AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:22-cv-00433	10/7/2022	Eastern District of Texas

PLAINTIFF	DEFENDANT
Mojo Mobility Inc.	Samsung Electronics Co., Ltd and Samsung Electronics America, Inc.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 7,948,208	5/24/2011	Mojo Mobility Inc.
2	US 9,577,440	2/21/2017	Mojo Mobility Inc.
3	US 11,292,349	4/5/2022	Mojo Mobility Inc.
4	US 11,201,500	12/14/2021	Mojo Mobility Inc.
5	US 11,316,371	4/26/2022	Mojo Mobility Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

ATTACHMENT TO FORM AO-120
REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
(Mojo Mobility Inc. v. Samsung Electronics Co., Ltd and Samsung Electronics America, Inc.)

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
6 US 11,342,777	5/24/2022	Mojo Mobility Inc.
7 US 11,462,942	10/4/2022	Mojo Mobility Inc.

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	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	76276

Acknowledgement of Change to Small Entity Status

The entity status change request below filed through Private PAIR on 11/25/2018 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

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	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1

CONFIRMATION NO. 2001

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

POA ACCEPTANCE LETTER

OC000000075986828

Date Mailed: 06/26/2015

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**.

/agizaw/

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	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1

CONFIRMATION NO. 2001

POWER OF ATTORNEY NOTICE



23910
TUCKER ELLIS LLP
ONE MARKET PLAZA
STEUART TOWER, SUITE 700
SAN FRANCISCO, CA 94105

Date Mailed: 06/26/2015

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

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

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(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**.

/agizaw/

PTO/SB/80 (11-08)
Approved for use through 11/30/2011. OMB 0651-0035
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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

☑ Practitioners associated with the Customer Number: 133328

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

☑ The address associated with Customer Number: 133328

OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

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.**

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

PTO/SB/96 (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 displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Mojo Mobility Inc.

Application No./Patent No.: 11/757,067 Filed/Issue Date: June 1, 2007

Titled: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

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 28769, Frame 532, or for which a copy therefore is attached.

OR

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

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

This collection of information is required by 37 CFR 3.73(b). 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. 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.

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.

Electronic Acknowledgement Receipt

EFS ID:	22706602
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Louis L. Wu
Filer Authorized By:	
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	23-JUN-2015
Filing Date:	01-JUN-2007
Time Stamp:	04:01:40
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	Power of Attorney	POAChange.pdf	46019 2ce0a31961b731df48974df06698a08748d9ea5d	no	1
Warnings:					
Information:					

2	Power of Attorney	POAChange01.pdf	423616 82103e3dea86c28d0a3b1dfcee7e2b7993868ec7	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	469635	

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.

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	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1

CONFIRMATION NO. 2001

23910
MEYER IP LAW GROUP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

POA ACCEPTANCE LETTER

OC000000071890462

Date Mailed: 11/21/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 11/11/2014.

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.

/snguyen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION
Inventor:	Partovi, et al.	
Appln. No.:	11/757,067	Art Unit: 2858
Patent No.:	7,948,208	Examiner: Ramadan, Ramy
Confirm. No.:	2001	
Filed:	June 1, 2007	
Title:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**Customer No. 23910**

NOTIFICATION OF LOSS OF ENTITLEMENT TO SMALL ENTITY STATUS

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

Sir:

Pursuant to 37 C.F.R. §1.27(g)(2), Applicant hereby notifies the Office that Applicant is no longer claiming small entity status for the purposes of paying reduced fees under 35 USC §41(a) and (b), to the United States Patent and Trademark Office, with regard to the patent application identified above.

Respectfully submitted,

Date: November 21, 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

Electronic Acknowledgement Receipt

EFS ID:	20765960
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	21-NOV-2014
Filing Date:	01-JUN-2007
Time Stamp:	17:01:57
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	Notification of loss of entitlement to small entity status	afpa_1001us1_Entity_Change.pdf	57367 5d6e5293a3314a9c0fe3fe7fbbd332424412f831	no	1

Warnings:	
Information:	

Total Files Size (in bytes):	57367

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.

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82B(07-12)
Approved for use through 11/30/2014. OMB 0651-0035
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.

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in the attached transmittal letter.

☒ I hereby appoint Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A or equivalent):

23910

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A or equivalent):

Name	Registration Number	Name	Registration Number

Please recognize or change the correspondence address for the application identified in the attached transmittal letter to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number: 23910

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant:

☐ Inventor or Joint Inventor

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (*e.g.*, a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document)

SIGNATURE of Applicant for Patent

Signature	Afshin	Date	2/13/2013
Name	Afshin Partovi	Telephone	(650)892-3001
Title and Company	CEO, Mojo Mobility, Inc.		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms for more than one signature, see below *.

☐ *Total of _____ forms are submitted.

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.**

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

PTO/SB/96 (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 displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Afshin Partovi

Application No./Patent No.: 11/757,067 Filed/Issue Date: 06-01-2007

Titled: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

Mojo Mobility, Inc. , a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] 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 _____, Frame _____, or for which a copy therefore is attached.

OR

B. [X] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Inventors To: MOJO MOBILITY, INC.

The document was recorded in the United States Patent and Trademark Office at
Reel 025190, Frame 0219, or for which a copy thereof is attached.

2. From: Inventors To: MOJO MOBILITY, INC.

The document was recorded in the United States Patent and Trademark Office at
Reel 028769, Frame 0532, or for which a copy thereof is attached.

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[ ] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

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

/Karl Kenna/ November 11, 2014

Signature Date

Karl Kenna Attorney of Record

Printed or Typed Name Title

This collection of information is required by 37 CFR 3.73(b). 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. 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.

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.

Electronic Acknowledgement Receipt	
EFS ID:	20666693
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/Christopher Burnharte
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	11-NOV-2014
Filing Date:	01-JUN-2007
Time Stamp:	18:09:18
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	Power of Attorney	afpa_1001us1_POA.pdf	175989 0d6c3954c434a8a2c6db0b0503380cd8d06c1add	no	1
Warnings:					
Information:					

2	Assignee showing of ownership per 37 CFR 3.73.	afpa_1001us1_373_Statement.pdf	427267 e3f440f8d12b767540e9ae00c5cfe7064956be71	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	603256

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	11757067
	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramadan, Ramy
	Attorney Docket Number	AFPA-01001US1

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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
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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
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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							☐
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]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11757067
	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramadan, Ramy
	Attorney Docket Number	AFPA-01001US1

	1	Office Action in connection with U.S. Application No. 12/116,876 dated May 2, 2011, 8 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	11757067
	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramadan, Ramy
	Attorney Docket Number	AFPA-01001US1

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 F. Kenna/	Date (YYYY-MM-DD)	2011-05-23
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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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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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:	10149995
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	23-MAY-2011
Filing Date:	01-JUN-2007
Time Stamp:	19:36:56
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	Transmittal Letter	afpa_1001us1_IDSTransmittal_AfterAllowance_052310.pdf	62069 e52b92b4bb4c61c417f503b317d46932a778c54f	no	1

Warnings:	
Information:	

2	Information Disclosure Statement (IDS) Filed (SB/08)	afpa_1001us1_IDS_List_AfterAllowance_052311.pdf	762377 f9c13f74cb7d9b35840df4001757b1350345b486	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.

3	NPL Documents	afpa_1013us0_COPY_OfficeAction_050211.pdf	223670 064c390d63b782393f76a79f14d0c4c24e64c54b	no	8

Warnings:

Information:

Total Files Size (in bytes):	1048116

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<u>New Applications Under 35 U.S.C. 111</u>
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.

<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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION
Inventor(s):	Afshin Partovi, et al.	
Application No.:	11/757,067	Art Unit: 2858
Confirm. No.:	2001	Examiner: Ramy Ramadan
Filed:	June 1, 2007	
Title:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**Customer No. 23910**

INFORMATION DISCLOSURE STATEMENT AFTER ALLOWANCE PURSUANT TO 37 C.F.R. §1.97(i)

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

Sir:

Applicant is filing this Information Disclosure Statement (IDS), after receipt of Notice of Allowance for the above-captioned application.

Applicant respectfully requests that this IDS and the reference be placed in the application file.

Applicant believes no fee is due in connection with this paper. However, 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 filing, including any fee for extension of time, which may be required.

Respectfully submitted,

Date: May 23, 2011

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

FLIESLER MEYER LLP
650 California Street, 14th Floor
San Francisco, California 94108
Telephone (415) 362-3800

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 NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	05/24/2011	7948208	AFPA-01001US1	2001

23910 7590 05/04/2011

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

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;
Michael Sears, Ben Lomond, CA;

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
Fliesler Meyer LLP
650 California Street, 14th Floor
San Francisco, CA 94108

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.

Karl F. Kenna	(Depositor's name)
/Karl F. Kenna/	(Signature)
April 13, 2011	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	6/1/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
NONPROVISIONAL	YES	$0	$0	$0	07/07/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAMADAN, RAMY O	2858	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 Fliesler Meyer LLP
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): SUNNYVALE, CALIFORNIA (US)

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 enclosed:
☑ Issue Fee
☑ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies

4b. Payment of Fee(s):
☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☑ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1325

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Karl F. Kenna/ Date April 13, 2011

Typed or printed name Karl F. Kenna Registration No. 45445

This collection of information 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.

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Electronic Acknowledgement Receipt

EFS ID:	9874959
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	13-APR-2011
Filing Date:	01-JUN-2007
Time Stamp:	19:13:12
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	Issue Fee Payment (PTO-85B)	afpa_1001us1_IssueFeeTransmittal_041311.pdf	243562 f05c1e2f90dec405482736385b0f26cb5e042ca3	no	1

Warnings:	
Information:	

Total Files Size (in bytes):	243562

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.

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
Fliesler Meyer LLP
650 California Street, 14th Floor
San Francisco, CA 94108



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.

Karl F. Kenna	(Depositor's name)
/Karl F. Kenna/	(Signature)
April 13, 2011	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	6/1/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
NONPROVISIONAL	YES	$0	$0	04/14/2011 HVUONG2 00000026 061325 07/07/2011 11757067 01 FC:2501 755.00 DA	

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAMADAN, RAMY O	2858	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 Fliesler Meyer LLP
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): SUNNYVALE, CALIFORNIA (US)

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 enclosed:
- ☑ Issue Fee
- ☑ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s):
- ☐ A check in the amount of the fee(s) is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☑ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1325.

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Karl F. Kenna/ Date April 13, 2011

Typed or printed name Karl F. Kenna Registration No. 45445

This collection of information 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.

Adjustment date: 04/14/2011 HVUONG2
04/22/2011 INTEFSW 00004295 061325 11757067

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

23910 7590 04/07/2011

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER
RAMADAN, RAMY O

ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 04/07/2011

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$0	$0	$755	$0	07/07/2011

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 SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

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**
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 04/07/2011
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

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.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$0	$0	$755	$0	07/07/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAMADAN, RAMY O	2858	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 _____
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 (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:

❑ 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 credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information 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.

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 NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

23910 7590 04/07/2011

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER	
RAMADAN, RAMY O	
ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 04/07/2011

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

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

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 Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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.

Notice of Allowability	Application No.	Applicant(s)	
	11/757,067	PARTOVI ET AL.	
	Examiner	Art Unit	
	RAMY RAMADAN	2858	

-- 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 *the communication filed March 14, 2011*.

2. ☒ The allowed claim(s) is/are *1,2,5-9,11,12,20-26,28,29 and 31-36*.

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

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date See Continuation Sheet
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Edward Tso/
Primary Examiner, Art Unit 2858

Continuation of Attachment(s) 3. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 03/10/2011, 03/14/2011.

DETAILED ACTION

Information Disclosure Statement

1. The Information Disclosure Statements dated March 10, 2011 and March 14, 2011 have been acknowledged by the examiner and the cited references have been considered in the examination of the pending claims. As required by M.P.E.P 609 C (2), copies of the Information Disclosure Statements initiated and dated by the examiner are attached.

Allowable Subject Matter

2. Claims 1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36 are allowed.

3. The following is an examiner's statement of reasons for allowance:

With respect to claim 1 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that decreases harmonics in that activated primary coil; and selectively switch, using their associated switching circuits to activate, only those one or more primary coils which are determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

With respect to claim 20 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, one or more capacitive or other components that decreases harmonics in the activated primary coil, and selectively switch, using their associated switching circuits to activate, only those primary coils which are determined to be in general alignment with a receiver coil at the device and/or battery.

With respect to claims 31 and 34 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that increases energy transfer

efficiency by that activated primary coil; and selectively switch, using their associated switching circuits to activate, only that one or more primary coils which is determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

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."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAMY RAMADAN whose telephone number is (571) 272-9761. The examiner can normally be reached on Mon-Fri 7:30 am-5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, PATRICK ASSOUAD can be reached on (571) 272-2210. 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.

