface. By using smaller or larger dimension coils along this path, the magnetic field physical dimension can be expanded or contracted as in a column of power from the aperture. By use of different coil turns and dimensions, different power levels and/or voltages can be extracted from this column at different positions.

[00253] The system described here, thus provides a 3-dimensional power outlet that allows the user to extract power at different locations on the surface and vertically above the

charger surface. Interesting and useful applications of this approach for powering products or power distribution can be envisioned. Such a system may also be used within an electric or electronic product to distribute different power or voltages to different locations.

[00254] For example, it would also be possible to develop multi-voltage and/or multi-power power supplies where different vertically stacked power receiver coils extract the appropriate power and voltage from a common primary (charger) coil. For fixed power supplies (where the receiver does not need to be physically removed), use of a switching layer may not be necessary since the x-y dimension flexibility is not required. Thus a charger coil and multiple vertically stacked receiver coils may be used.

[00255] In accordance with some embodiments, it may not be desirable to have the magnetic field extend beyond the first receiver. As described earlier, use of appropriate ferromagnetic, shielding, and/or metal layer behind any of the receiver coils can suppress this field reducing any potential effect of the magnetic radiation on nearby devices, objects, or living tissue. So the field extending in the z direction can be manipulated not to produce undesirable results. In accordance with some embodiments, it may also be possible to route the magnetic field past sensitive parts and have it then extend beyond the device to the next device without affecting the parts to be shielded. For example in the case a charger for multiple mobile phones is developed that allows stacking of the phones on the charger, the first receiver coil and magnet closer to the mobile device would open the aperture in the charger and provide power to the first receiver. This can be followed by a structure of ferrite and/or metal layer that protects the sensitive electronics of the mobile phone or any metal layers from the magnetic field but routes it above the first mobile device or phone to reach a second device's receiver coil and power that and so on and so forth, thus simultaneously powering multiple stacked mobile devices and yet shielding the electronics inside them.

[00256] While the above description is provided for the MA configuration, it also applies to the MC configuration or a combination of MA and MC chargers and receivers can be combined.

[00257] As described earlier, in accordance with an embodiment, the charger can be implemented so that it is able to decode and implement multiple communication and regulation protocols and respond to them appropriately. This enables the charger to be provided as part of a multi-protocol system, and to operate with different types of receivers, technologies and manufacturers.

[00258] To implement this, at the initial stage, the Charger may send out a ping signal at a frequency that is known to be able to power the multiple types of protocols in existence and

then “listen” for a response. If the frequency range of the potential types of receivers is very wide (e.g. from kHz to MHz) it may be necessary to change the resonant frequency by changing the coupling capacitor. For example, the system may be designed so that a number of resonant capacitors such as C1 in Figure 2 are connected through switches in between the drive circuit and the coil so that the resonant condition can be changed over a wide range. The charger can switch in a capacitor and couple to the coil through that capacitor, apply power (ping), listen for a response or check for current draw due to a receiver and if no response is detected, move to switch in another capacitor, apply power (ping), look for a response, etc. to ensure all possible protocols and possible receiver types have been interrogated.

[00259] As shown in Figure 10, in one protocol, after the receiver sends back a communication signal back to the charger, in response to it, the charger adjusts its frequency (to get closer or further from resonance and power transferred) and then awaits further information from the receiver. The receiver acknowledges the change and as shown in the second data packet in the receiver signal, has modified its state and communicates back to the charger. This closed loop continues during the charging process.

[00260] One of the issues in developing multi-protocol systems is that the operating frequency of the different systems and protocols may be sufficiently different (e.g. from kHz to MHz) that the charger system may not achieve resonance with the receiver in the frequency range possible with the charger coil and the resonant capacitor used and therefore efficient operation with the receiver nearby can’t be achieved. To solve this problem, the system may be designed so that a number of resonant capacitors such as C1 in Figure 2 are connected through switches in between the drive circuit and the coil so that the resonant condition can be changed over a wide range. One method to overcome this is shown 560 in **Figure 43** where to achieve larger operating frequency range, the charger may contain a series of capacitors (C1 … Cn) and switches (S1 … Sn) under microcontroller control MCU1 to switch in and out the appropriate values of resonant capacitance in series or parallel to the charger coil inductance L1 to have a resonant frequency in the range appropriate for different protocols. In idle condition with no receiver nearby, the charger MCU1 may periodically power up and sequentially connect the appropriate capacitance value through S1 to Sn switches and then start powering the coil L1 by switching the AC switch S at the appropriate ping or interrogation frequency. If an appropriate receiver is nearby and is powered by the charger, it would respond back and the signal can be detected by the current detection and demodulation circuit in the charger and appropriate action can be taken by MCU1 to verify and/or continue charging / apply power at the appropriate power level by changing the switching frequency and/or duty cycle, and/or changing the input

voltage level to the switch S which is switched rapidly to generate the switching frequency. If no response is received, either no receiver is nearby or it operates at a different protocol or frequency and the Charger MCU would proceed to check for a receiver at a different protocol or frequency by interrogating at a different frequency range or if necessary, switching in a different or additional capacitor before proceeding with the ping as described above. The charger would continue interrogation / pinging at different protocols until a receiver responding to one is found to be nearby and then moves to apply power appropriately and based on decoding the signal pattern of the receiver to proceed with the appropriate algorithm / protocol to continue power application.

[00261] **Figure 44** shows the system of Figure 43 implemented in a resonant Converter architecture 570. The microcontroller MCU1 adjusts power to the coil L1 by adjusting Vin, the frequency, or duty cycle of the generated AC voltage or a combination thereof and generate the desired signal by switching Q1 and Q2 transistors. MCU1 also controls switches S1 through Sn to connect appropriate resonant capacitors to achieve a wide range of resonant frequencies. It must be noted that in a charger with different sections to charge different devices as shown in Figures 40 and 41, the different sections can operate at different frequencies or protocols as described above since they are independent.

[00262] In addition or instead of changing the resonant capacitor, it may be also possible to have different charger coils that are constructed of PCB or wire or Litz wire or a combination of such coils and have different turns, diameters, number of layers, construction, etc. in the entire charger pad or a subsection of the charger that can be switched in and out of the electrical path in the charger to achieve optimum power or communication coupling between the Charger and Receivers of different protocol, voltage, or power levels The added cost of inclusion of such additional coils or capacitors and possibly the extra complexity in the Firmware in the Microcontroller may be quite small but allow much more flexibility and interoperability with different receivers of different protocol, power, or voltage in these cases.

[00263] The same procedure or a subset of this can also be adopted for cases where communication is accomplished by other means than communication through coil such as RF or optical, etc. or in cases where different frequencies and also communication paths (through coil, through optics, and/or through RF) are employed in the different protocols. In this manner a multi-protocol architecture that is adaptable to many systems, powers, and/or voltage levels can be implemented.

[00264] Alternately, the receiver can be designed or implemented to accommodate different types of chargers or be multi-protocol. For example, once a receiver is awakened by a

charger, it can try to detect the ping or the operating frequency used by the charger. This can be done by any number of phase locking or other frequency detection techniques. Alternately, the receiver can send back a variety of trial communication signals during ping process to establish which type of device is performing the ping. Once the type of the charger is established, the receiver can proceed and communicate with the appropriate communication protocol and frequency with the charger.

[00265] Another advantage of an architecture such as Figure 39(c) and 39(d) or Figure 40 and 41 is that in the position free systems (loosely coupled and magnetic aperture) the power transfer efficiency of a system in general decreases with the surface area of the charger. It may be therefore advantageous to subdivide a large area charger into smaller sections and by detecting the receiver's placement on this section through in coil or separate coil communication, RF, mechanical, optical, magnetic or weight detection, etc. and only activate the section where a receiver is placed to enable higher efficiencies or output powers. Of course this can be combined with verification, etc. to provide further security and safety in these conditions.

[00266] **Figure 45** shows a geo-cast architecture 580 (similar to Figure 39(c) and (d) where a number of charger power and/or communication sub-units are connected through a multiplex system to the coil or coils in each section and can be connected to each section to support receivers placed in each. In a variation of this with multiple sub-units driving a single or multiple coils in a single section, multiple receivers may also be charged or powered in each section. To implement this architecture effectively, it may be necessary to have multiple coils of the same or dissimilar pattern cover the same area of a sector. For example, multiple coils patterns of shape shown in Figure 12 or other shape / size can be stacked on top of each other under the charger top surface and connected to the multiplexer so each can be individually driven. Each coil may be designed to have different number of turns and/or shape or pattern to be more advantageous for powering different receiver types (protocols), powers, and/or voltages. Each of the coils may be driven at a different frequency and operate one at a time or simultaneously to provide power to one or more receivers placed in that sector with different protocols, power, or voltage levels. It must be noted in magnetic coupling or magnetic aperture charger geometries that the charger AC magnetic field generated in the magnetic / switching layer would be an addition of the magnetic fields from different drivers and/or coils and/or frequencies and while all receivers with appropriate resonance and/or magnets or other parts would sense the AC magnetic field in the magnetic / switching layer, only receivers that are designed to operate at a particular frequency range or tuned to that frequency intentionally

would have power coupled out to them. Thus an individual virtual path (channel) for power transfer and/or communication between the appropriate sub-unit and receiver would exist. Inclusion of a parallel or series resonant capacitor in the receiver and tuning would enhance this strong dependency on the frequency and enable such independent channels to operate simultaneously.

[00267] In addition, in such architectures, it is possible to increase the amount of power delivered to a device in any section by multiplexing power from sub-unit drivers or operating multiple coils in that section (displaced vertically – i.e. stacked; or laterally – i.e. side by side) simultaneously to increase the AC magnetic field in that section. In order for this addition from multiple coils to add constructively, it may be necessary to keep the phase of the sub unit drive circuits in phase with each other. This can be easily achieved by controlling the control signal to the drive circuit from the microcontroller in the charger (MCU1).

[00268] Moving to architectures where higher degrees of flexibility in the positioning is achievable, **Figure 46** shows possible architectures for full positioning freedom 600. Figure 46(a) shows a charger which broadcasts power to a number of receivers placed anywhere on its surface. In the simplest case, the charger may broadcast power in an open loop geometry to one or more receivers which may or may not regulate the received power and deliver it to a load. Presence of one or more loads near or on the charger can be detected by the charger being brought into resonance by presence of one or more receivers and an increase in input current. Techniques such as periodic pinging of power can be used to detect the presence of receivers. In more controlled architectures, the receiver and or the receiver in combination with the charger establish some form of communication and control protocol to control and/or regulate the output power, voltage, or current from each receiver. In the case shown in Figure 45 (a), all receivers operate with the same protocol and require the same voltage and power level. In Figure 46(b), the charger powers or charges multiple receivers that may operate in different protocols, and/or have different voltage and/or power requirements. Figure 46(c) In this architecture, different sub-units and/or coils in the charger power or charge receivers with different protocols, voltage and/or power levels placed anywhere on a charger. And finally in Figure 46(d), each sub-unit and/or coil in the charger is responsible for up to one receiver on the charger. Each sub-unit and/or coil may be multi-protocol, support different voltages, and/or powers. The maximum number of receivers that can be powered or charged on a charger is the same as the number of sub-units.

[00269] It must also be noted that it is possible to provide a system that can operate in any of the modes shown in Figure 39 as well as a mode or architecture in Figure 46. For

example, it may be possible to have a charger that contains 3 sets of coils and drivers and communication sub-units configured to operate as in Figure 39(d) to provide charging for up to 3 receivers operating in different voltages, powers, or protocols simultaneously with each receiver being limited to a certain surface area of charger only (similar to shown in Figure 39) so no more than one receiver can be placed in each area. At the same time, the charger can for example have a large coil covering the entire or majority or a section of the charger surface that allows the charger to simultaneously or at different times power one or many receivers operating in a different protocol placed at any location on the charger such as in Figure 46(a) or 46(b) by broadcasting power and receiving it on this particular type or types of receivers. This may be achieved by having different coils and/or power driver / communication circuits power the different parts or multiplexing the same coil and/or power driver / communication circuit to function in the different modes. In an embodiment, the 3 coils to achieve the operation for mode shown in Figure 39(d) (Multi-protocol Geo-cast) are in one physical layer behind the charger top surface and/or the magnetic switching layer and the coil or coils to achieve the mode shown in Figure 46(a) or 46(b) are in another layer. These may be PCB, wire, or a combination of PCB and wire coils. The 2 modes mentioned here are only by way of example. Obviously, even more simultaneous modes of operation or different modes allowing simultaneous interoperability or support for many modes of operation are possible.

[00270] In accordance with an embodiment, to implement the architectures in Figure 46, a number of methods for communication and/or regulation of power can be used.

[00271] In many wireless power / charger systems, it is desired to control the output power, voltage, or current from a receiver. In many cases where the receiver is used to power or charge a device, it is necessary to keep the output voltage constant as the impedance of the device changes. In other cases where the output is used to charge a battery, it may be beneficial to adjust the output voltage in a pre-determined or pre-programmed manner as the impedance of the battery is changed. Figure 8 is an example of such a charging profile. To achieve such a result, a regulator comprising buck, boost, buck-boost, flyback, or linear type can be incorporated into the receiver output stage. In order to operate efficiently, it is desirable for any wireless charger system to be designed so that as the output current is reduced (higher load resistance), the input power draw by the charger and the output power of the receiver is reduced. It is found that in many cases, a higher load resistance (lower output current), shifts the resonance curve of the system (output voltage or power vs. Frequency) to the lower frequency. In such cases, especially for systems where the frequency and/or duty cycle of the charger power signal is not changed during charging, the system must be operated at

frequencies higher than the resonance peak so that as the battery connected to the receiver is charged and the current drawn decreases, less power is delivered by the receiver and also drawn from the input power source to the charger avoiding unnecessary heating / over voltage at the receiver regulator and efficient operation throughout the charging profile.

[00272] In addition, the output voltage of the receiver coil may be measured and its value or the difference between its value and the desired value may be reported to the charger to adjust one or many parameters such as voltage, duty cycle, and/or frequency of the charger signal to bring the voltage from the coil to within an acceptable range. Methods for such communication and control have been described earlier. However, such a closed loop may not be able to provide rapid adjustment of the power to transients and the optional output regulator stage can provide another level of regulation to provide faster performance. Figures 2, 3, 4, 6, 42, 43, and 44 show systems where this optional output regulator stage is included. In an embodiment here with a multi-receiver system such as architectures shown in Figure 46 and developed with loosely coupled or magnetic coupling or magnetic aperture technology, a regulation stage in the receiver can be used to provide the output power to the device or battery. This regulator may or may not be in addition to any communication, active feedback and/or control to control the output from the receiver coil to the regulator. Systems such as shown in Figure 46(a) or 46(b) may use such a regulation in the receiver to provide appropriate output power to devices and batteries.