/Edward Tso/
Primary Examiner, Art Unit 2858

/Ramy Ramadan/
Examiner
Art Unit 2858

/RR/

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
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	11757067
Filing Date	2007-06-01
First Named Inventor	Afshin Partovi
Art Unit	2858
Examiner Name	Ramy O. Ramadan
Attorney Docket Number	AFPA-01001US1

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	7804054		2010-09-28	Shalom	
	2	4873677		1989-10-10	Sakamoto	
	3	6301128		2001-10-09	Jang	
	4	5600225		1997-02-04	Goto	
	5	5963012		1999-10-05	Garcia	
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Receipt date: 03/10/2011	Application Number	11757067 11757067 - GAU: 2858
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
(Not for submission under 37 CFR 1.99)	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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	1	20100259401		2010-10-14	Azancot	
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	2	WO03105308A1	WO		2003-12-18	City University of Hong Kong		☐

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	3	WO2005109598A1	WO		2005-11-17	Splashpower Limited		☐

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Art Unit	2858
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/R.R./	1	STOKES, "Palm Strikes Back with new OS, Pre Handset at CES, http://arstechnica.com/news.ars/post/20090101-palm-laundhes -new-handset-pre-operating", January 8, 2009, 6 pages.	☐
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11757067	PARTOVI, AFSHIN
	Examiner	Art Unit
	RAMY RAMADAN	2858

✓	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	03/23/2011								
1	1	=								
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	RAMY RAMADAN	2858

ORIGINAL		**INTERNATIONAL CLASSIFICATION**									
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/RAMY RAMADAN/ Examiner.Art Unit 2858	03/23/2011	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	24	
/Edward Tso/ Primary Examiner.Art Unit 2858	03/26/2011	O.G. Print Claim(s)	O.G. Print Figure
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
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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.

☐ 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 F. Kenna/	Date (YYYY-MM-DD)	2011-03-14
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.

Electronic Acknowledgement Receipt

EFS ID:	9655913
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	14-MAR-2011
Filing Date:	01-JUN-2007
Time Stamp:	18:38:17
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	NPL Documents	A1_STOKES_PalmStrikesBack.pdf	834135 c92a16ef54c729475099d40114968c0449fa6141	no	6

Warnings:	
Information:	

2	NPL Documents	B1_SULLIVAN_WireFreeTechnology.pdf	683877 a77c01b83fc30918f167aeef803d24874d3c9ae8	no	2
Warnings:					
Information:					
3	NPL Documents	C1_KIM_WirelessChargerNewPalmPhone.pdf	1037126 88d916c0c1c163068afbccf88db7b964b45d932e	no	2
Warnings:					
Information:					
4	NPL Documents	D1_REDZENMARKETING_CouldThisBethePalmMojo.pdf	439655 a1236e12f43c0a63c92a0b8fbd3fad88b4ca8d01	no	3
Warnings:					
Information:					
5	NPL Documents	E1_ThePublicDebutECoupled.pdf	363948 36ceb79238cfa38846c2d39a4415e13a2ff99372	no	2
Warnings:					
Information:					
6	NPL Documents	F1_MILLER_PalmMayMakePreScarce.pdf	274626 993eb00223577edbb6b58e5a2f0329a35a8a2a24	no	1
Warnings:					
Information:					
7	NPL Documents	G1_MURAKAMI_ConsiderationCordlessPowerStation.pdf	859888 a9b3cef85b554a83a522a24505a77c0d191b9d50	no	3
Warnings:					
Information:					
8	NPL Documents	H1_Epson_airtrans.pdf	280623 69cd0b0014789c30c435dee9d5a2e4b5a0bdd3a7	no	2
Warnings:					
Information:					
9	NPL Documents	K_Choi_ANewcontactlessBatteryCharger.pdf	579021 a1f089f814d5c394ec99205b2f69cb35010fce31	no	2
Warnings:					
Information:					
10	Transmittal Letter	afpa_1001us1_IDS_transmittal_031411.pdf	144095 90a53d2e2f23eb973a111c2238304f65284feea5	no	2
Warnings:					
Information:					

11	Information Disclosure Statement (IDS) Filed (SB/08)	afpa_1001us1_IDS_031411.pdf	830121 ad269fff36e27bcd6a26884abc7332628456f427	no	5

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.

Total Files Size (in bytes):	6327115

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		PATENT APPLICATION	
Inventor(s):	Afshin Partovi et al.		
Appl. No.:	11/757,067	Art Unit:	2858
Confirm. No.:	2001	Examiner:	Ramy O. Ramadan
Filed:	06/01/2007		
Title:	POWER SOURCE CHARGING SYSTEM AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**Customer No. 23910**	

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/SB/08a. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ Copies of cited U.S. patents and publications are not enclosed. However, copies of cited foreign patent documents and non-patent literature are enclosed in accordance with 37 CFR 1.98(a)(2), as required, except for those items designated by an asterisk (*), which were previously submitted by the applicant in a parent application, from which benefit under 35 U.S.C. §120 is claimed, with an *Information Disclosure Statement* submitted in the parent application which complies with the September 8, 2000 or subsequent revision of 37 C.F.R. §1.98(a-c), as allowed under 37 C.F.R. §1.98(d)(1).

___ 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.

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

Respectfully submitted,

Date: March 14, 2011

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

FLIESLER MEYER LLP
650 California Street, 14th Floor
San Francisco, California 94108
Telephone: (415) 362-3800
Facsimile: (415) 362-2928

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO CA 94108

MAILED

MAR 14 2011

OFFICE OF PETITIONS

In re Application of	:	
Afshin Partovi, et al.	:	
Application No. 11/757,067	:	DECISION GRANTING PETITION
Filed: June 1, 2007	:	UNDER 37 CFR 1.313(c)(2)
Attorney Docket No. AFPA-01001US1	:	

This is a decision on the petition under 37 CFR 1.313(c)(2), filed, March 10, 2011 to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED**.

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). *See* 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid on February 18, 2011 cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.[1]

Telephone inquiries should be directed to Terri Johnson at (571) 272-2991.

This application is being referred to Technology Center AU 2858 for processing of the request for continued examination under 37 CFR 1.114 and for consideration of the concurrently filed information disclosure statement.

/Terri Johnson/
Terri Johnson
Petitions Examiner
Office of Petitions

[1] *The request to apply the issue fee to the new Notice may be satisfied by completing and returning the new Part B – Fee(s) Transmittal Form (along with any balance due at the time of submission). Petitioner is advised that the Issue Fee Transmittal Form must be completed and timely submitted to avoid abandonment of the application.*

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Date : March 11, 2011

TO : Director, Office of Data Management

FROM : Office of Petitions

SUBJECT : Withdrawal from Issue of **Application No. 11/757,067**

Applicant(s) : Afshin Partovi, et al.
Application No. : 11/757,067
Filed : June 1, 2007

The above-identified application has been assigned Patent No. 7,915,857 and an issue date of March 29, 2011.

It is hereby directed that this application be withdrawn from issue at the request of the applicant. Do not refund the issue fee.

The following erratum should be published in the Official Gazette if the above-identified application is published in the OG of March 29 2011:

"All reference to Patent No. 7,915,857 to Afshin Partovi, et al. of California for POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES appearing in the Official Gazette of March 29, 2011 should be deleted since no patent was granted."

/Terri Johnson/
Terri Johnson
Petitions Examiner
Office of Petitions

cc: Paul Harrison
Deneise Boyd
Mary Louise McAskill
Niomi Farmer
Mary E. Johnson (Cookie)
Brad Harris
Kim Terrell
Lamont Fletcher

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	11/757,067	Filing Date	2007-06-01	Docket Number (if applicable)	AFPA-01001US1	Art Unit	2858
First Named Inventor	Afshin Partovi			Examiner Name	Ramy O. Ramadan		

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 _____

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)	2011-03-10
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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION	
Inventor(s):	Afshin Partovi et al.		
Appl. No.:	11/757,067	Art Unit:	2858
Confirm. No.:	2001	Examiner:	Ramy O. Ramadan
Filed:	06/01/2007		
Title:	POWER SOURCE CHARGING SYSTEM AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**Customer No. 23910**	

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.56

Mail Stop Petition 1.313(c)
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/SB/08a. The Examiner is requested to initial the form and return it to the undersigned in accordance with M.P.E.P. §609.

✓ Copies of cited U.S. patents and publications are not enclosed. However, copies of cited foreign patent documents and non-patent literature are enclosed in accordance with 37 CFR 1.98(a)(2), as required, except for those items designated by an asterisk (*), which were previously submitted by the applicant in a parent application, from which benefit under 35 U.S.C. §120 is claimed, with an *Information Disclosure Statement* submitted in the parent application which complies with the September 8, 2000 or subsequent revision of 37 C.F.R. §1.98(a-c), as allowed under 37 C.F.R. §1.98(d)(1).

___ 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.

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

Respectfully submitted,

Date: March 10, 2011

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

FLIESLER MEYER LLP
650 California Street, 14th Floor
San Francisco, California 94108
Telephone: (415) 362-3800
Facsimile: (415) 362-2928

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION	
Inventor(s):	Afshin Partovi et al.		
Appl. No.:	11/757,067	Art Unit:	2858
Confirm. No.:	2001	Examiner:	Ramy O. Ramadan
Filed:	06/01/2007		
Title:	POWER SOURCE CHARGING SYSTEM AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**Customer No. 23910**	

PETITION TO WITHDRAW APPLICATION FROM ISSUE UNDER 37 C.F.R. §1.313(c)

Mail Stop Petition 1.313(c)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants are submitting this petition under 37 C.F.R. § 1.313(c) to withdraw the above-identified patent application from issue, so that the Examiner can consider the accompanying Request for Continued Examination in compliance with 37 C.F.R. §1.114, and Information Disclosure Statement.

This petition is being filed after payment of the Issue Fee, which was paid on February 18, 2011. According to 37 C.F.R. §1.313(c)(2), filing a Request for Continued Examination in compliance with 37 C.F.R. §1.114 is a good and sufficient reason to withdraw an application from issue after the issue fee has been paid.

The present petition requires a $130.00 fee set forth in §1.17(h), and a fee of $405.00 pursuant to 37 C.F.R. §1.17(e) for the filing of the RCE and Information Disclosure Statement. The payment of such fees accompanies this petition. The Commissioner is authorized to charge the required fees and any underpayment of fees, or credit any overpayment to Deposit Account No. 06-1325 for any matter in connection with this petition, including any fee for extension of time, which may be required.

Respectfully submitted,

Date: March 10, 2011

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

FLIESLER MEYER LLP
650 California Street, 14th Floor
San Francisco, California 94108
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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	11757067
Filing Date	2007-06-01
First Named Inventor	Afshin Partovi
Art Unit	2858
Examiner Name	Ramy O. Ramadan
Attorney Docket Number	AFPA-01001US1

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	7804054		2010-09-28	Shalom	
	2	4873677		1989-10-10	Sakamoto	
	3	6301128		2001-10-09	Jang	
	4	5600225		1997-02-04	Goto	
	5	5963012		1999-10-05	Garcia	
	6	6870089		2005-03-02	Gray	
	7	3938018		2011-03-07	Dahl	
	8	5991170		1999-11-23	Nagai	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Afshin Partovi
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	9	5550452		1996-08-27	Shirai	
	10	4311953		1982-01-19	Fukuda	
	11	6310465		2001-10-30	Najima	
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	18	6888438		2005-05-03	Shu-Yuen Ron Hui	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	20	6913477		2005-07-05	Dayan	
	21	4415959		1983-11-15	Vinciarelli	
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	1	20100259401		2010-10-14	Azancot	
	2	20100257382		2010-10-07	Azancot	

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	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

	3	20100253282		2010-10-07	Azancot	
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	14	20100066176		2010-03-18	Azancot	
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	1	WO03096512A2	WO		2003-11-20	Splashpower Limited		☐
	2	WO03105308A1	WO		2003-12-18	City University of Hong Kong		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11757067
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	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
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	3	WO2005109598A1	WO		2005-11-17	Splashpower Limited		☐

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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.	☐
	2	TANG, et al., "Evaluation of the Shielding Effects on Printed-Circuit-Board Transformers Using Ferrite Plates and Copper Sheets", IEEE Transactions on Power Electronics, Vol. 17, No. 6, November 2002, pp. 1080-1088, 9 pages.	☐
	3	LIU, et al., "An Analysis of a Double-Layer Electromagnetic Shield for a Universal Contactless Battery Charging Platform", Department of Electronic Engineering City University of Hong Kong, IEEE, 2005, pp. 1767-1772, 6 pages.	☐
	4	LIU, et al., "Equivalent Circuit Modeling of a Multilayer Planar Winding Array Structure for Use in a Universal Contactless Battery Charging Platform, IEEE Transactions on Power Electronics, Vol. 22, No. 1, January 2007, pp. 21-29, 9 pages.	☐
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	18	TOPFER, et al., "Multi-Pole Magnetization of NdFeB Sintered Magnets and Thick Films for Magnetic Micro-Actuators", ScienceDirect, Sensor and Actuators, 2004, pp. 257-263, 7 pages.	☐
	19	TOPFER, et al., "Multi-Pole Magnetization of NdFeB Magnets for Magnetic Micro-Actuators and Its Characterization with a Magnetic Field Mapping Device", ScienceDirect, Journal of Magnetism and Magnetic Materials, 2004, 124-129, 6 pages.	☐

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	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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 F. Kenna/	Date (YYYY-MM-DD)	2011-03-10
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.