[00273] In a multi-receiver system such as shown 610 in **Figure 47**, presence of one receiver may also influence the power delivered to other receivers. This effect has been observed previously (Zhen Ning Low, Joaquin Jesus Casanova, and Jenshan Lin, Advances in Power Electronics, Volume 2010, PP 1-13) where 2 receivers were connected directly to individual variable resistors and the individual and combined performance of the power transfer was studied. In the above references, it was noted that the power delivered to one receiver was not affected by another receiver placed on a loosely coupled charger as long as the load resistance for the second receiver was greater than a certain value (40 Ω in this case). In this method, the input impedance of the receivers is designed to be high to allow operation of the system with no or minimal interference between 2 or more receivers. Using regulators in the output stage to control the output power, it is necessary to select the appropriate regulator and design the overall system so that the interaction due to presence of multiple receivers is minimized or eliminated. Loss of efficiency due to the regulation stage can be minimized by using switching regulators that can have very high efficiencies. In addition, any inductor for the switching regulator can be similarly integrated into the printed circuit board of the receiver or on

the magnetic material used for the shield or another magnetic component in the receiver to provide lower cost, smaller size, or further integration.

[00274] Furthermore, the receivers can communicate with the charger by in-band (modulating the power signal such as load modulation) or out of band (Separate RF, optical or other) communication and can be uni-directional or bi-directional. This communication can validate the receivers, provide info about the power requirement, output voltage, power, temperature, state of charge, foreign object detection (metal in between charger and receiver) or other fault conditions. The charger can act on this info by adjusting the overall power transmission frequency, duty cycle or voltage input to the switching stage to bring the overall output to a range to provide sufficient power to the multiple receivers. The charger can also decide to terminate charge, declare a fault condition or take other actions.

[00275] For example if in-band communication is used, this can be achieved by load modulation as described earlier or through a separate RF, optical or other method. To avoid collision between messages being sent from different receivers acting independently and transmitting messages to a charger, the interval between message transmission packets from the receiver can be pre-programmed to be random, semi-random, or have a pattern to allow the charger to be able to distinguish between messages from each receiver without confusion about its origin or corruption of the message. If two messages from 2 receivers are received by a charger at the same time, it can ignore the messages and wait for the next transmission from those receivers until a valid transmission is received.

[00276] As described above, charger surfaces with sizes of up to 18 x 18 cm with loosely coupled, Magnetic Aperture or Magnetic Coupling technology have been tested and provide high efficiencies and power transfers to multiple receivers. In certain applications, it may be desirable to have even larger charger areas, for example, a full table top or surface (such as kitchen counter, etc.) that is fully active and can charge or power multiple devices placed anywhere on its surface. To enable such an embodiment and retail high efficiency, uniformity, or power transfer, it may be necessary to use multiple charger sections 620 as shown in **Figure 48** that are tiled to be adjacent or overlapping to provide a continuous active surface. In cases that some gap between the charger coils exist, if the receiver coil area is larger than this gap, the existence of the gap would not pose a non-uniformity problem. The sections may be driven by one charger, in parallel by one charger circuit or by multiple drive circuits or have a multiplexer that connects charger circuits possibly with even different protocols or power levels to different sections as needed.

[00277] Another method of regulating the output voltage of a wireless charger receiver

has recently been demonstrated by Seong-Wook Choi and Min-Hyong Lee, ETRI Journal, Volume 30, PP 844-849. In **Figure 49** a simplified system 630 for wireless transmission of power with constant output voltage is shown. A capacitor C2 is added in parallel in the charger. The system is operated at slightly higher frequency than the resonance at an optimum frequency that can be calculated. With the optimum frequency determined, the value of C2 can be optimized to minimize the current in the charger coil and optimize transfer efficiency. It can be shown that by choosing the values of capacitors C1, C2 and C_r appropriately, constant voltage V_1 regardless of the load value can be obtained. The output stage regulator and/or switch are optional and are another safety / reliability measure that can be added if needed. For cases where the output is charging a battery directly, the output regulator would provide the necessary output voltage profile for the particular type of battery as for example shown in Figure 8 earlier. In the simple geometry shown in Figure 49, no communication and/or feedback between the receiver and charger is assumed. Optionally, the charger may include a means of measuring the current through the charger coil and using it to determine the number of receivers on the charger or presence of a receiver or fault conditions. An optional microcontroller detects this current and controls the drive circuitry.

[00278] The optimum frequency in the geometry above is dependent on the coupling coefficient between the charger and receiver coils and therefore the gap between the charger and receiver coil. In practice a system that is more robust may be needed. Presence of multiple receivers may also require adjustment of the frequency or other operating conditions of the system. Furthermore, fault or end of conditions or other information may need to be relayed back to the charger. **Figure 50** shows a system 640 that is similar to the system of Figure 49 but with a simplified communication and feedback channel added. Such a system may provide more functionality and a closed loop system in addition to the inherent design to provide constant voltage V_1 regardless of coupling coefficient variations and affects of coil to coil distance, etc. therefore providing a more robust system.

[00279] In cases where direct communication or control and/or regulation between the receiver and charger are necessary or desired (such as architectures in Figure 46(c) and 46(d), this may be achieved by using a different frequency and/or charger or receiver coil to provide separate communication and/or power channels to individual receivers and/or groups of receivers. In addition, such techniques and/or Frequency Division Multiplexing (FDM) may be used to communicate and/or power devices using different protocols or no protocols at all (where the receiver does not communicate and receives power passively when placed on a charger). As shown in Figure 47, one or more charger units operating at same or different

frequencies can drive one or multiple charger coils that may cover the same physical area or cover different distinct regions of the charger surface. In the receiver, by closing the appropriate switch S_{r1} to S_m, the receiver can tune to receive power from the power and/or communication channel for itself or its group of receivers. In the charger, the communication back from each receiver or types of receivers is demodulated at a different frequency of its communication or in a Time Division Multiplexed method and regulation or adjustment of power or other changes to power or termination for that device or group of device is carried out. While in Figures 43, 44 and 47, adjustment of resonant frequency by changing of the capacitor is shown, any change to impedance of the charger or receiver circuit would provide a shift in the optimum charging frequency as shown in Figure 14. It is therefore possible to use inductive or capacitive components in the charger and receivers to shift the optimum power transfer frequency.

[00280] In U.S. Patent Application Nos. 2008/0211478, 2007/0109708, and 2008/0247210, methods for regulation of output power that depend on charger and/or receiver based regulation are described. The main method used (shown 650 in **Figure 51**) introduces a variable inductor in parallel to the charger and/or receiver coil that can be optimized to adjust the frequency and/or phase of the power transfer to the output stage. The current through the inductor is adjusted by a phase and voltage detection and control circuit to adjust the control voltage to the transistor gates and use the transistors to adjust the current through the variable inductor and regulate the output. Similar performance may be achieved by using a variable capacitor.

[00281] In an embodiment described here, the inductance in the receiver and/or charger is adjusted by using multi-tap coil(s) (with PCB or Litz wire coil) and by adjusting the length of the coil used and therefore the related inductance (as well as the coupling between the receiver and charger coils) by connecting or disconnecting switches to change the resonance condition of the system and therefore control the output power. Thus regulation of the output power could be realized by the receivers or chargers. In particular, it would be beneficial to perform the regulation completely by the receivers individually and independently.

[00282] It can be readily appreciated that in the above descriptions many geometries and systems have been described. In practice, one or several of these systems can be used in combination in a charger and/or receivers to provide the desired performance and benefits.

[00283] The above description and embodiments are not intended to be exhaustive, and are instead intended to only show some examples of the rich and varied products and technologies that can be envisioned and realized by various embodiments of the invention. It will be evident to persons skilled in the art that these and other embodiments can be combined

to produce combinations of above techniques, to provide useful effects and products.

[00284] Some aspects of the present invention can be conveniently implemented using a conventional general purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as will be apparent to those skilled in the art.

[00285] In some embodiments, the present invention includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of the present invention. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, DVD, CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00286] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

Claims:

What is claimed is:

1. A system for use in charging and/or powering one or more devices and/or batteries by wireless power, comprising:

one or more components including a ferromagnetic, ferrite, or other magnetic material or layer, which are used to modify the magnitude and/or phase of an electromagnetic field in one or multiple dimensions.

2. The system of claim 1, wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within

one or more wireless chargers or power supplies and/or the electronics, coils, magnetic material, or magnets therein, and/or

one or more wireless power receivers and/or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices and/or batteries.

3. The system of claim 1, wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is used to provide a degree of position independence in charging or powering the one or more devices and/or batteries.

4. The system of claim 1, wherein the modifying the magnitude and/or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

5. The system of claim 1, wherein the ferromagnetic, ferrite, or other magnetic material or layer includes one or more materials selected from the list consisting of soft iron, silicon steel, laminated materials, silicon alloyed materials, powder iron, hydrogen reduced iron), carbonyl iron, ferrites, vitreous metals, alloys of Ni, Mn, Zn, Fe, Co, Gd, and Dy, nano materials, ferrofluids, magnetic polymers, or similar materials or combination thereof.

6. The system of claim 4, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

7. The system of claim 6, wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC and/or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

8. The system of claim 7, wherein the permanent magnet and/or electromagnet is incorporated behind, in front, around or at the center of the receiver and/or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

9. The system of claim 7, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC and/or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

10. The system of claim 1, further comprising one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices and/or batteries by wireless power.

11. The system of claim 1, wherein the power at the devices and/or batteries charged or powered by wireless power is unregulated or regulated at wireless power receivers connected to the devices and/or the batteries.

12. The system of claim 11, wherein the regulation mechanism is by use of a voltage or power regulator, voltage limiter, Zener diodes, or varying an impedance or reactance of the

receivers or a combination thereof.

13. The system of claim 1, wherein the power at the devices and/or batteries charged or powered by wireless power is regulated by varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

14. The system of claim 1, wherein the power at the devices and/or batteries charged or powered by wireless power is regulated by a combination of regulation or variation of impedance or reactance of wireless power receivers connected to the devices or batteries and varying the frequency, duty cycle, impedance or reactance or input voltage or a combination thereof of one or more wireless chargers or transmitters.

15. The system of claim 1, wherein the wireless power transmitted to the devices and/or batteries charged and/or powered wirelessly is transmitted at substantially the same or similar frequencies.

16. The system of claim 1, wherein the wireless power transmitted to the devices and/or batteries charged and/or powered wirelessly is transmitted at different frequencies.

17. The system of claim 2, wherein the chargers and/or receivers include one or more microcontrollers or programmable parts and/or memory.

18. The system of claim 2, wherein the chargers and receivers communicate through the same coils as used for transfer of power or through a separate coil and/or load modulation or through an RF or optical link or through RFID, Bluetooth, WiFi, Wireless USB, NFC, Felica, Zigbee, Wireless Gigabit (WiGig), etc. or through the Wireless Power Consortium (WPC) or other protocols or standards, developed for wireless power, or other communication protocols, or combination thereof.

19. The system of claim 2, wherein the presence of the one or more receivers is detected by the one or more chargers and/or power supplies and/or causes a change in the operating behavior or characteristics of the chargers and/or power supplies.

20. The system of claim 2, wherein the chargers and/or receivers may consist of one set of electronics and/or coils or several sets of similar or dissimilar electronics and/or coils to provide flexibility in wirelessly charging devices and/or batteries at different voltages, powers, current levels, geometries or functions and/or communication and regulation or detection protocols.

21. The system of claim 2, wherein the chargers and/or receivers may include shielding materials such as ferromagnetic or other magnetic materials and/or metal or other conductive layers, and/or thin metal layers covering a portion or all of the charger and/or receiver coils to reduce the undesirable electromagnetic emission from the wireless charger system.

22. The system of claim 2, wherein the frequency of the charging system is varied or dithered to reduce the undesirable electromagnetic emission from the wireless charger system.

23. The system of claim 1, wherein one or more repeater antennas or coils and/or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets and/or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

24. The system of claim 1, wherein the system includes one or more metal layers included on the top of the receiver shield and/or the bottom of the charger / transmitter shield to provide further shielding from the magnetic field.

25. The system of claim 1, wherein the wireless charger or power supply may be a stand-alone part, device, or product, or may be incorporated into another electric or electronics device, table, desk chair, TV stand or mount or furniture or vehicle or airplane or marine vehicle or boat or objects such as a table, desk, chair, counter-top, shelving or check out or cashier counters, kiosk, car seat, car console, car door, netting, cup holder, dashboard, glovebox, etc., airplane tray, computer, laptop, netbook, tablet, display, TV, magnetic, optical or semiconductor storage or playback device such as hard drive, optical players, etc., cable or game console, computer pads, toys, clothing, bags or backpack, belt or holster, etc., industrial, military or kitchen counter, area, devices and appliances, phones, cameras, radios, or stereo system.

26. The system of claim 1, wherein the wireless charger or power supply may be directly powered by an AC power input, DC power, or other power source such as a car, motorcycle,

truck or other vehicle or airplane or boat or ship power outlet, or vehicle, boat, ship or airplane itself, primary (non-rechargeable) or rechargeable battery, solar cell, fuel cell, mechanical (hand crank, wind source, etc.), nuclear source or other or another wireless charger or power supply or a combination thereof or have other functions built in or be constructed such that it is modular and additional capabilities / functions can be added as needed.

27. The system of claim 1, wherein the receivers are integrated to or connected to batteries, cell phones, smart phones, cordless phones, communication devices, personal data assistants, portable media players, global positioning (GPS) devices, Bluetooth headsets and other devices, shavers, watches, tooth brushes, calculators, cameras, optical scopes, infrared viewers, computers, laptops, tablets, netbooks, key boards, computer mice, book readers or email devices, pagers, computer monitors, televisions, music or movie players and recorders, storage devices, radios, clocks, speakers, gaming devices, game controllers, toys, remote controllers, power tools, construction tools, office equipment, robots including vacuum cleaning robots, floor washing robots, pool cleaning robots, gutter cleaning robots or robots used in hospital, clean room, military or industrial environments, industrial tools, mobile vacuum cleaners, medical or dental tools, military equipment or tools, kitchen appliances, mixers, cookers, can openers, food or beverage heaters or coolers such as electrically powered beverage mugs, massagers, adult toys, lights or light fixtures, or advertising applications, printers, fax machines, scanners, automobiles, buses, or other vehicles or mobile transportation machines, and other battery or electrically powered devices or products.

28. The system of claim 1, wherein the receiver and/or the charger is incorporated into a bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle or device etc. to enable some function inside the bag, carrier, skin, clothing, case, packaging, product packaging or box, crate, box, display case or rack, table, bottle to cause a display case or packaging to display promotional information or instructions, or to illuminate.

29. A method of charging and/or powering one or more devices and/or batteries by wireless power, comprising the steps of:

using one or more components including a ferromagnetic, ferrite, or other magnetic material or layer to modify the magnitude and/or phase of an electromagnetic field in one or multiple dimensions.