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Electronic Patent Application Fee Transmittal

Application Number:	11757067
Filing Date:	01-Jun-2007
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Filer:	Karl Kenna/narissa besada
Attorney Docket Number:	AFPA-01001US1

Filed as Small 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:				
Petition fee- 37 CFR 1.17(h) (Group III)	1464	1	130	130
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	2801	1	405	405
		Total in USD ($)		**535**

Electronic Acknowledgement Receipt	
EFS ID:	9635386
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	10-MAR-2011
Filing Date:	01-JUN-2007
Time Stamp:	19:39:26
Application Type:	Utility under 35 USC 111(a)

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Payment was successfully received in RAM	$535
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1	NPL Documents	A_Hui_ANewGenerationUniversalContactless.pdf	1886206 52c3f5557ad4b1cc979b69e80372fafaff9eeb3e	no	8
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2	NPL Documents	B_Tang_EvaluationoftheShieldingEffects.pdf	1949323 cbc4386d4178703f2e89263d5dc296316f5edd54	no	9
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Warnings:					
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17	NPL Documents	Q_Liu_OptimalDesignofaHybridWinding.pdf	453644 e96beed301532822d287655e8cc16b70467c26ad	no	8
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18	NPL Documents	R_Topfer_MultiPoleMagnetization.pdf	1677327 b199bcbdce14a2236605a26c3d6df5e621e4f84d	no	7
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Information:					
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Warnings:					
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21	NPL Documents	U_Hui_SomeElectromagneticAspectsOfCoreless.pdf	146915 316fef171a67883c837bf0265a4b60a4c23c4011	no	6
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24	Foreign Reference	WO03105308A1.pdf	2486171 ab529fb98dea6909c0683b0b35ae360ede5fca22	no	71
Warnings:					
Information:					
25	Foreign Reference	WO2005109598A1.pdf	2220277 b87b2f3d765300e42c8999b1aa2dbc890a426665	no	48
Warnings:					
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28	Petition to Withdraw from Issue	afpa_1001us1_petition_to_withdraw_from_issue.pdf	79854 ade64c30c9d3889723a548eb4ed6be9b76b2ecd2	no	1
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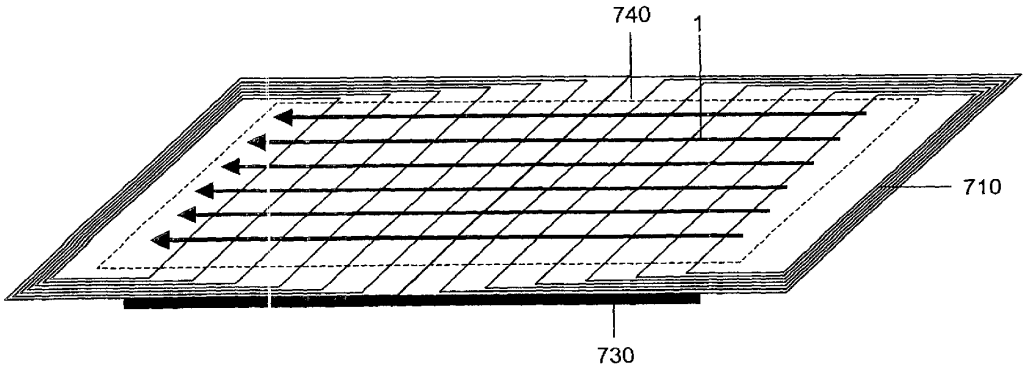
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(54) Title: IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER



(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.

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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.

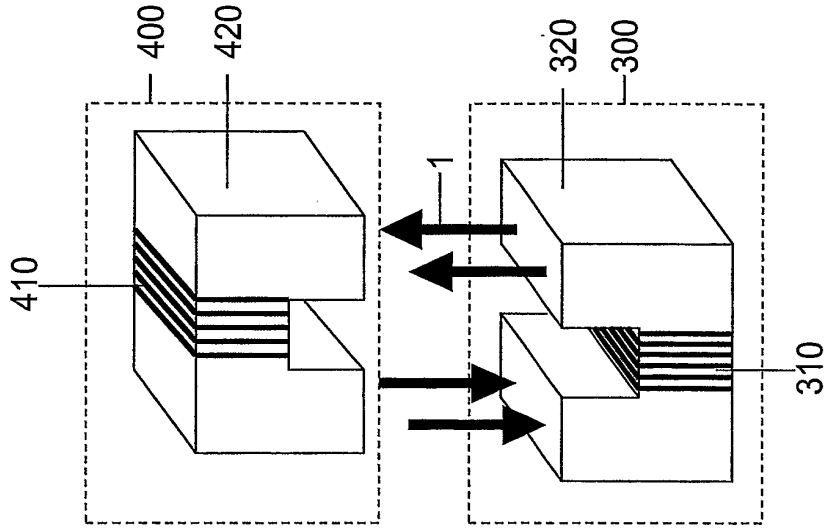


Figure 1b
(Prior Art)

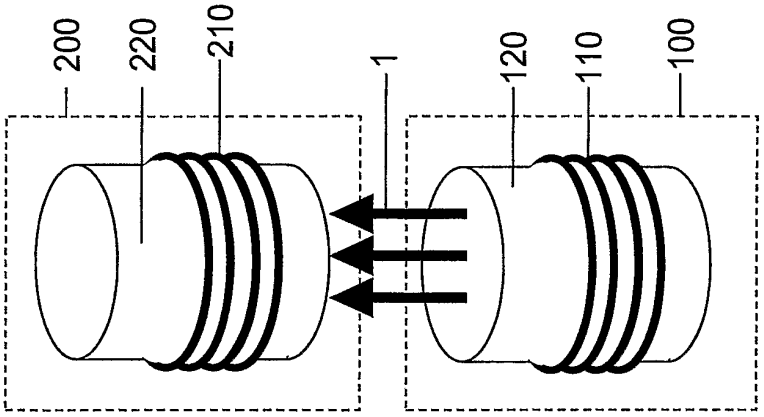


Figure 1a
(Prior Art)

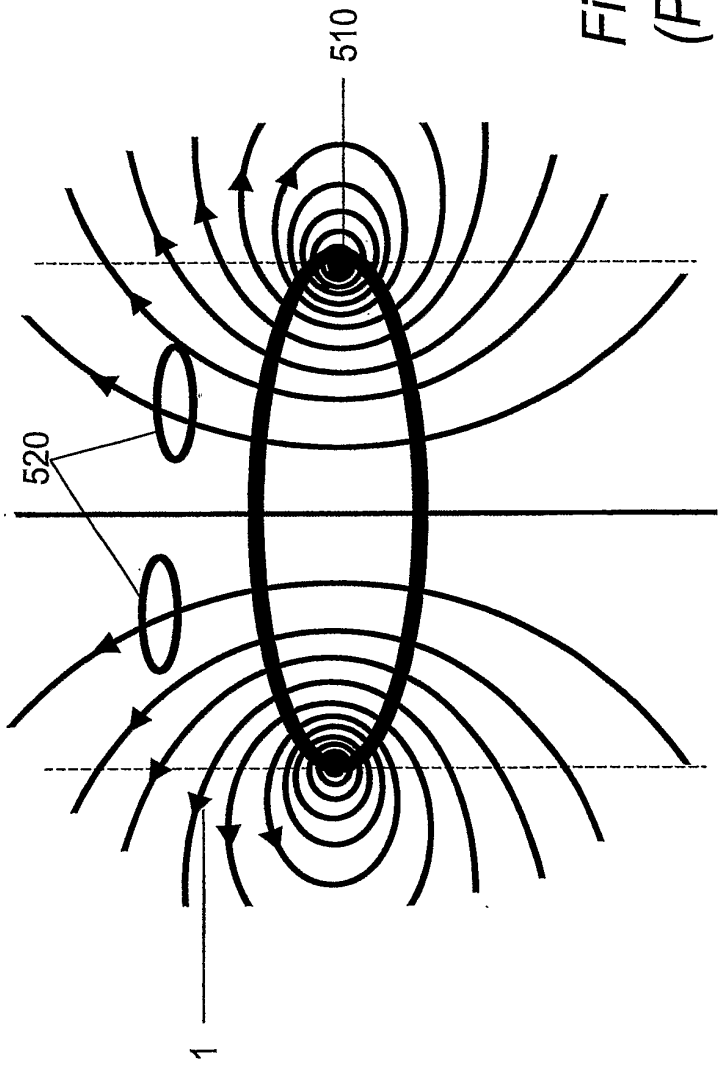


Figure 2a
(Prior Art)

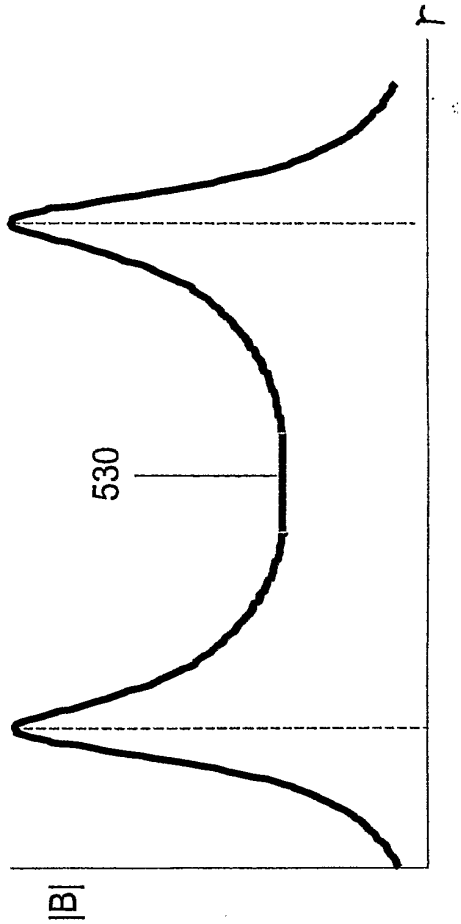


Figure 2b
X =5mm

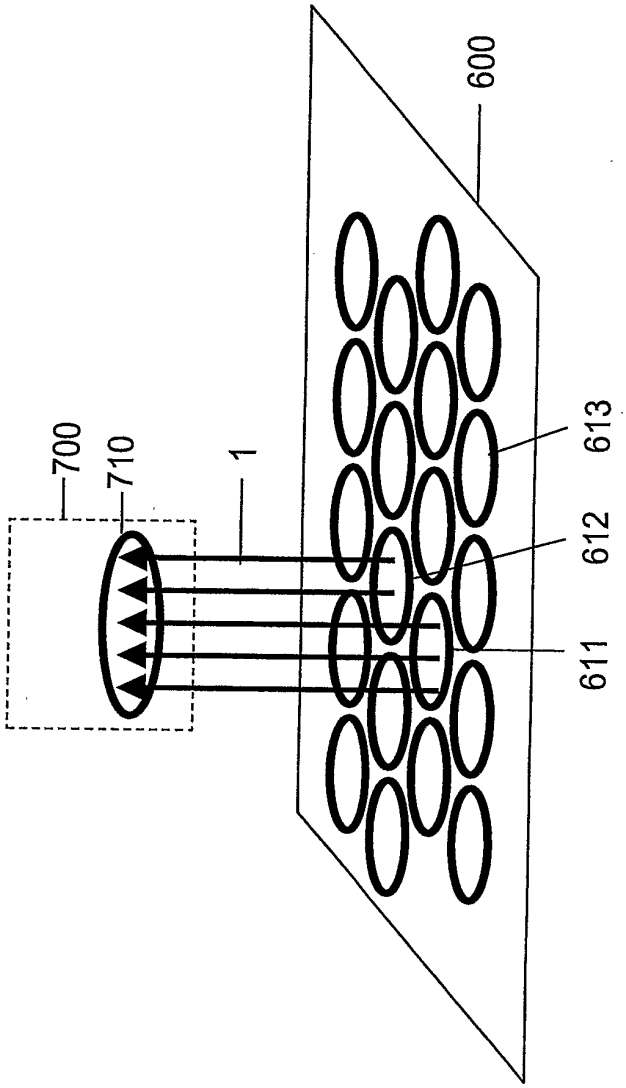


Figure 3

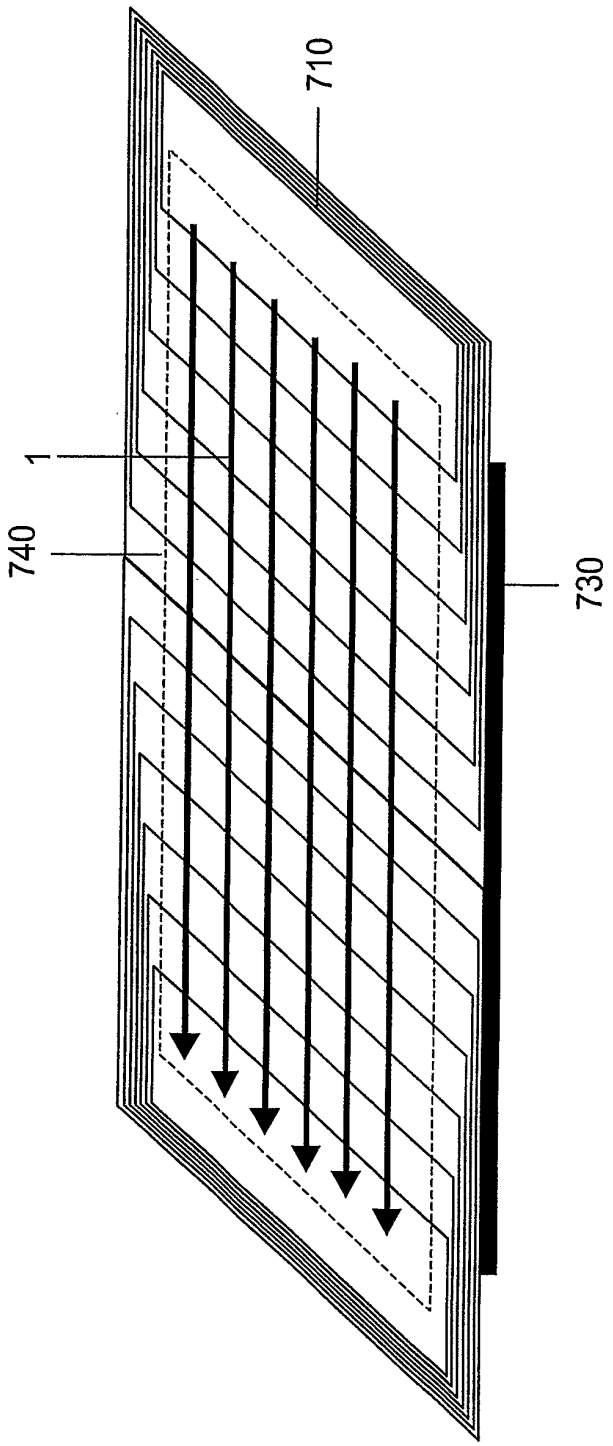


Figure 4a

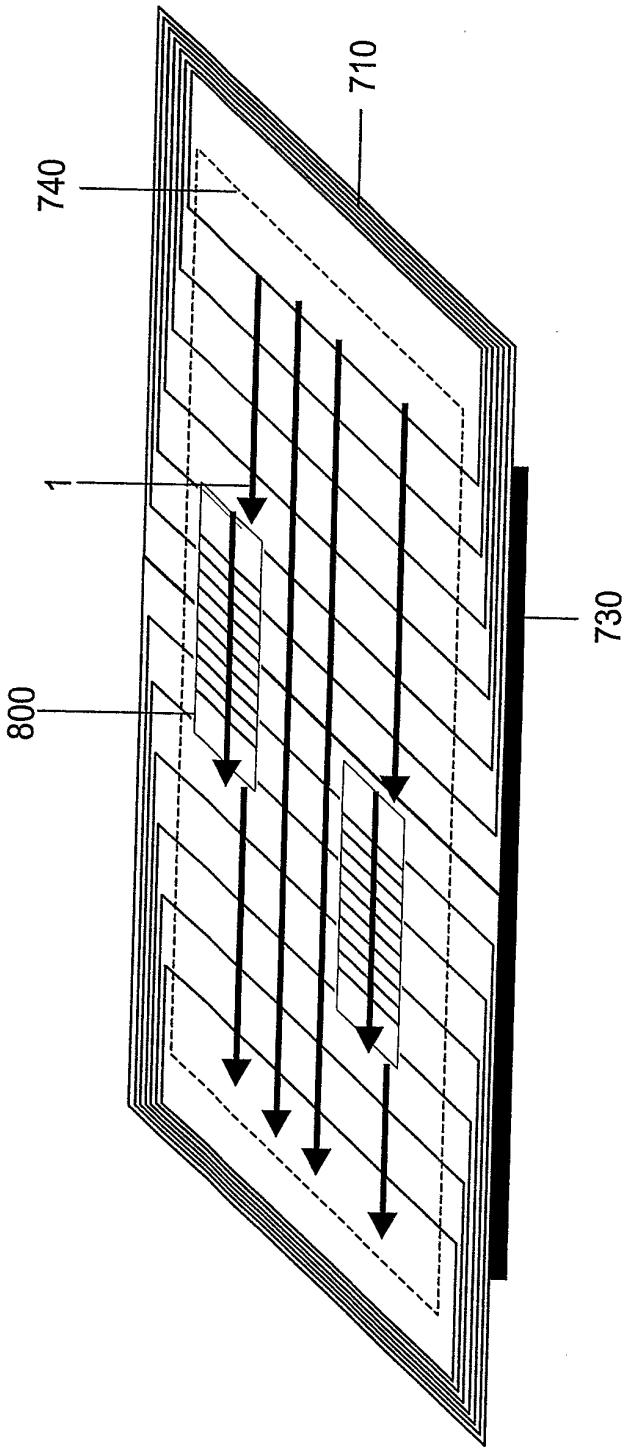


Figure 4b

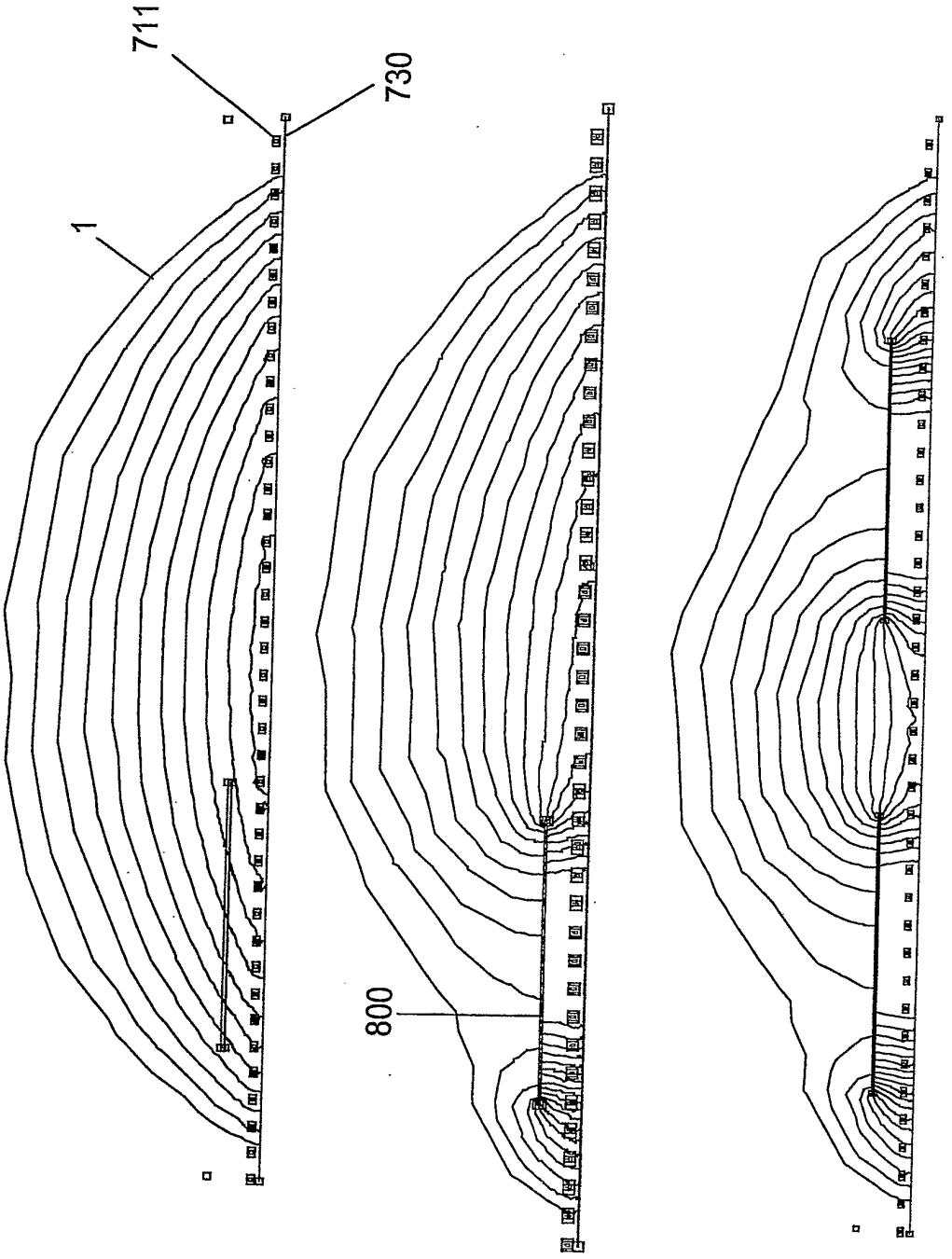


Figure 4c

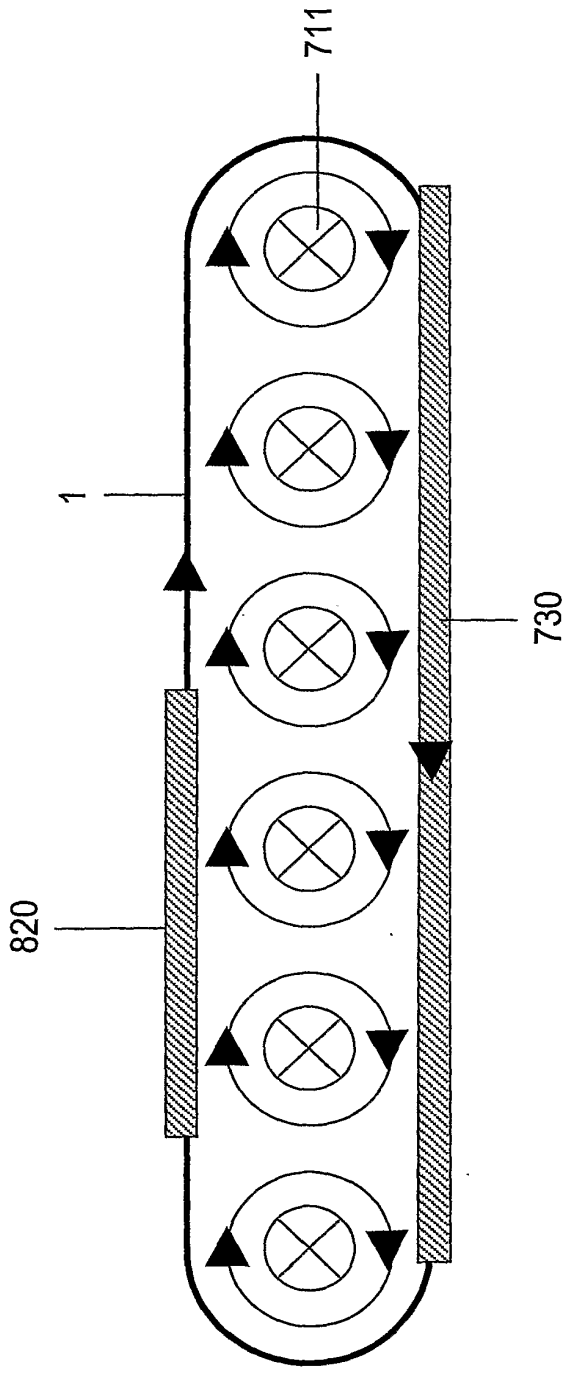