30. The method of claim 29, wherein the ferromagnetic, ferrite, or other magnetic material or layer is provided within

one or more wireless chargers or power supplies and/or the electronics, coils, magnetic material, or magnets therein, and/or

one or more wireless power receivers and/or the electronics, coils, magnetic materials, or magnets therein;

and used in charging or powering the one or more devices and/or batteries.

31. The method of claim 29, wherein the one or more components including the ferromagnetic, ferrite, or other magnetic material or layer is used to provide a degree of position independence in charging or powering the one or more devices and/or batteries.

32. The method of claim 29, wherein the modifying the magnitude and/or phase of the electromagnetic field in one or multiple dimensions includes locally modifying the properties of the ferromagnetic, ferrite, or other magnetic material or layer so that it acts as a switching layer, allowing a transmitter coil electromagnetic field to be preferentially transmitted through a locally modified area.

33. The method of claim 32, wherein the locally modified area of the switching layer is created by saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

34. The method of claim 33, wherein the saturating or altering the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally is provided by saturating or modifying the permeability of the layer through application of one or more DC and/or AC magnetic field such as a permanent magnet or electromagnet or local application of heat or a combination thereof.

35. The method of claim 34, wherein the permanent magnet and/or electromagnet is incorporated behind, in front, around or at the center of the receiver and/or charger coil or a combination thereof such that it has sufficient magnetic field to saturate or alter the magnetization curve of the ferromagnetic, ferrite, or other magnetic material or layer locally on or near where the receiver coil is placed.

36. The method of claim 34, wherein the permanent magnet or electromagnet includes one or more disc, square, rectangular, oval, curved, ring, or other shape of magnet and combination thereof or a multi-pole magnet and with appropriate magnetization orientation and strength that can provide sufficient DC and/or AC magnetic field to shift the operating position of the magnetization curve, so that the combination of the transmitter coil, the affected ferrite or ferromagnetic or magnetic material or switching layer and the receiver coil move to a resonance condition at a given frequency for power transfer.

37. The method of claim 29, further comprising using one or more additional components or features to improve the performance or usability of the system in charging or powering one or more devices and/or batteries by wireless power.

38. A system for use in charging or powering one or more devices and/or batteries by wireless power, comprising:

one or more components including a large area transmitter coil of wire, Litz wire, or PCB type, or a combination thereof, covered by a ferromagnetic, ferrite, or other magnetic material or layer and having a relatively higher permeability, that acts to guide, confine, and shield a field therein.

39. The system of claim 38, wherein one or more repeater antennas or coils and/or one or more ferrite or ferromagnetic or magnetic material or switching layers and optionally magnets and/or electromagnets are used to extend the range between the charger and receiver while controlling the emissions.

Abstract:

Systems and methods for modifying the magnitude and/or phase of an electromagnetic field in one or multiple dimensions. Applications for use in charging or powering multiple devices with a wireless power charger system are also described. Applications include beam shaping, beam forming, phase array radar, beam steering, etc. and inductive charging and power, and particularly usage in mobile, electronic, electric, lighting, or other devices, batteries, power tools, kitchen, industrial applications, vehicles, and other usages. Embodiments of the invention can also be applied generally to power supplies and other power sources and chargers, including systems and methods for improved ease of use and compatibility and transfer of wireless power to mobile, electronic, electric, lighting, or other devices, batteries, power tools, kitchen, military, industrial applications and/or vehicles.

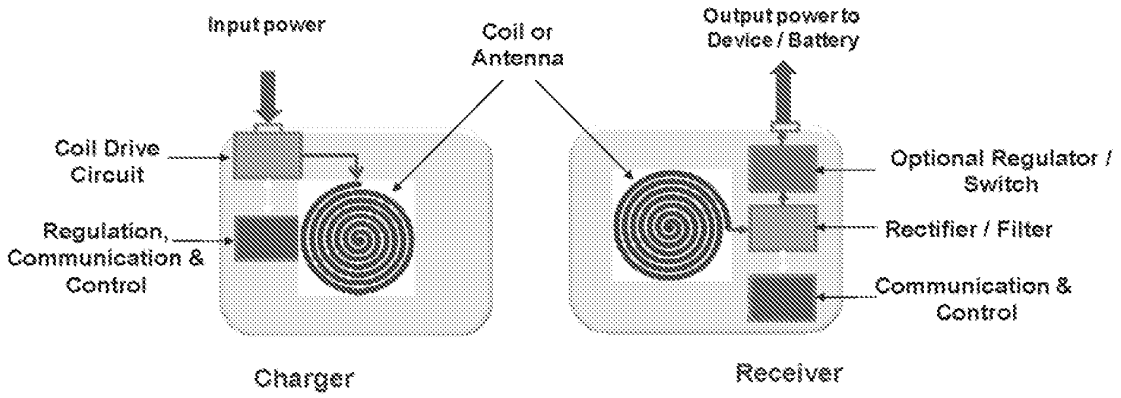


FIGURE 1

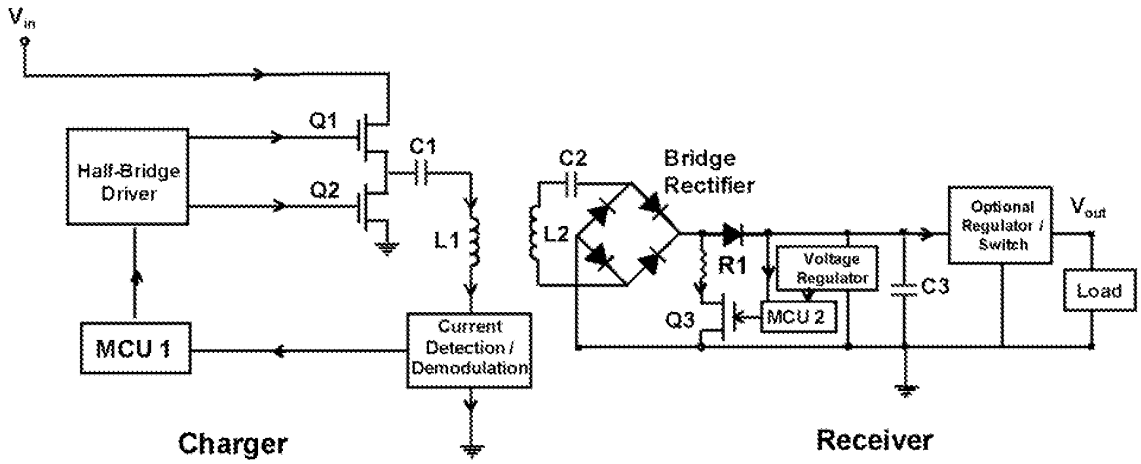


FIGURE 2

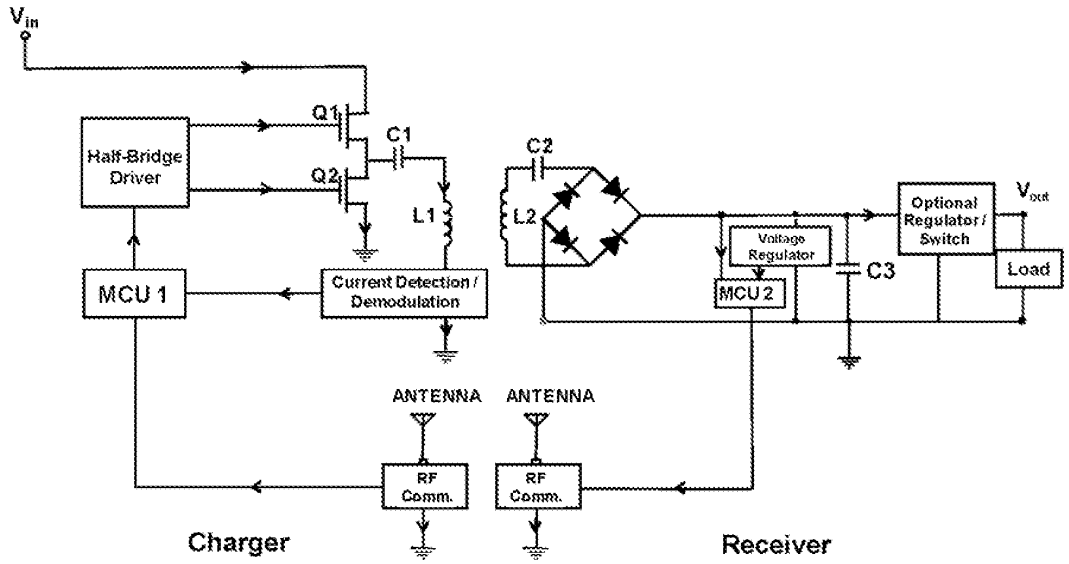


FIGURE 3

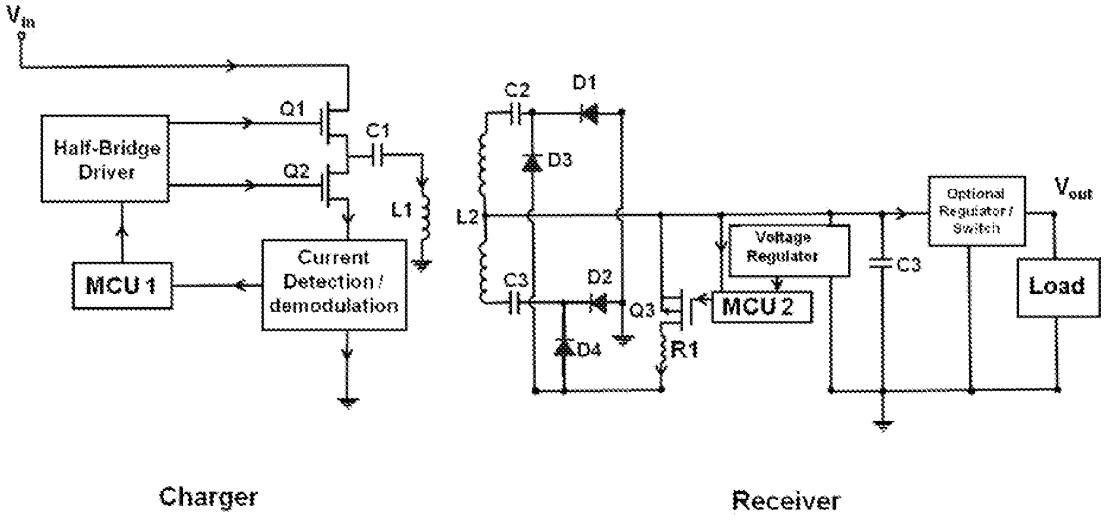
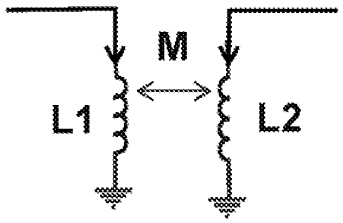
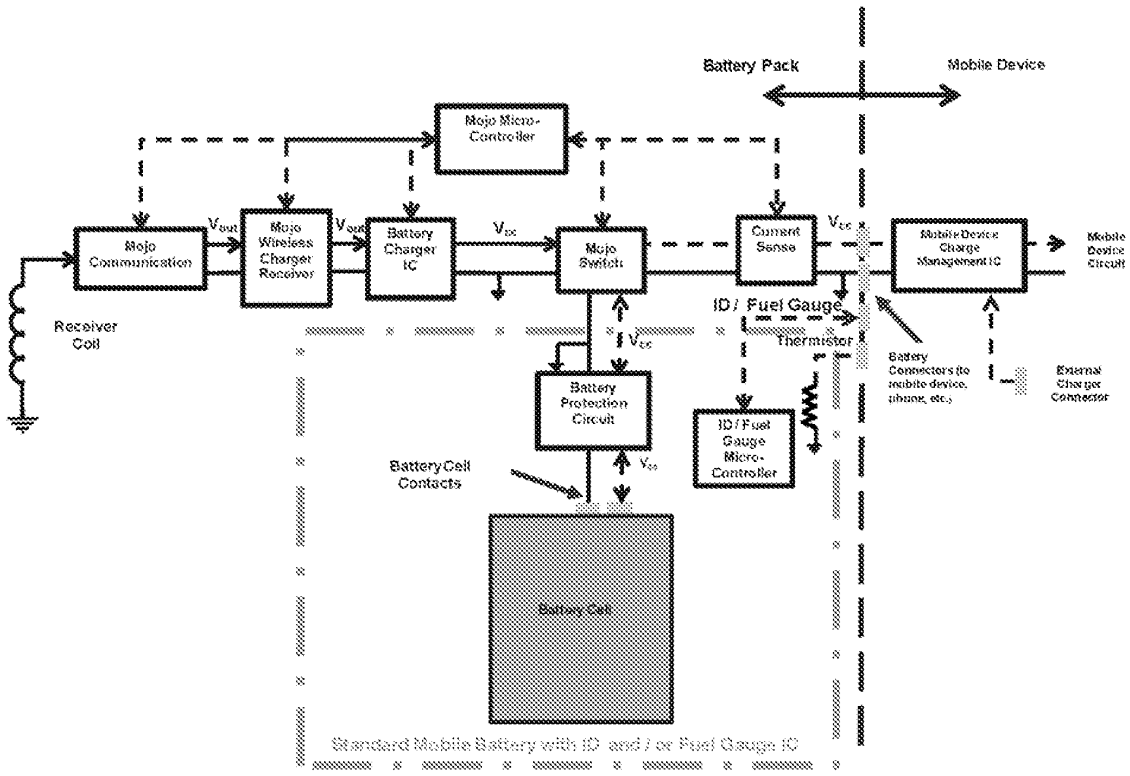


FIGURE 4



150

FIGURE 5



160

FIGURE 6

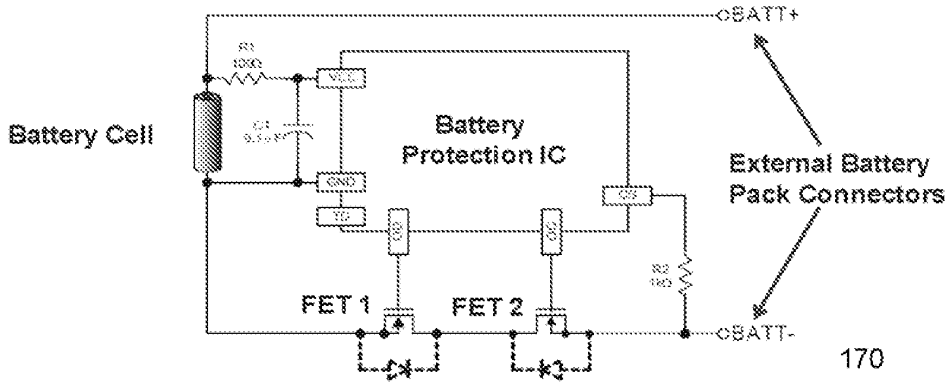


FIGURE 7

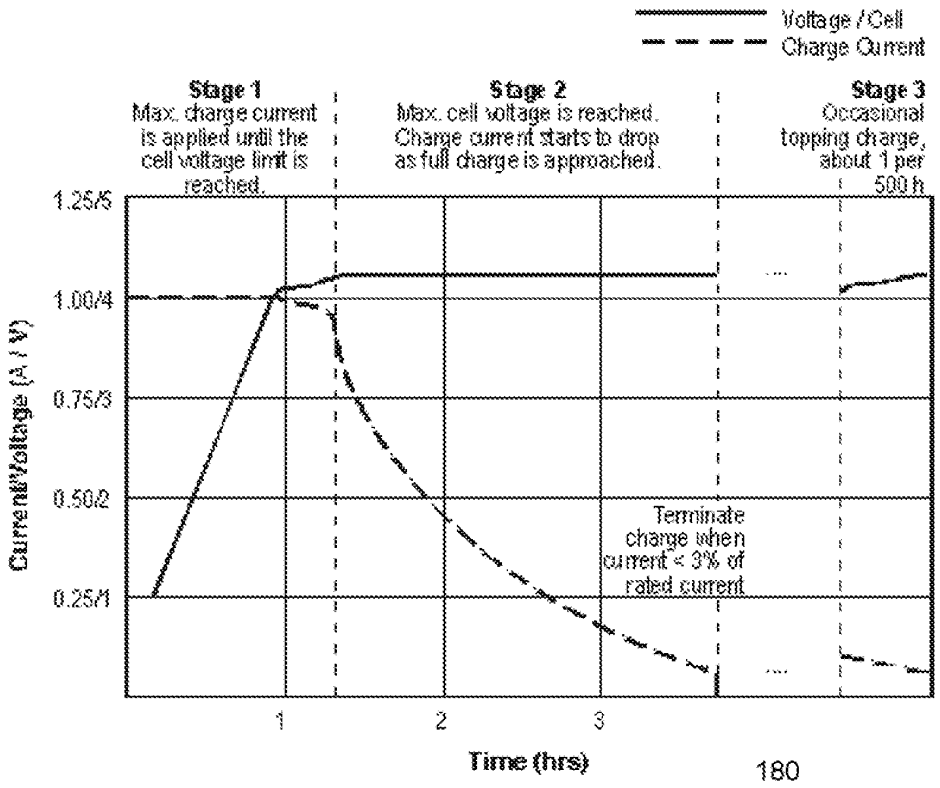


FIGURE 8

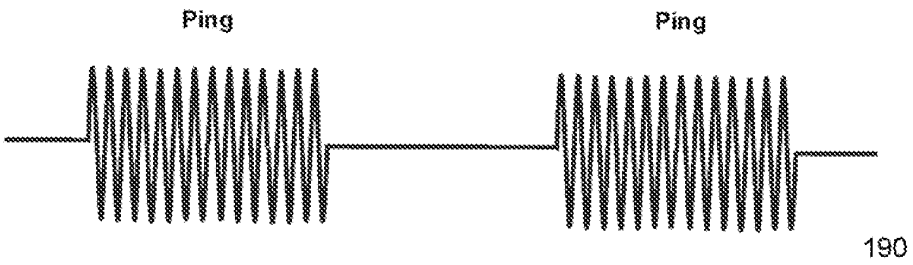


FIGURE 9

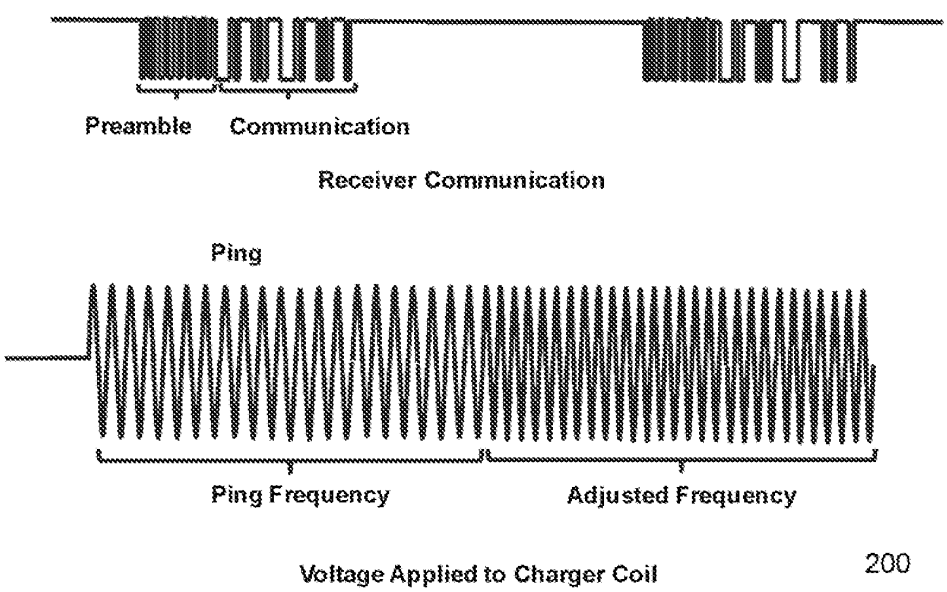


FIGURE 10

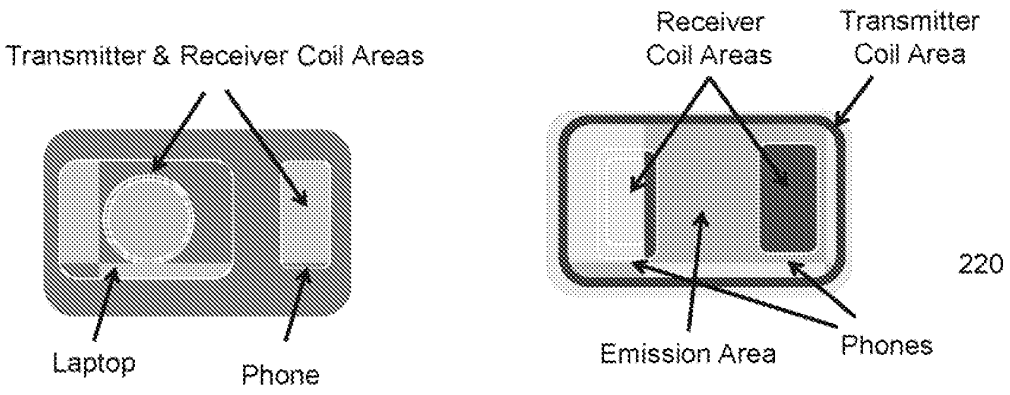


FIGURE 11

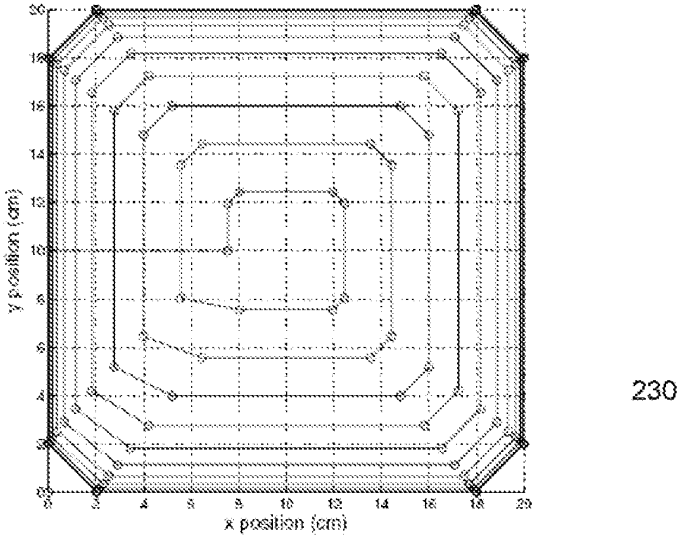
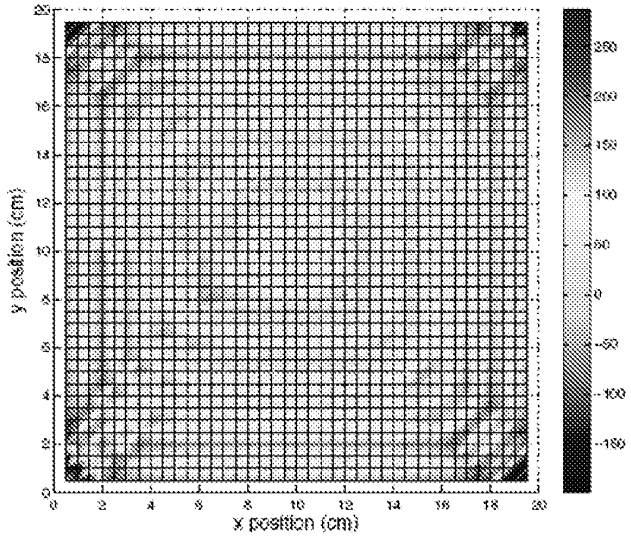
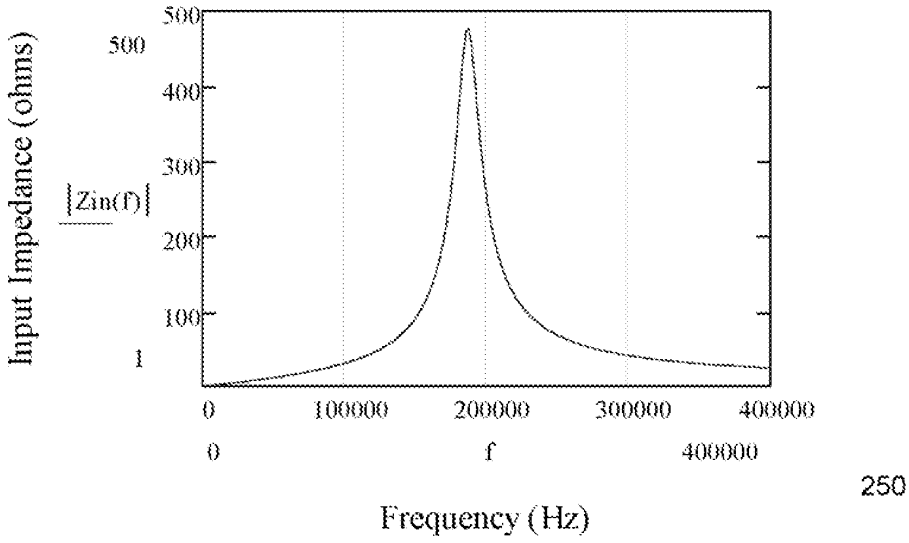


FIGURE 12



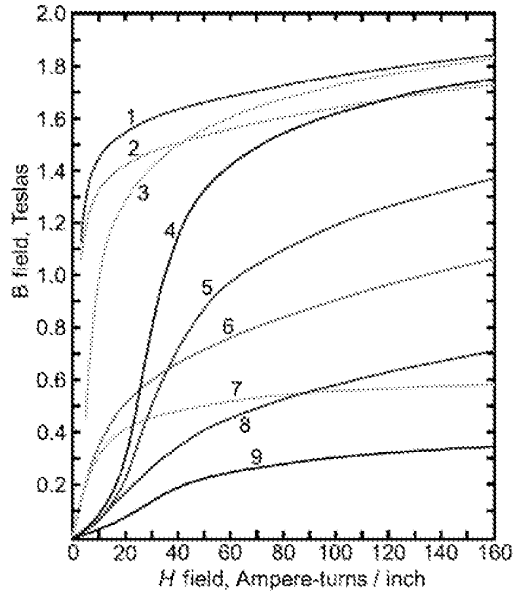
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FIGURE 13



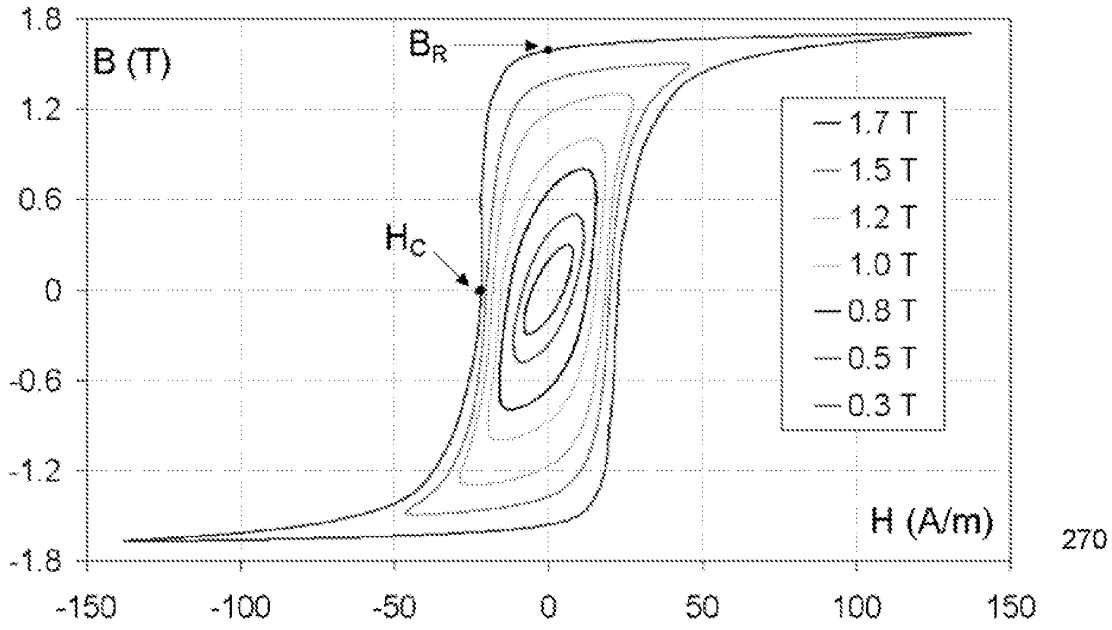
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FIGURE 14