Figure 4d

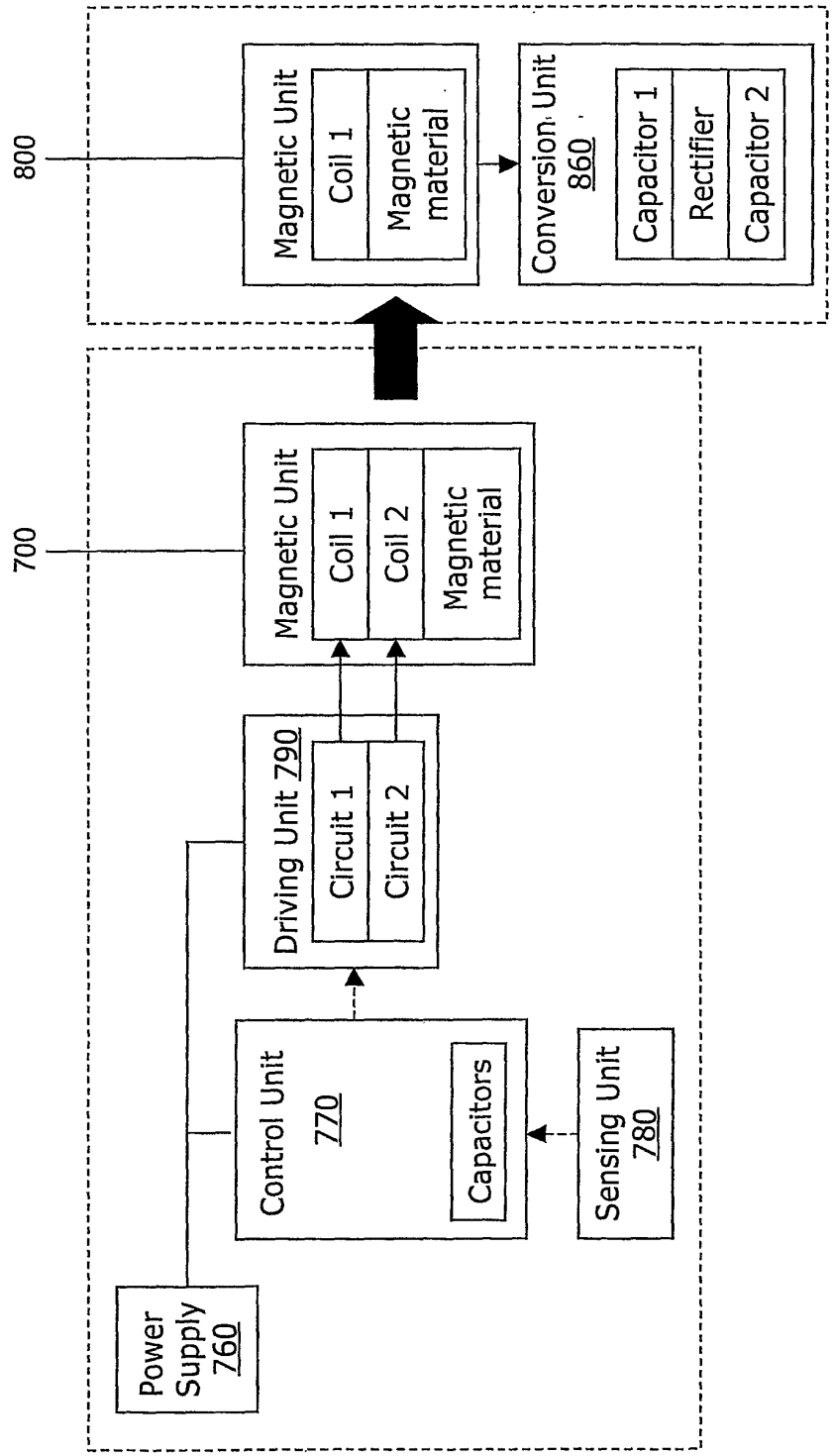

800
Magnetic Unit
Coil 1
Magnetic material
Conversion Unit 860
Capacitor 1
Rectifier
Capacitor 2
700
Magnetic Unit
Coil 1
Coil 2
Magnetic material
Driving Unit 790
Circuit 1
Circuit 2
Control Unit 770
Capacitors
Sensing Unit 780
Power Supply 760