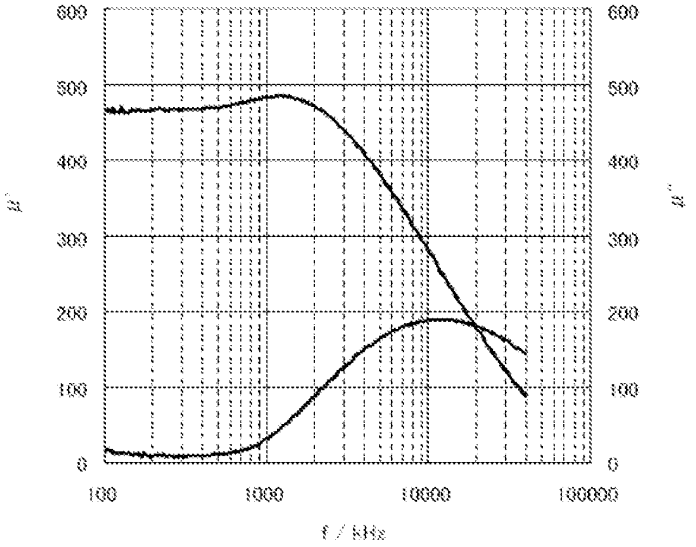
260

FIGURE 15



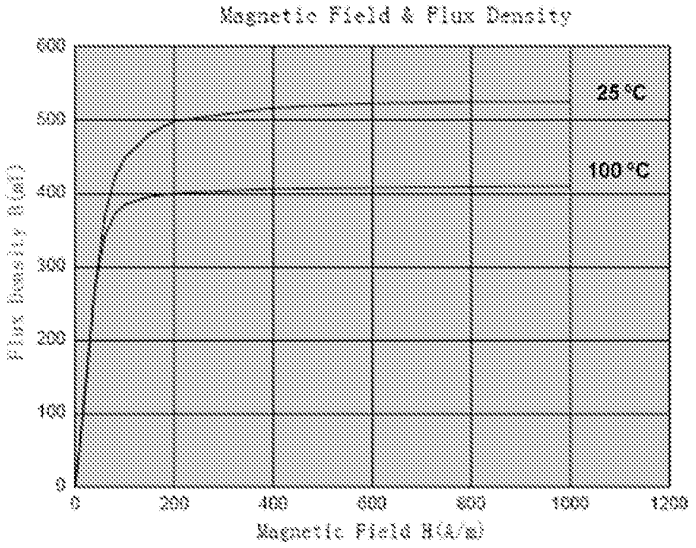
270

FIGURE 16



280

FIGURE 17



290

FIGURE 18

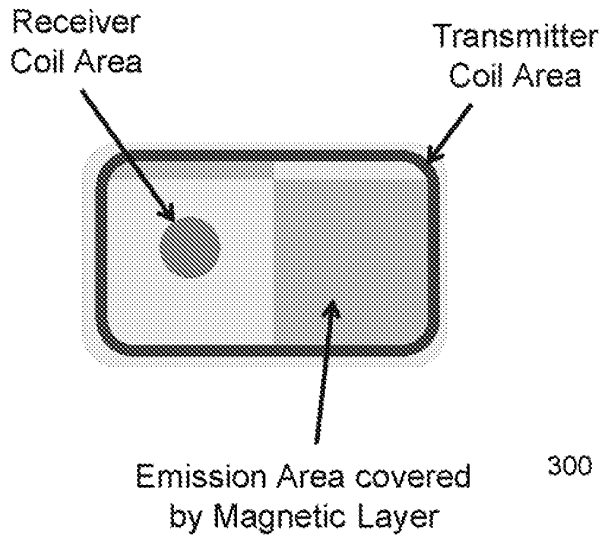


FIGURE 19

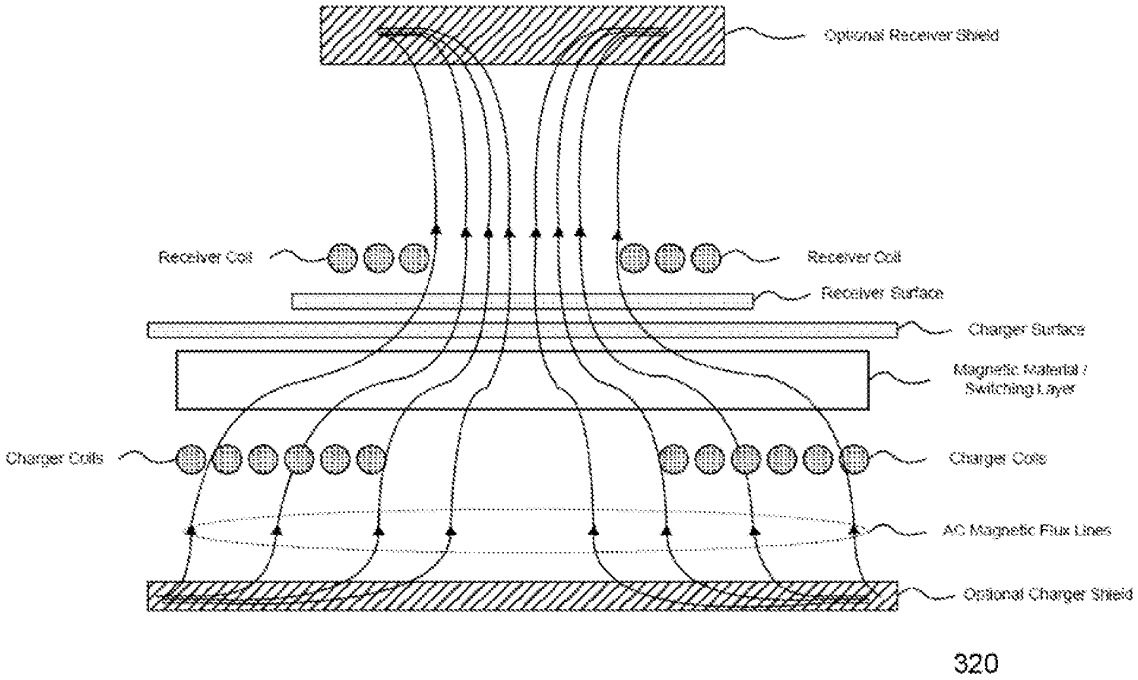


FIGURE 20

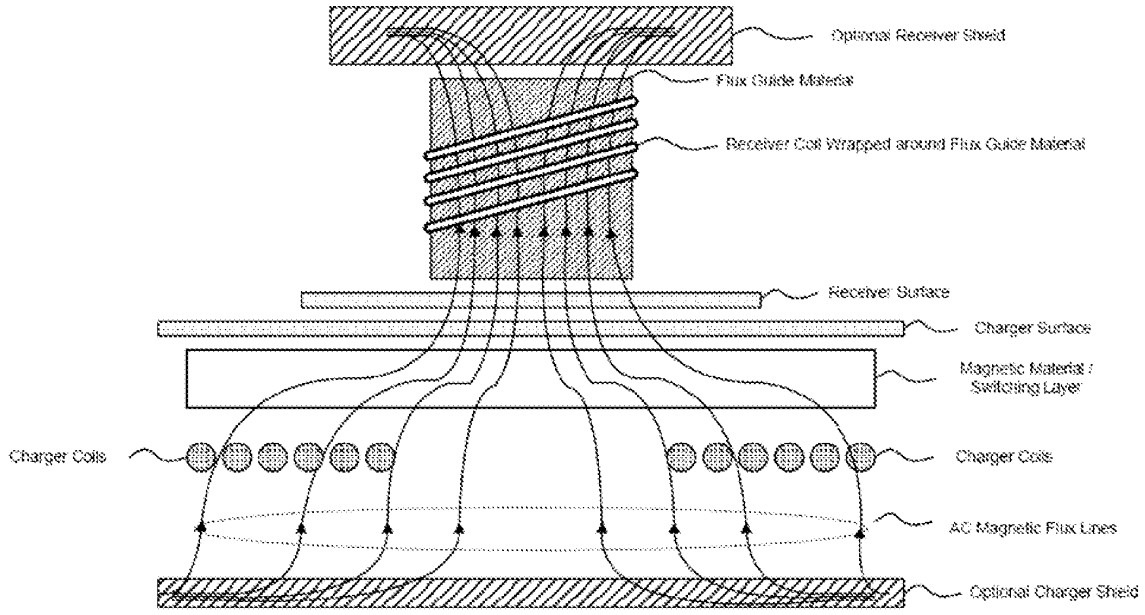


FIGURE 21

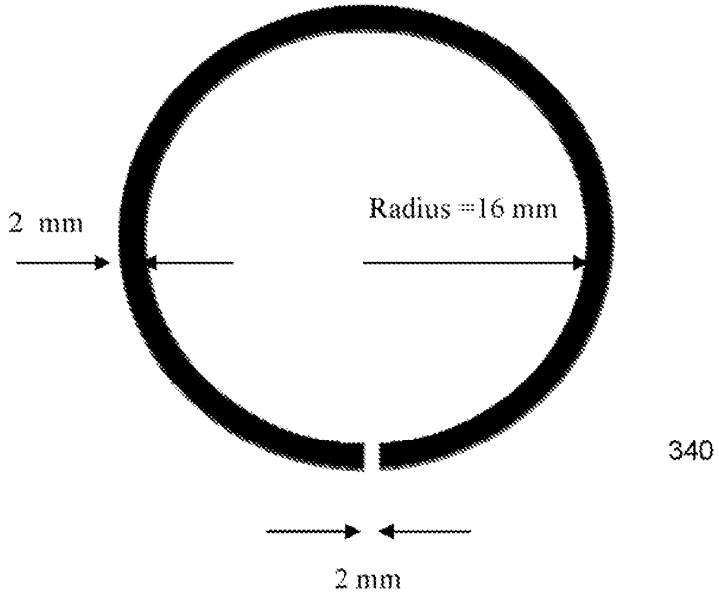


FIGURE 22

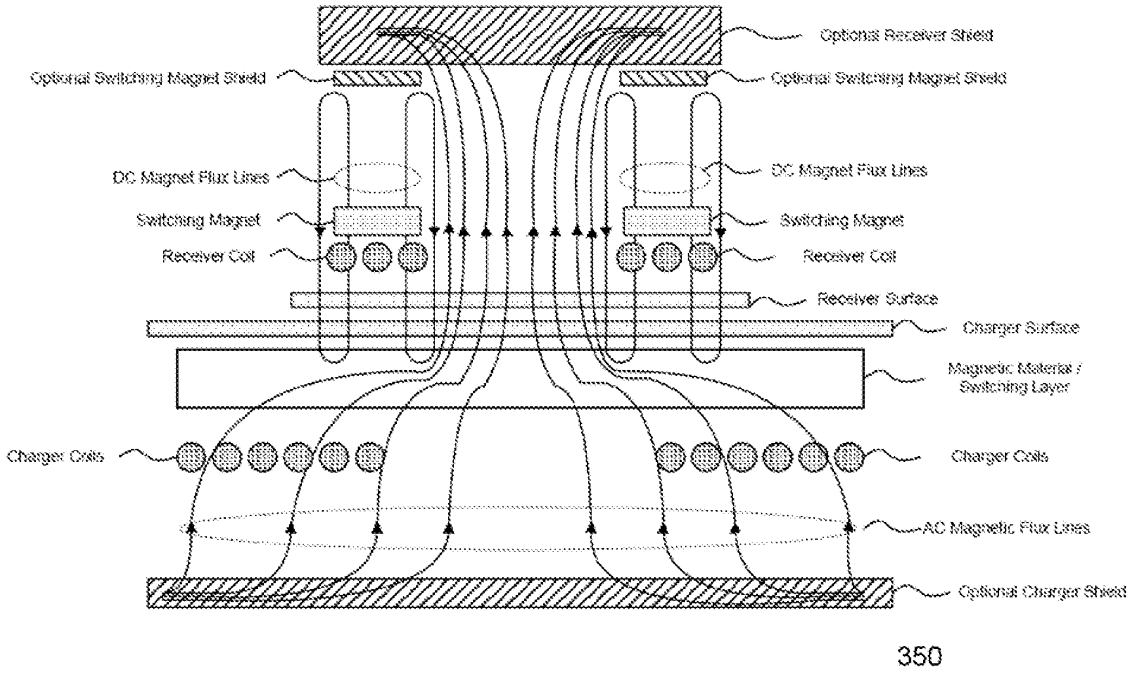

Optional Receiver Shield
Optional Switching Magnet Shield
Optional Switching Magnet Shield
DC Magnet Flux Lines
DC Magnet Flux Lines
Switching Magnet
Switching Magnet
Receiver Coil
Receiver Coil
Receiver Surface
Charger Surface
Magnetic Material / Switching Layer
Charger Coils
Charger Coils
AC Magnetic Flux Lines
Optional Charger Shield
350

FIGURE 23

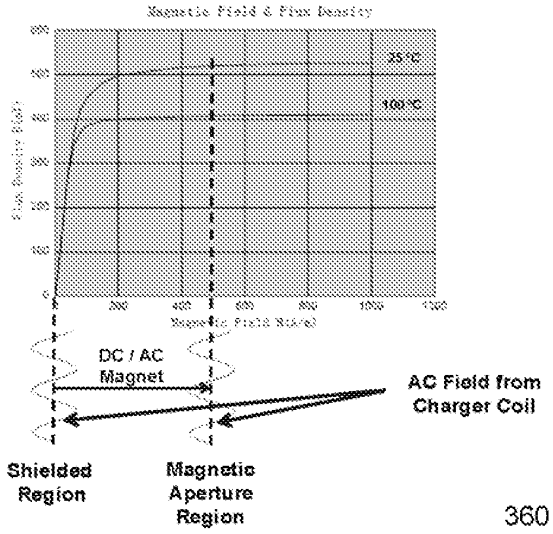


FIGURE 24

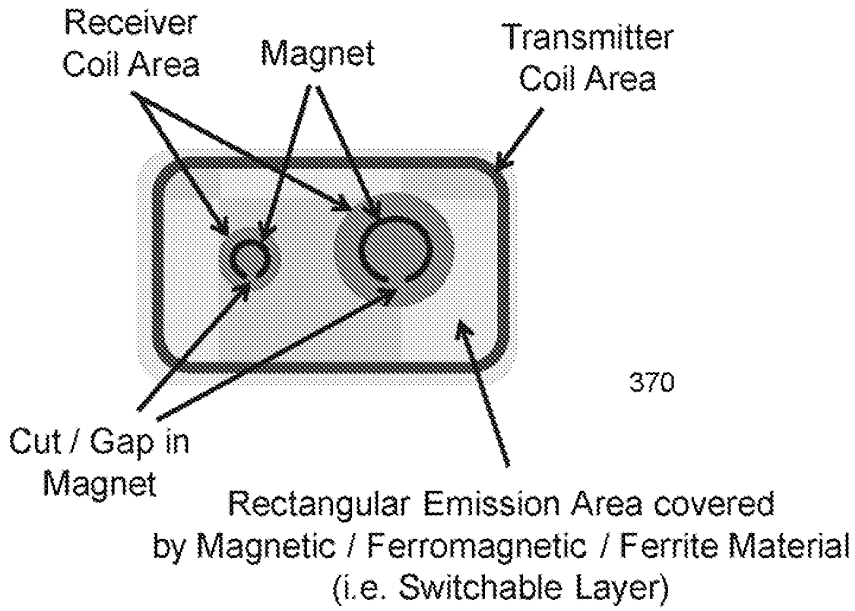


FIGURE 25

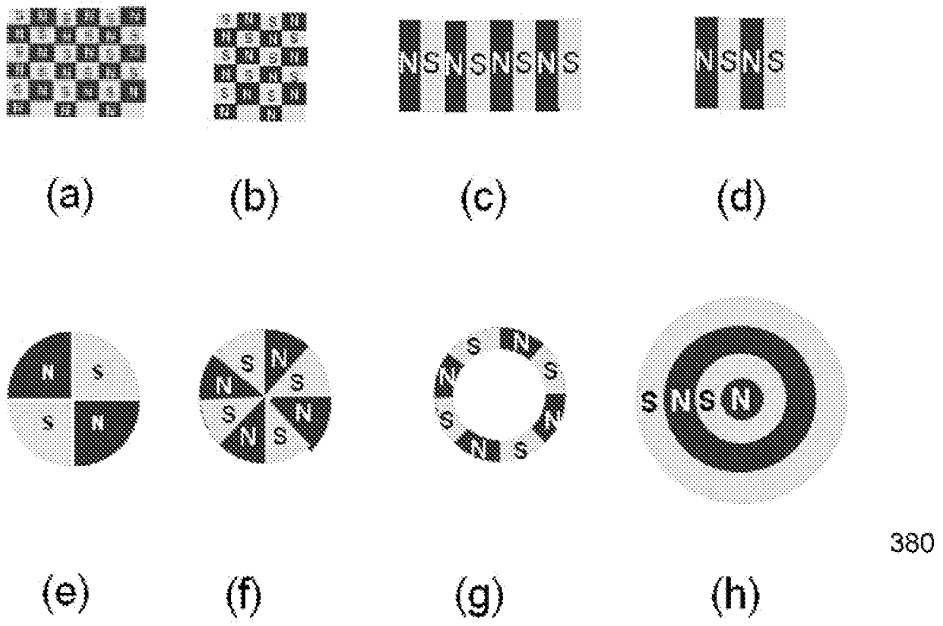


FIGURE 26



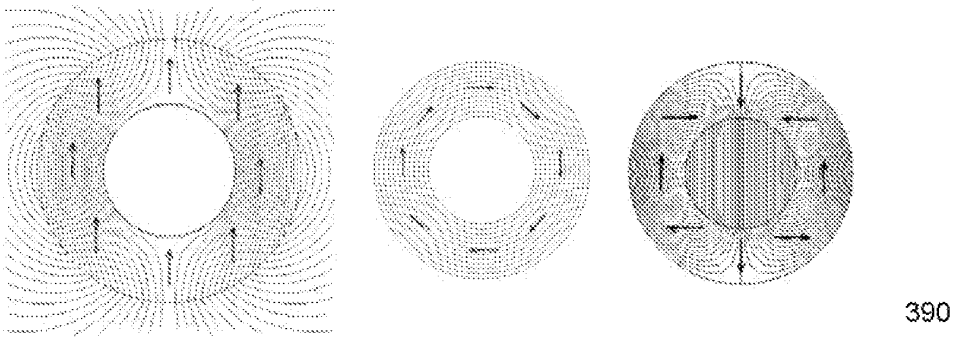
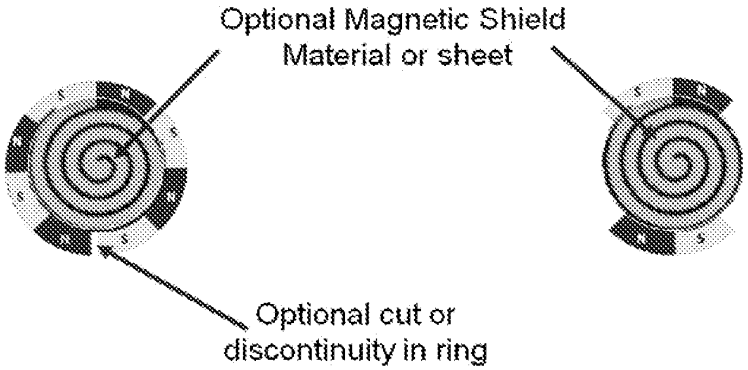
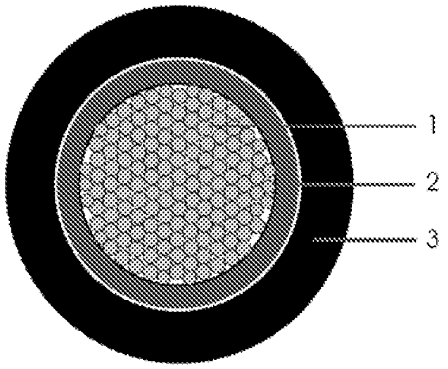


FIGURE 27



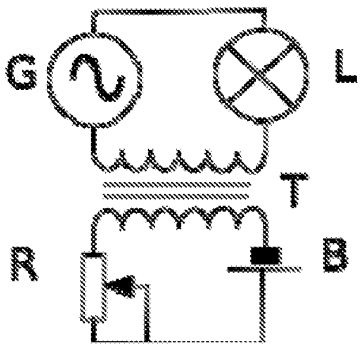
400

FIGURE 28



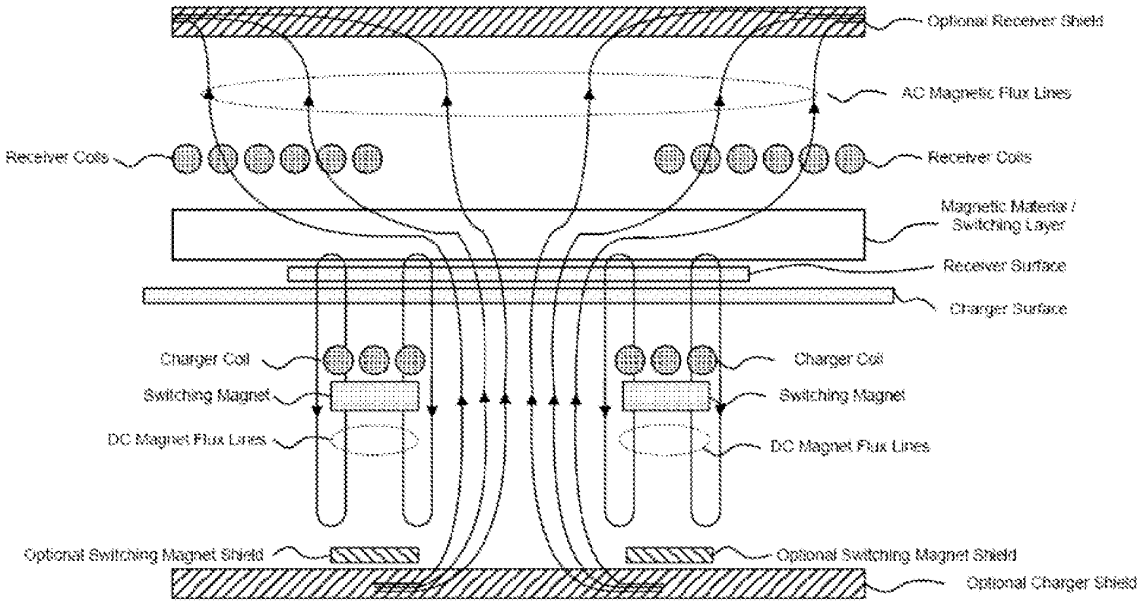
410

FIGURE 29



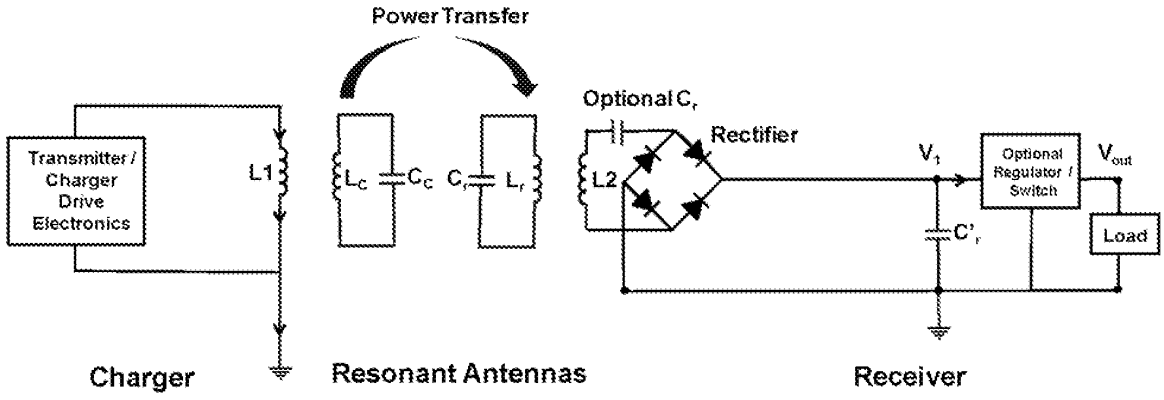
430

FIGURE 30



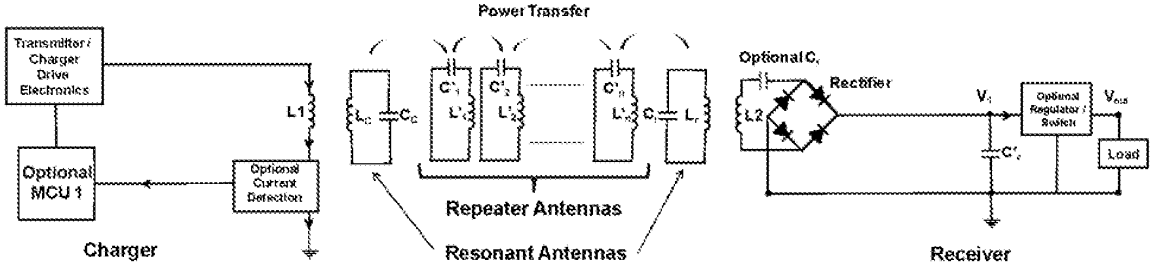
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FIGURE 31