Figure 5

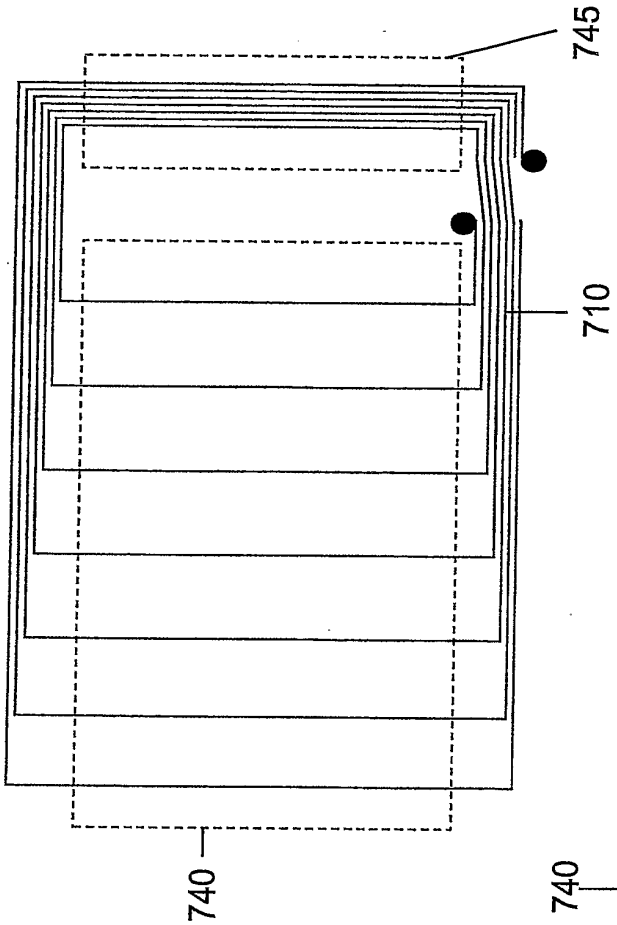


Figure 6a

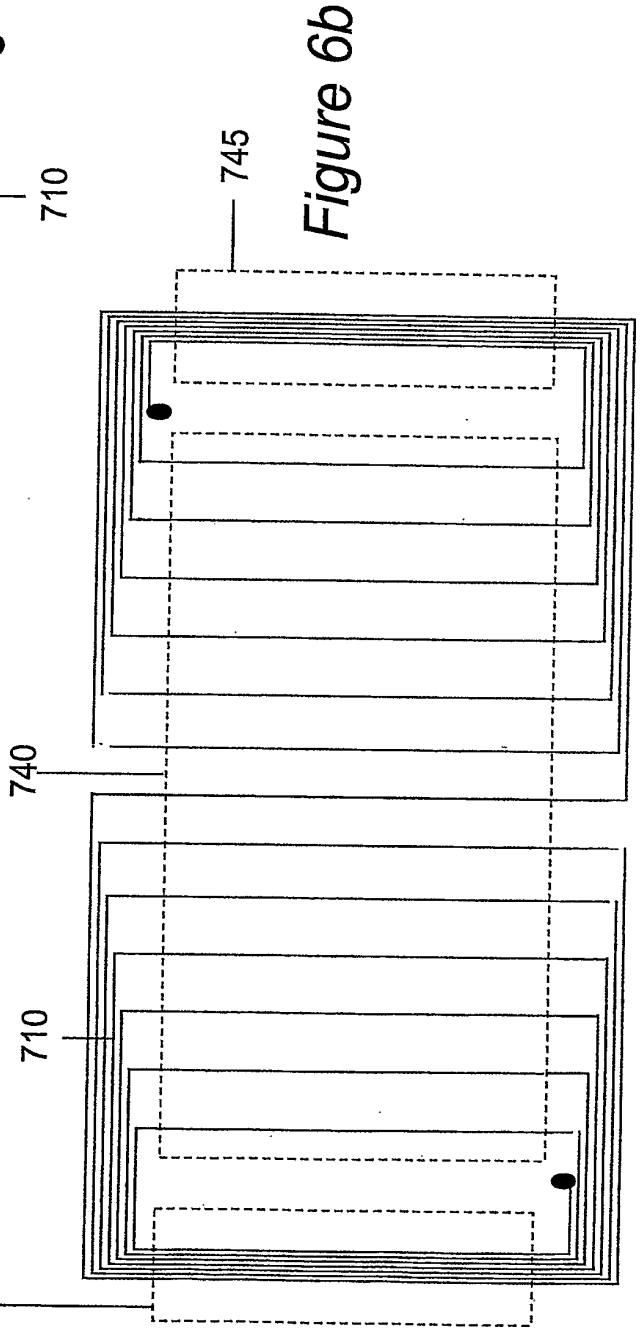


Figure 6b

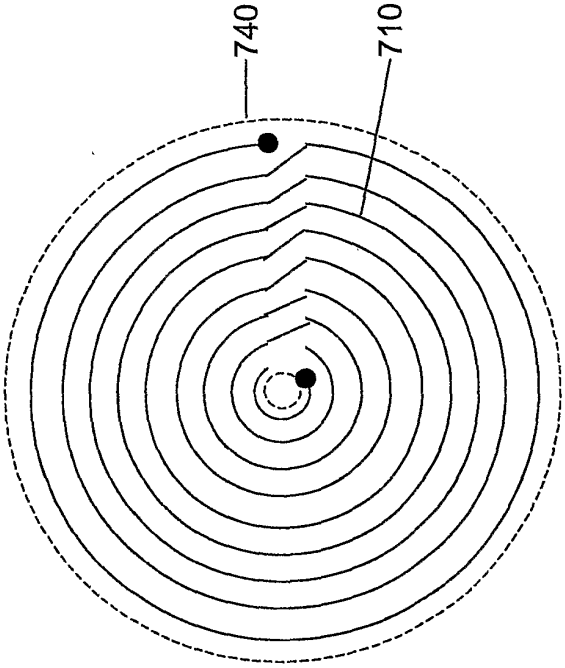


Figure 6c

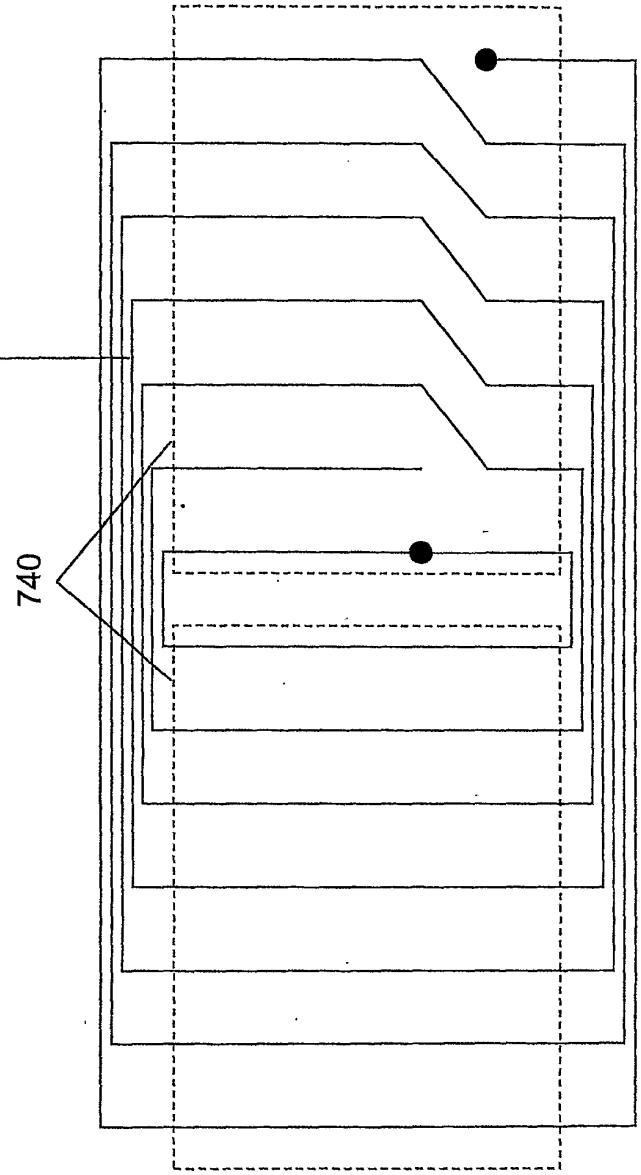


Figure 6d

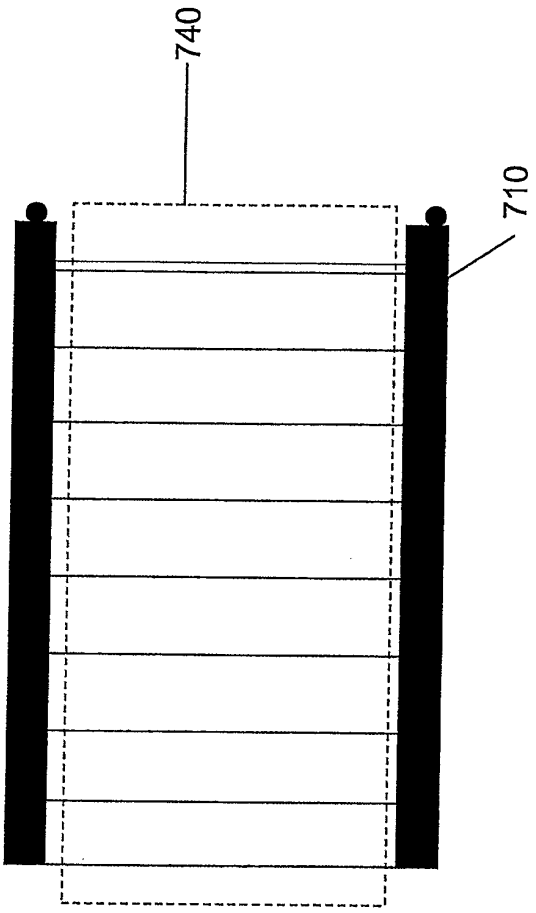


Figure 6e

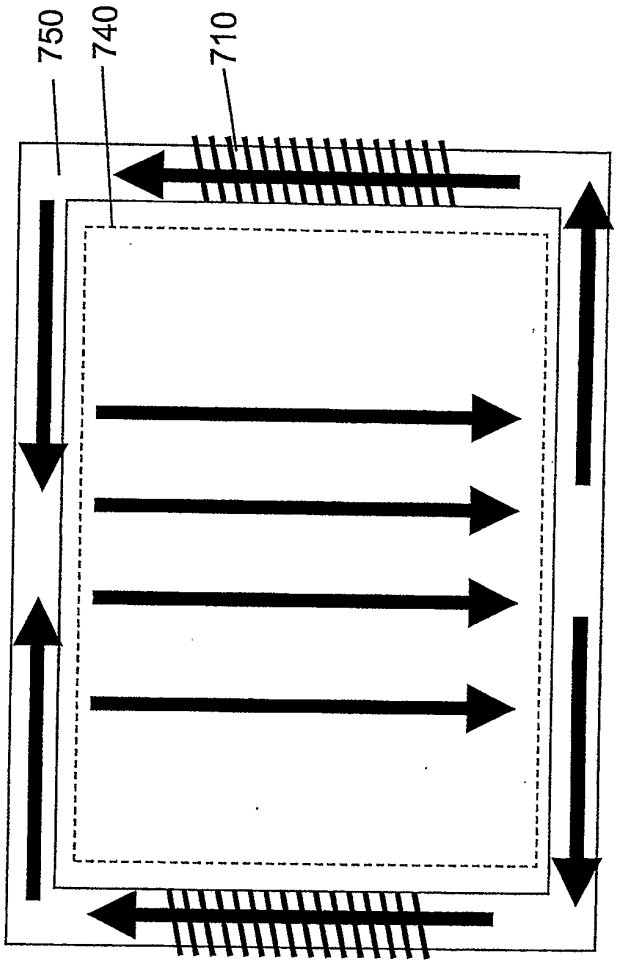


Figure 6f

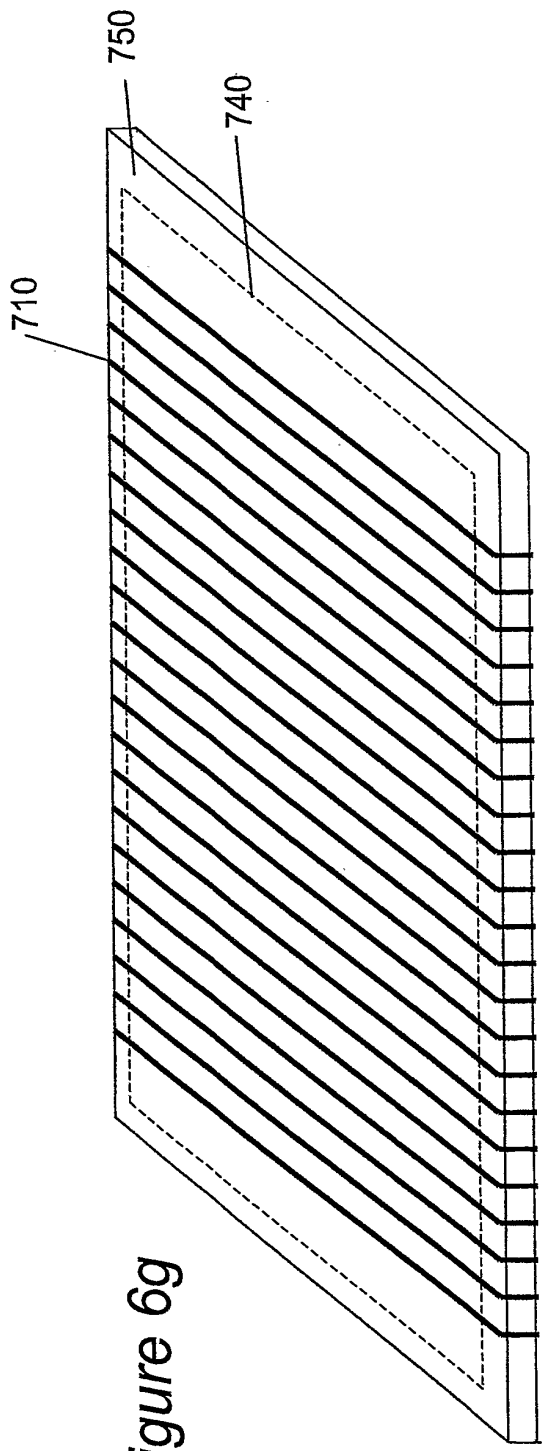


Figure 6g

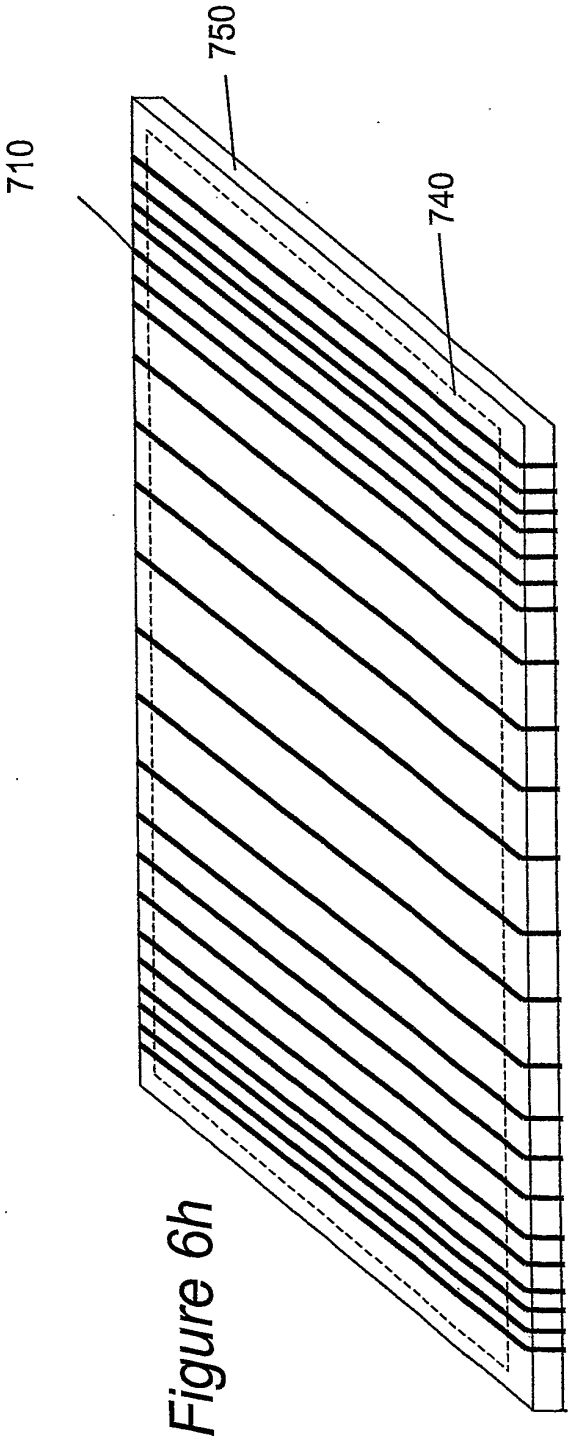


Figure 6h

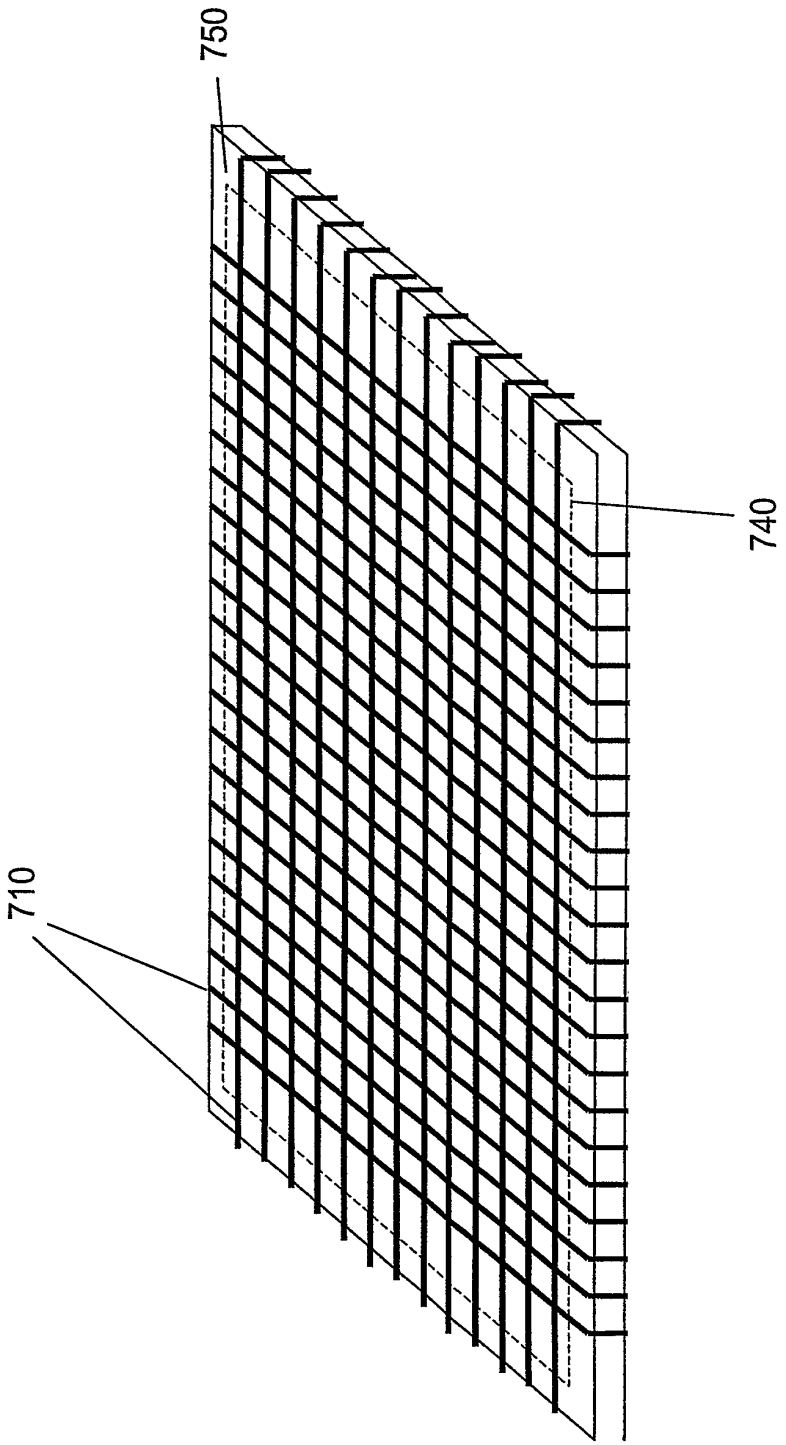


Figure 6i

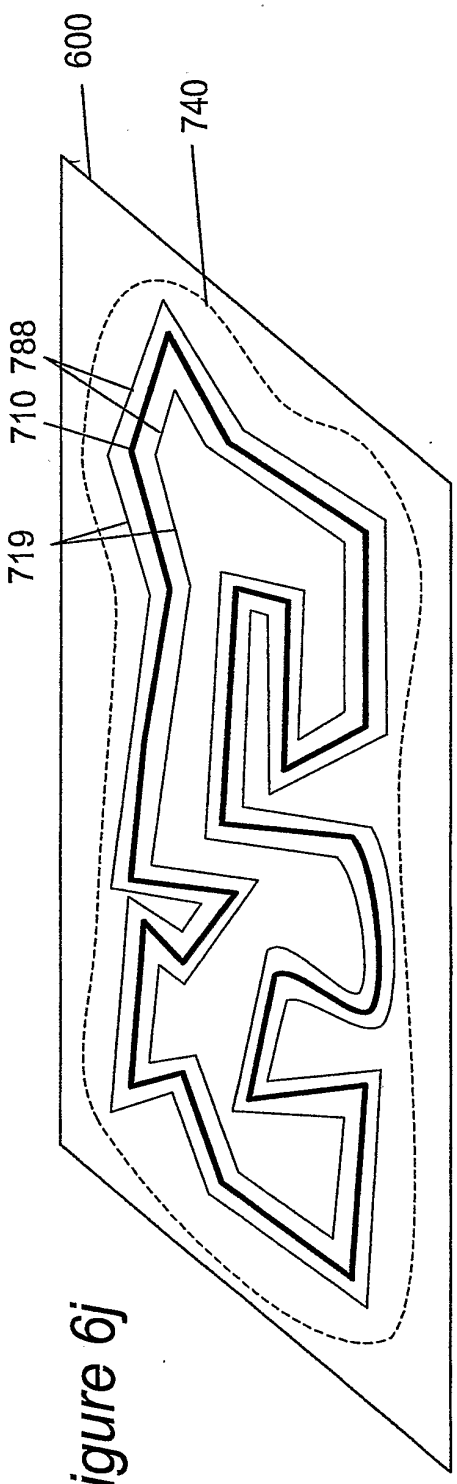


Figure 6j

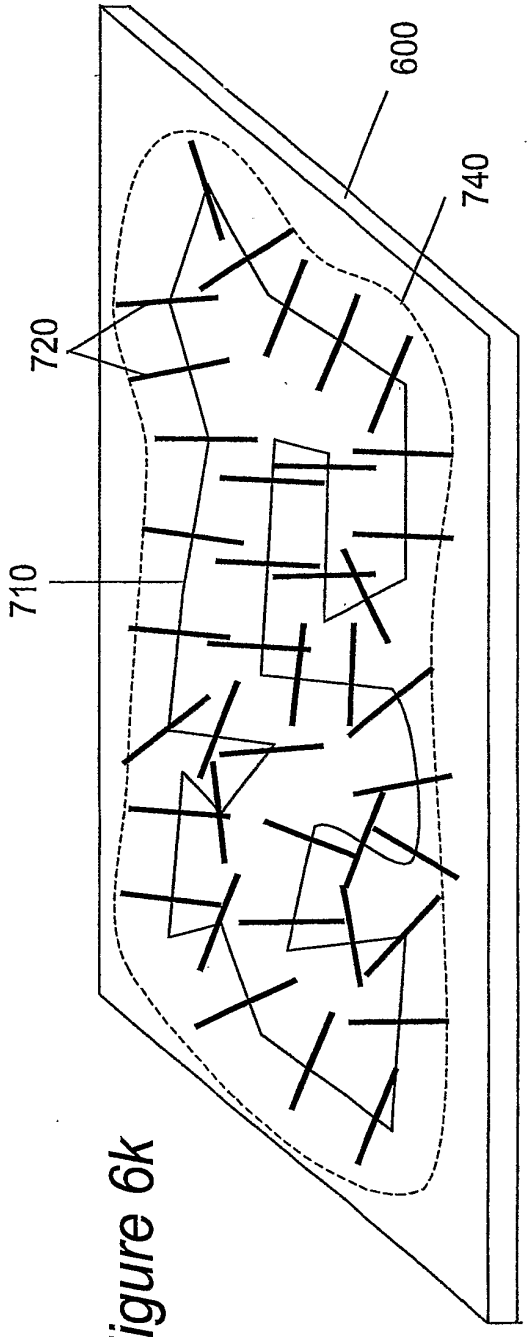


Figure 6k

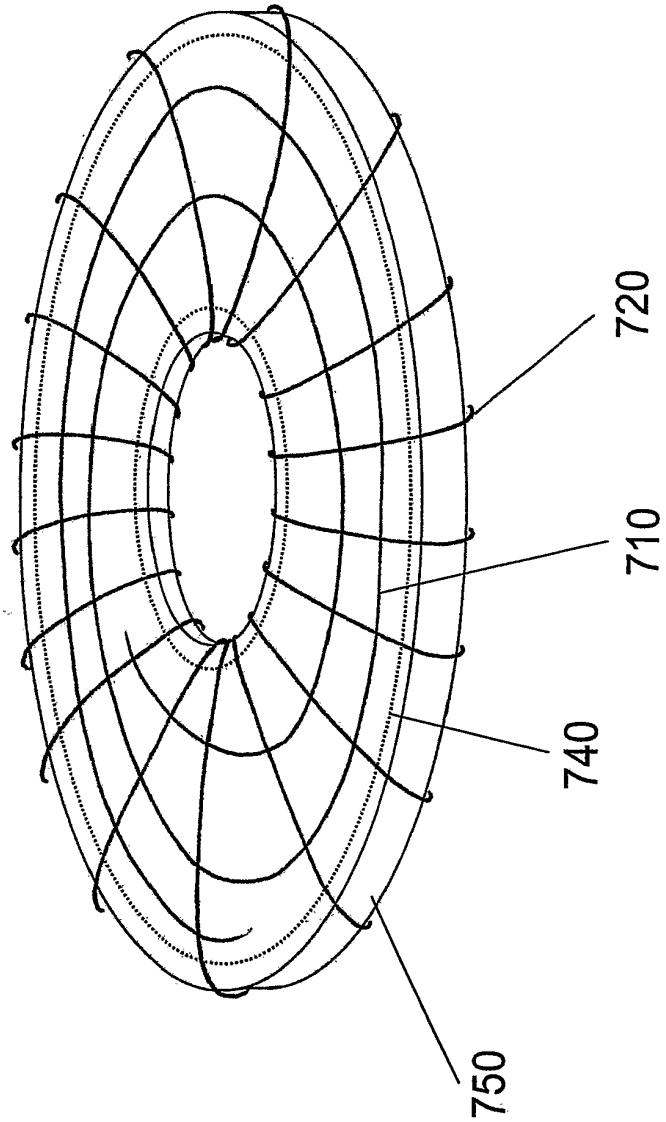


Figure 6L

Figure 7a

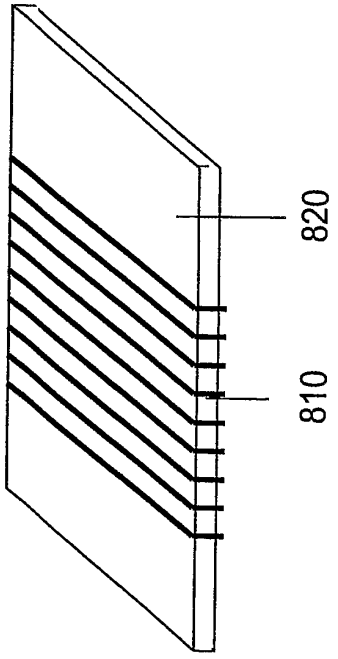
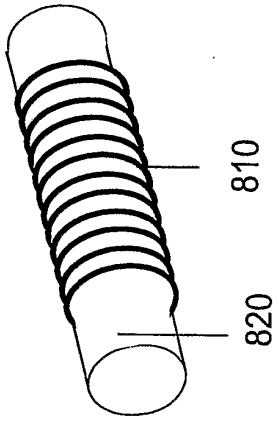