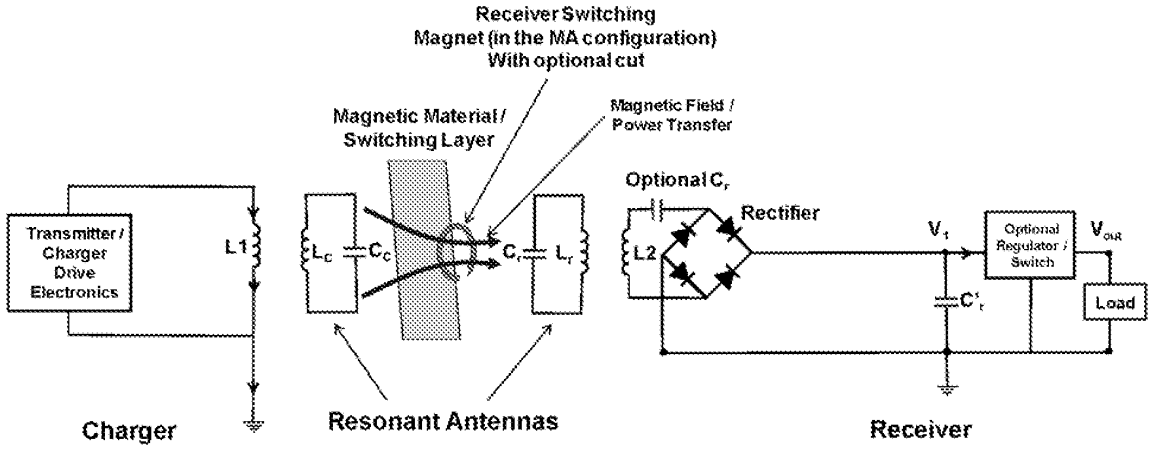
450

FIGURE 32



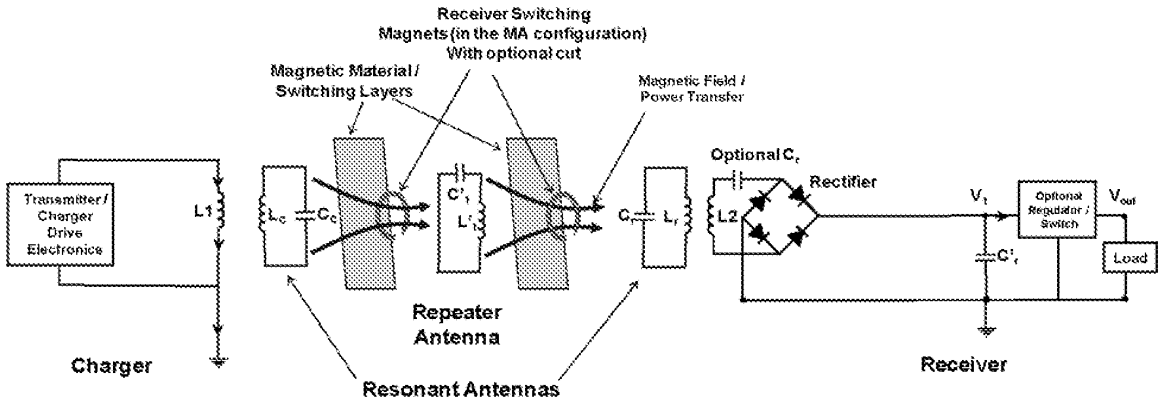
460

FIGURE 33



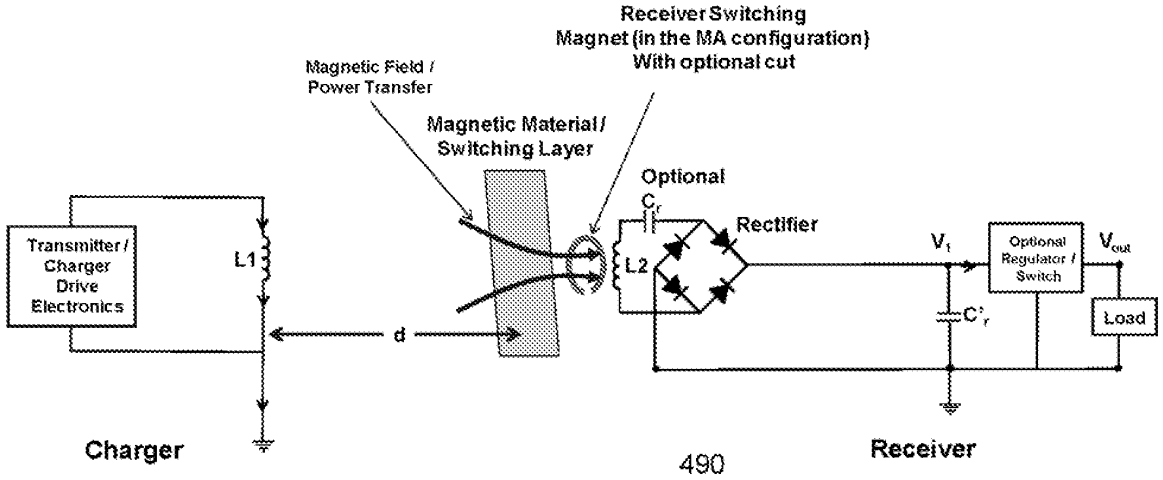
470

FIGURE 34



480

FIGURE 35



490

FIGURE 36

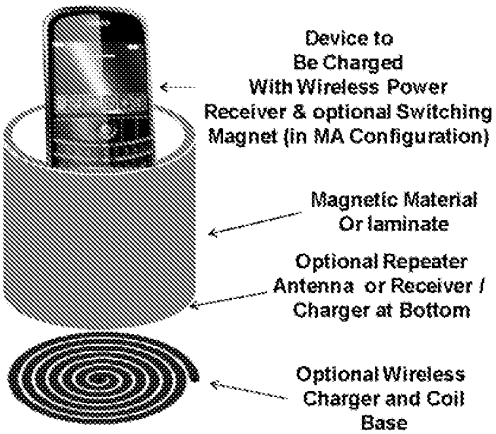


FIGURE 37

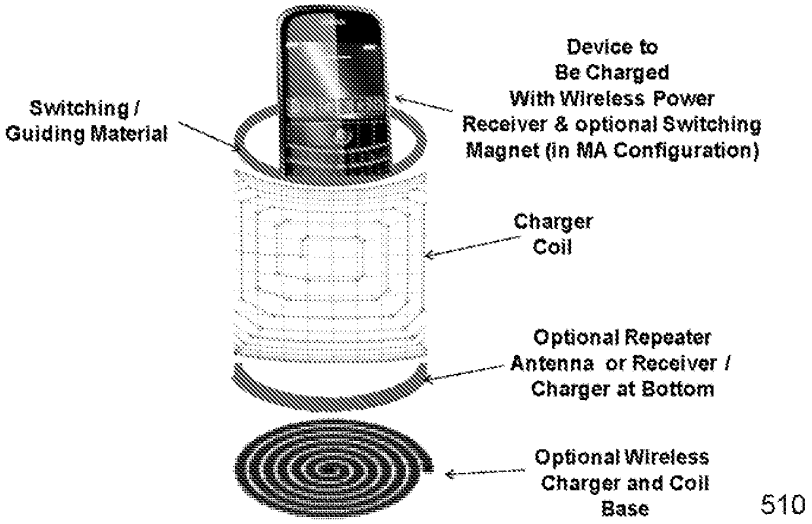


FIGURE 38

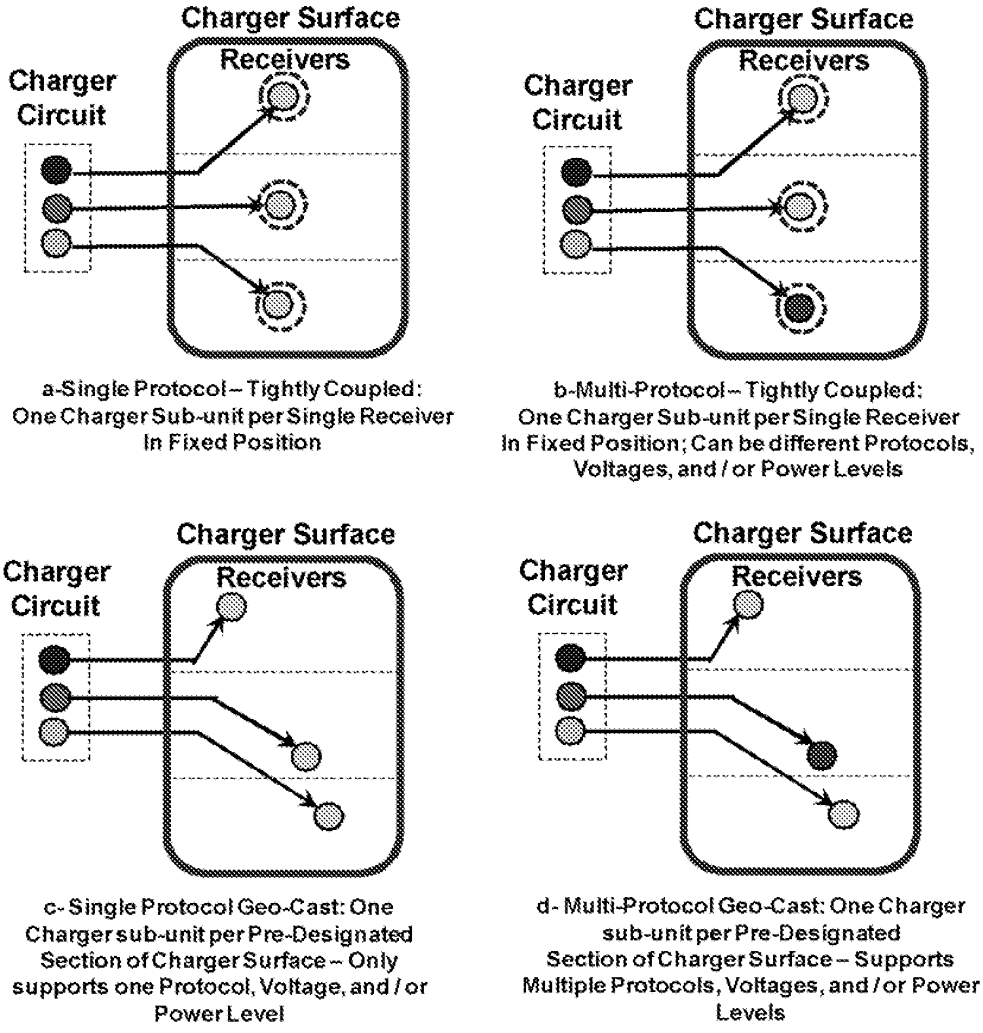

Charger Surface
Receivers
Charger Circuit
a-Single Protocol – Tightly Coupled: One Charger Sub-unit per Single Receiver In Fixed Position
b-Multi-Protocol – Tightly Coupled: One Charger Sub-unit per Single Receiver In Fixed Position; Can be different Protocols, Voltages, and / or Power Levels
c- Single Protocol Geo-Cast: One Charger sub-unit per Pre-Designated Section of Charger Surface – Only supports one Protocol, Voltage, and / or Power Level
d- Multi-Protocol Geo-Cast: One Charger sub-unit per Pre-Designated Section of Charger Surface – Supports Multiple Protocols, Voltages, and / or Power Levels
520

FIGURE 39

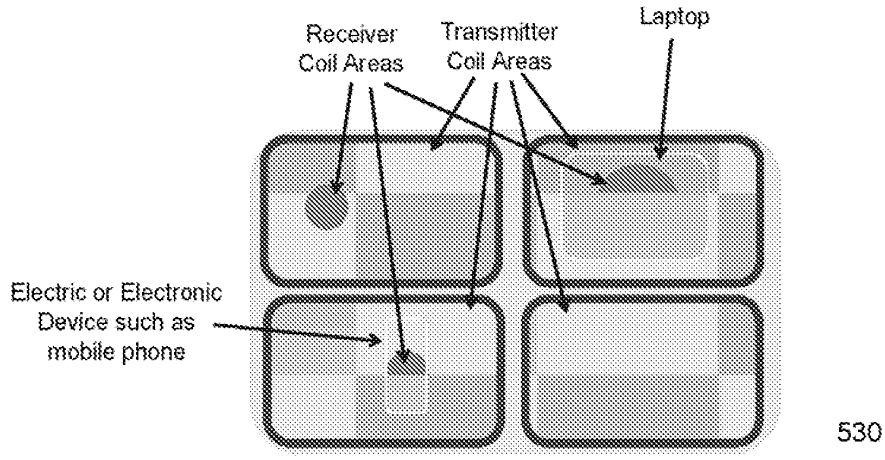


FIGURE 40

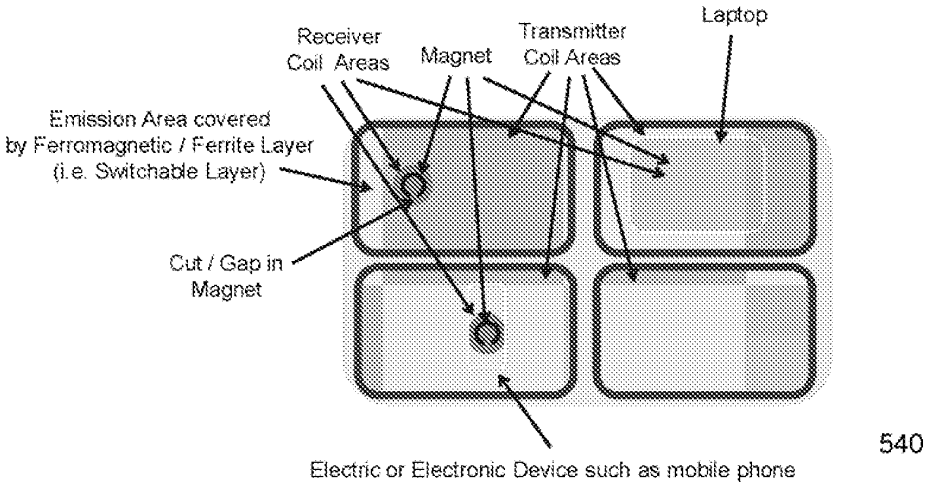


FIGURE 41

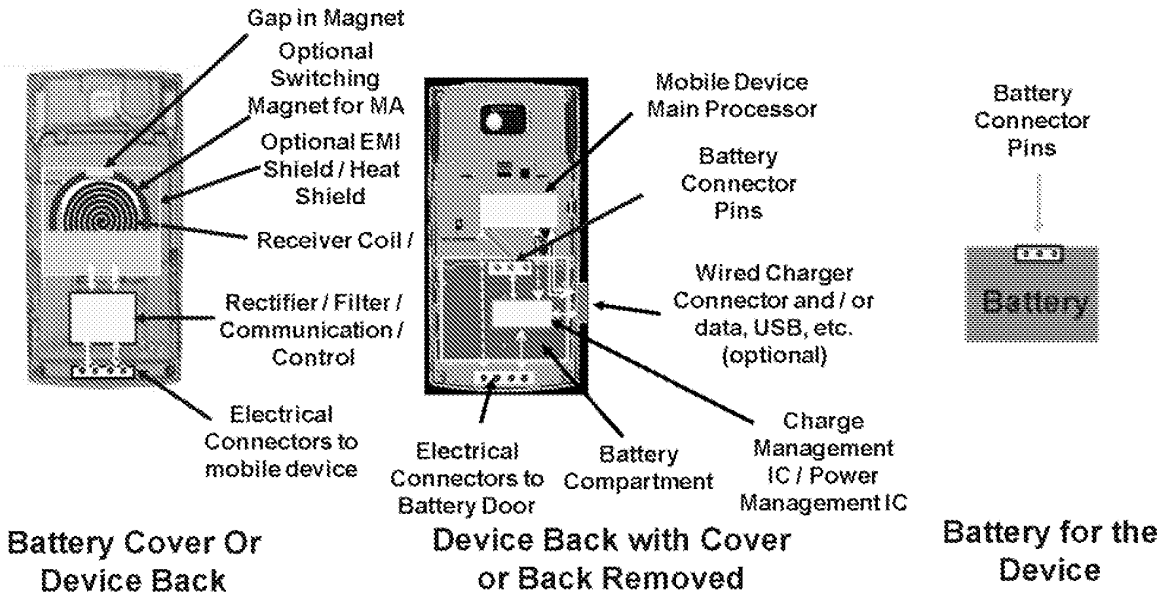


FIGURE 42

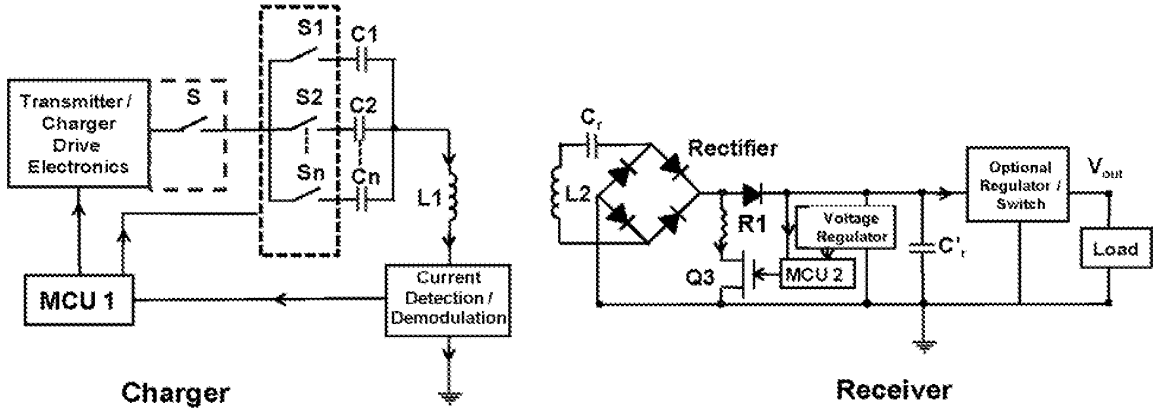
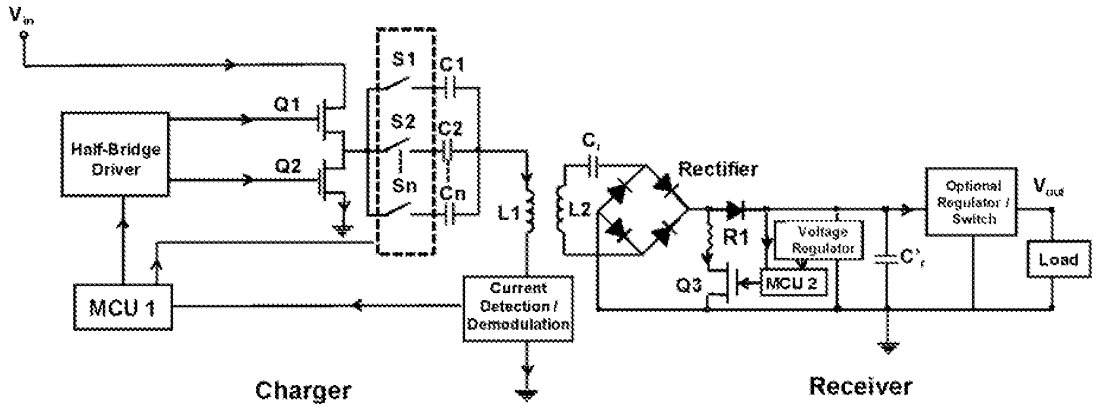


FIGURE 43



570

FIGURE 44

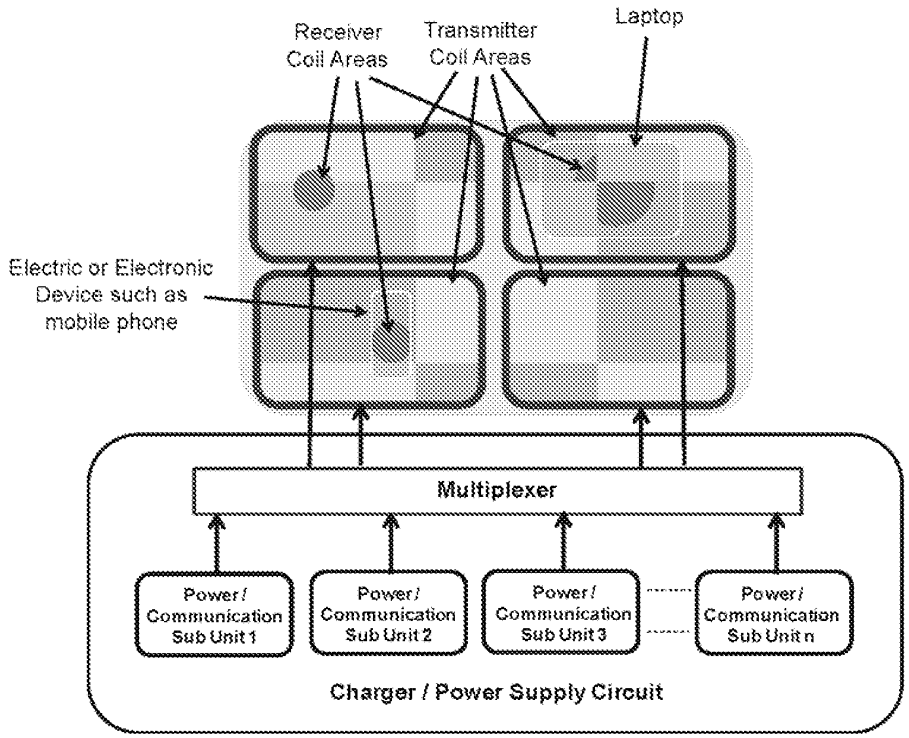


FIGURE 45

580

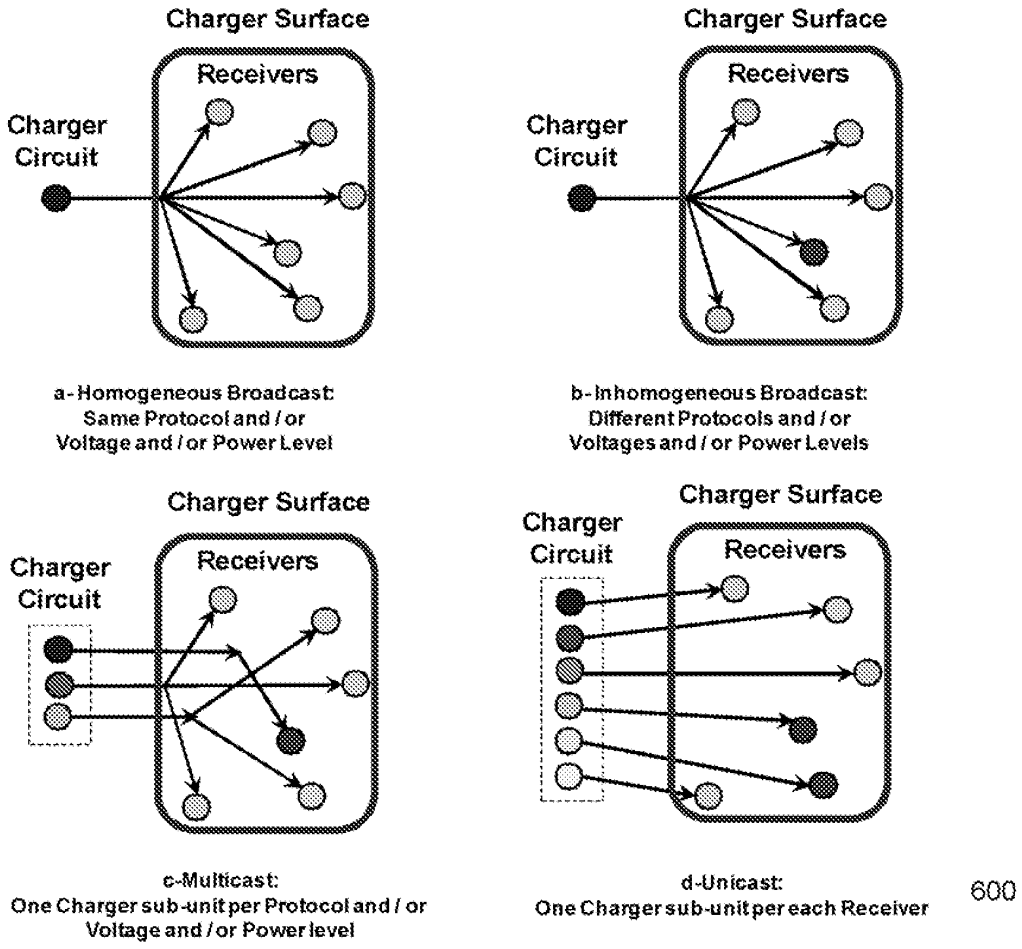


FIGURE 46

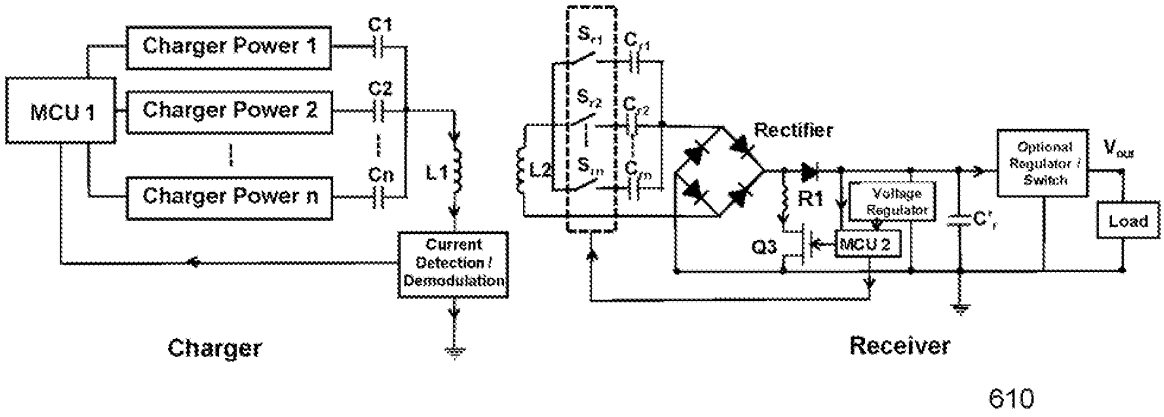
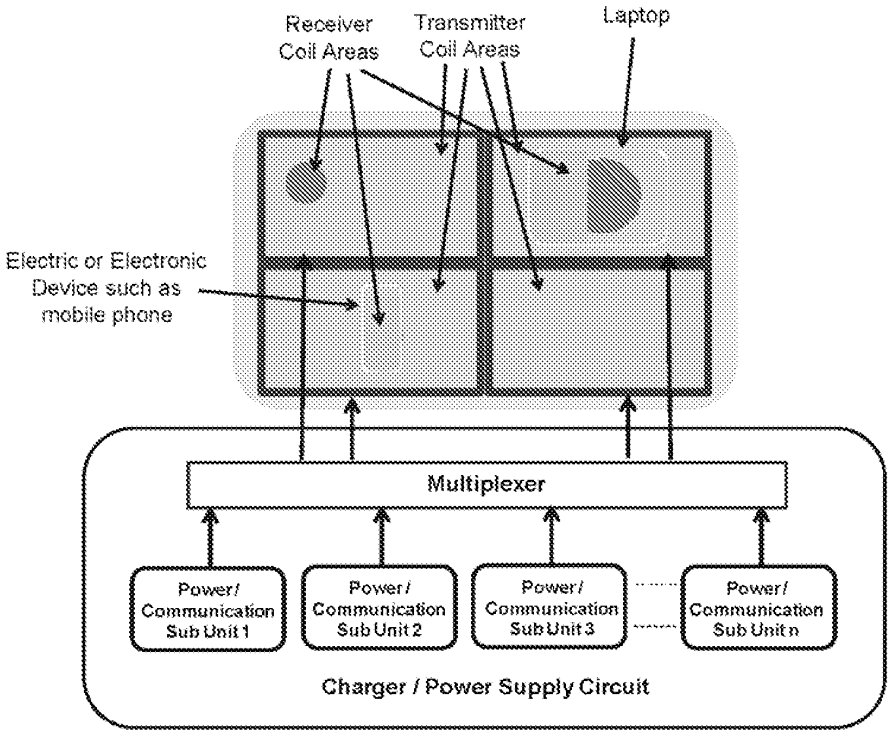
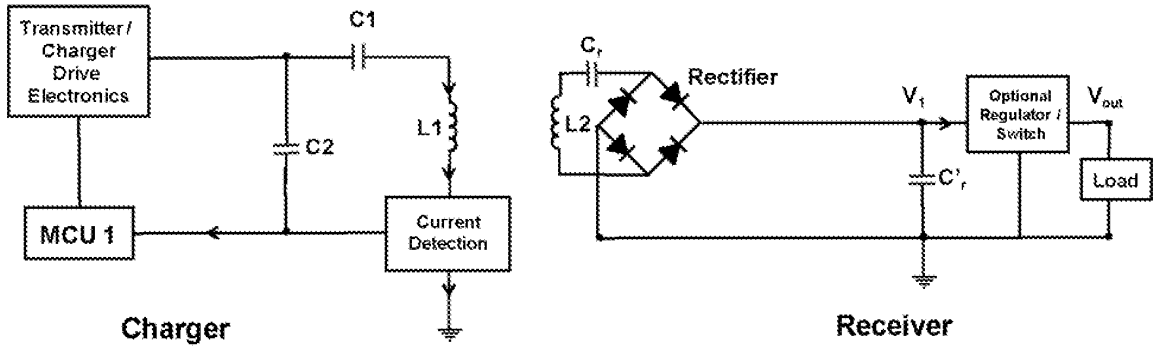


FIGURE 47



620

FIGURE 48



630

FIGURE 49

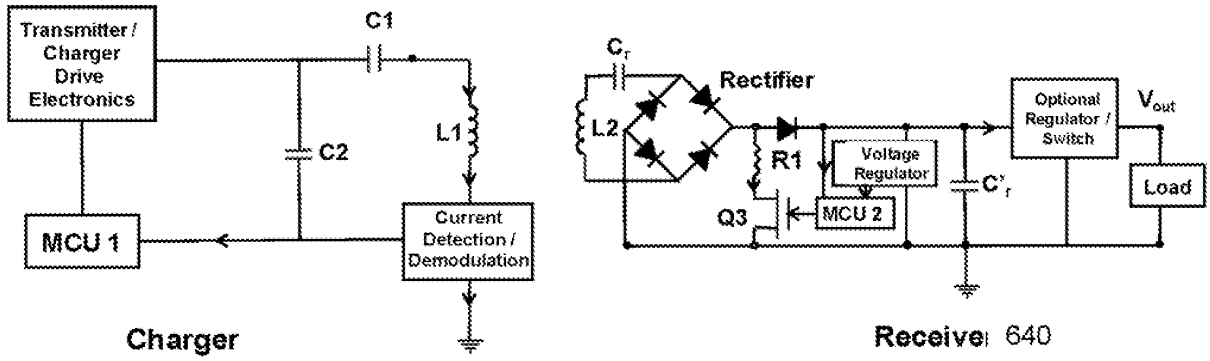


FIGURE 50

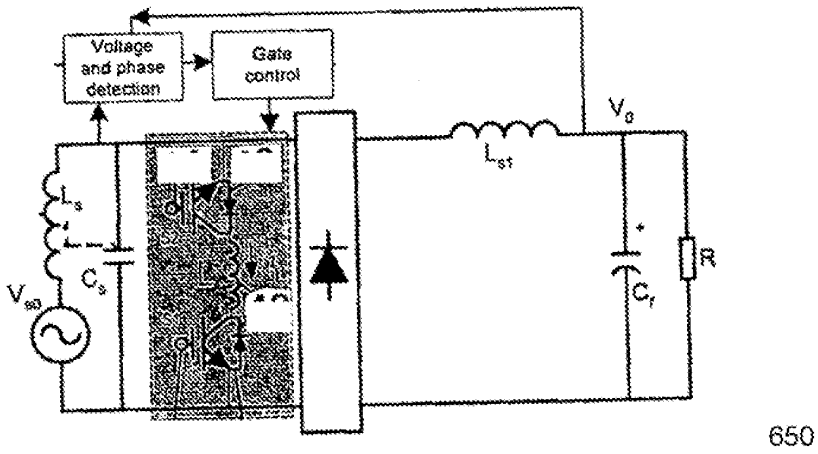


FIGURE 51

PTO/SB/14 (11-08)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01032US0
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Afshin		Partovi	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Sunnyvale	State/Province	CA	Country of Residence i	US

Citizenship under 37 CFR 1.41(b) i: US

Mailing Address of Applicant:

Address 1	1063 Morse Avenue		
Address 2	#5-100		
City	Sunnyvale	State/Province	CA
Postal Code	94089	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	23910		
Email Address	officeactions@fdml.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM		
Attorney Docket Number	AFPA-01032US0	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	26	Suggested Figure for Publication (if any)	23

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01032US0
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	23910		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61433883	2011-01-18
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61478020	2011-04-21
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61546316	2011-10-12

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

PTO/SB/14 (11-08)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01032US0
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:

Address 1			
Address 2			
City		**State/Province**	
Country [i]		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button. Add

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Karl F. Kenna/			Date (YYYY-MM-DD)	2012-01-17
First Name	Karl F.	Last Name	Kenna	Registration Number	45445

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	11849198
Application Number:	13352096
International Application Number:	
Confirmation Number:	4453
Title of Invention:	SYSTEMS AND METHODS FOR PROVIDING POSITIONING FREEDOM, AND SUPPORT OF DIFFERENT VOLTAGES, PROTOCOLS, AND POWER LEVELS IN A WIRELESS POWER SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
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Attorney Docket Number:	AFPA-01032US0
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Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		afpa_1032us0_application.pdf	386005 08df9c1dfb8747cc609cf1b17646a8e2196446d2	yes	94

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	86	
	Claims		87	93	
	Abstract		94	94	
Warnings:					
Information:					
2	Drawings-only black and white line drawings	afpa_1032us0_figures.pdf	2618029 59189d8992bb19e0f5b651aa512d90865c168c89	no	26
Warnings:					
Information:					
3	Application Data Sheet	afpa_1032us0_ADS.pdf	1387130 0401c465e75afaf407180016020a8b9509fc01d8	no	4
Warnings:					
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		Total Files Size (in bytes):	4391164		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

SCORE Placeholder Sheet for IFW Content

Application Number: 13352096 Document Date: 1/17/2012

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

- Drawings – Other than Black and White Line Drawings

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

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Form Revision Date: February 8, 2006