Figure 7b



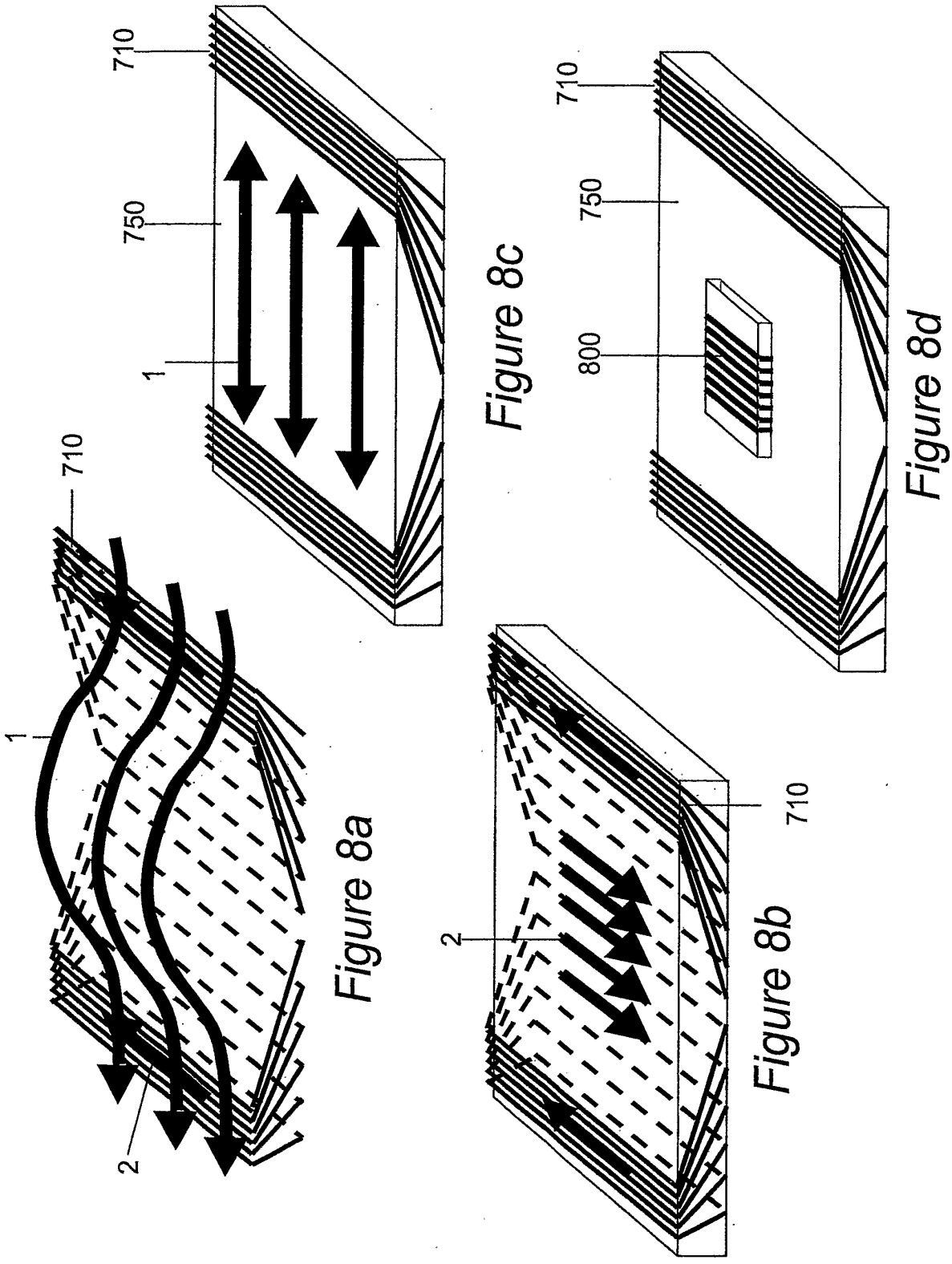


Figure 8a

Figure 8b

Figure 8c

Figure 8d

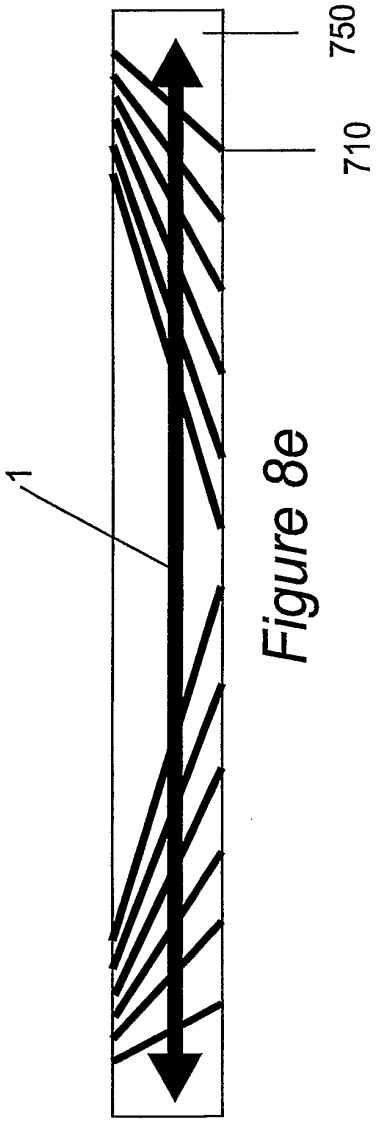


Figure 8e

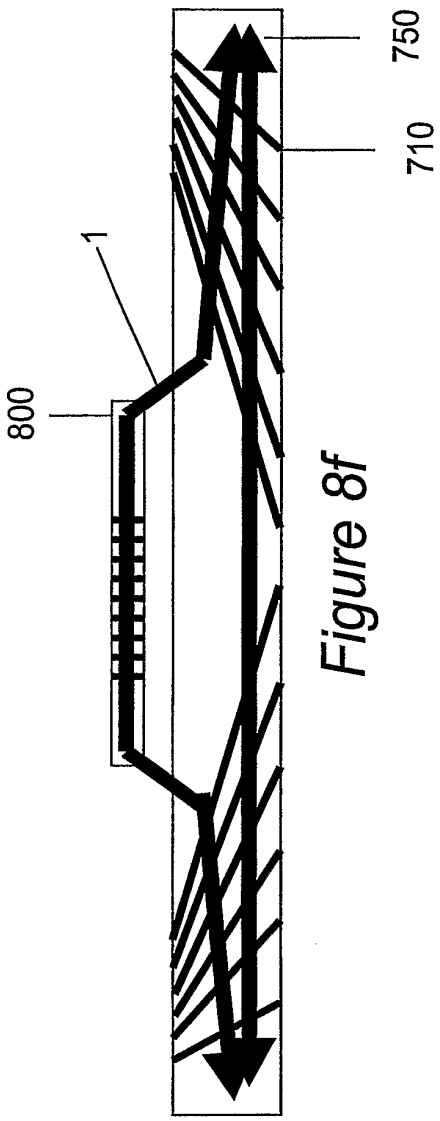


Figure 8f

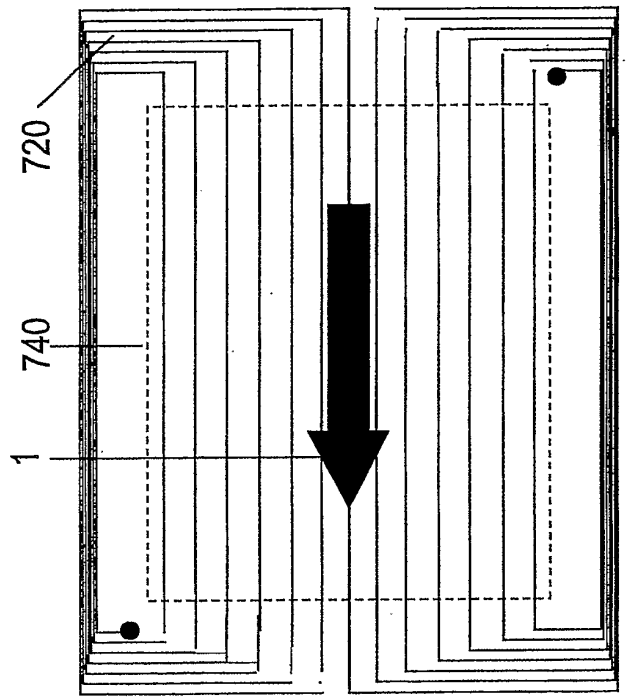


Figure 9b

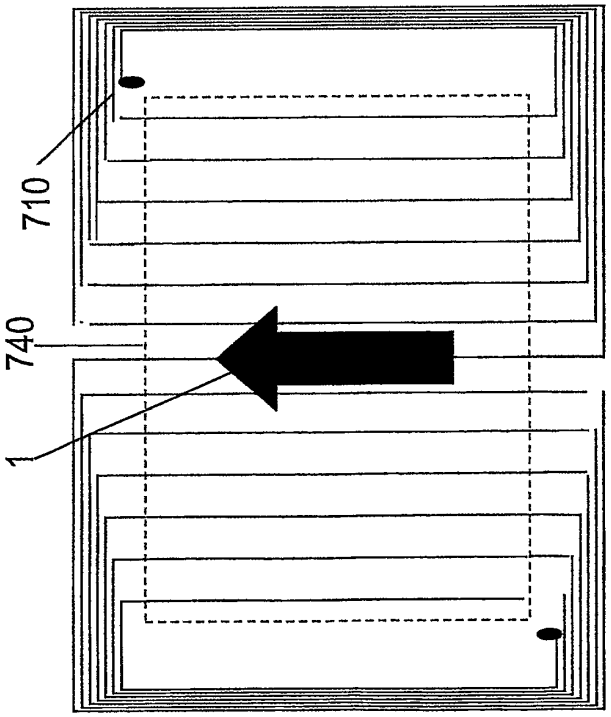


Figure 9a

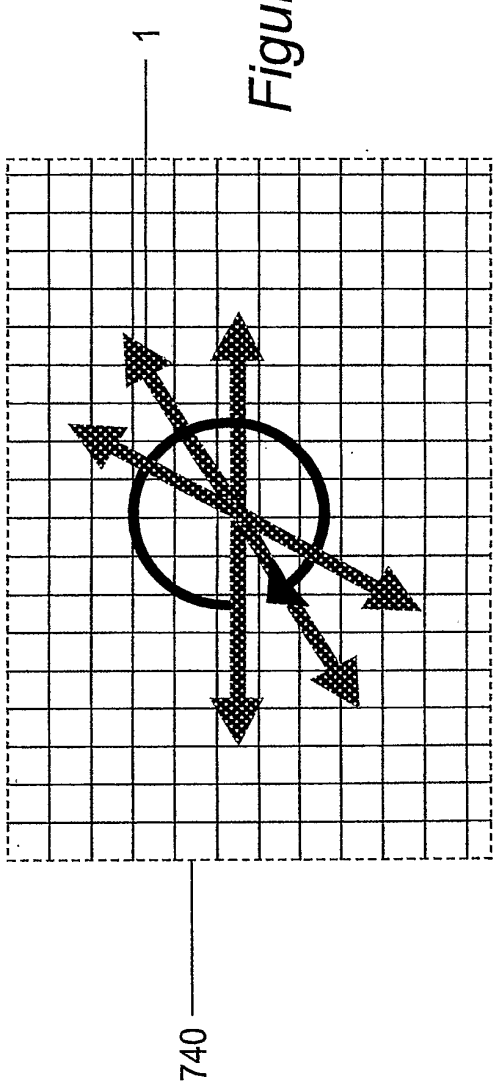


Figure 9c

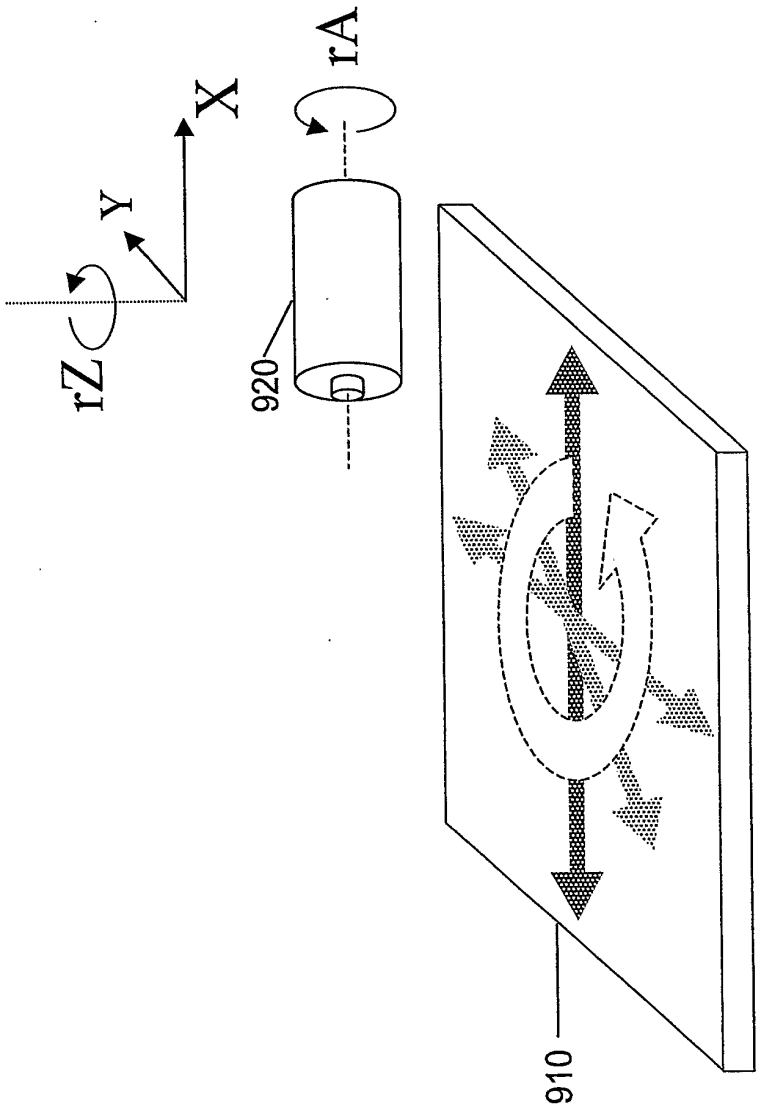


Figure 10

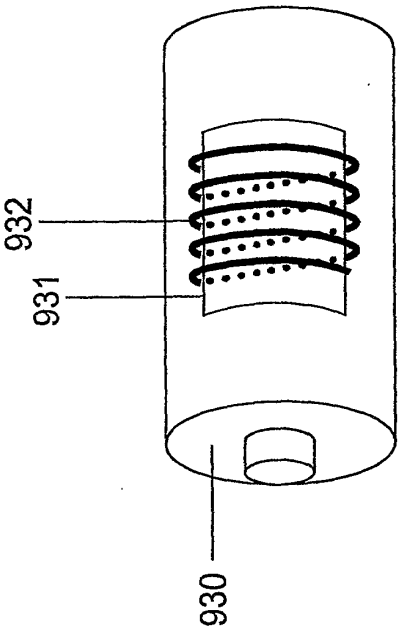


Figure 11b

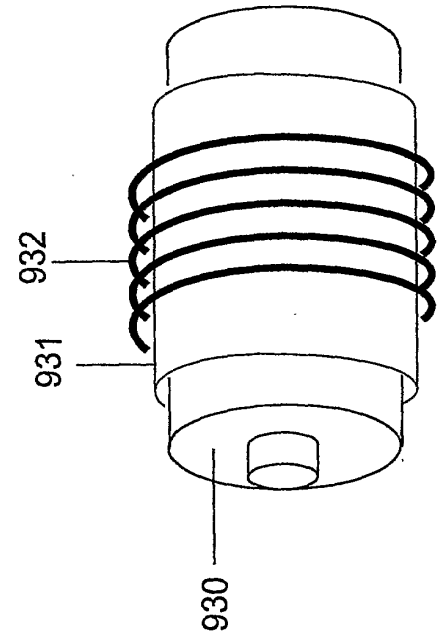


Figure 11a

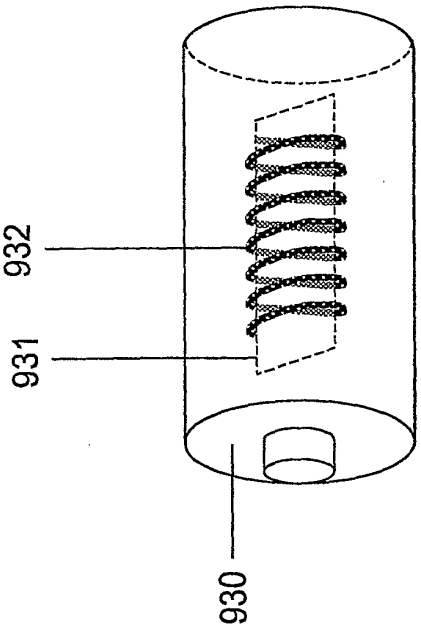


Figure 11c

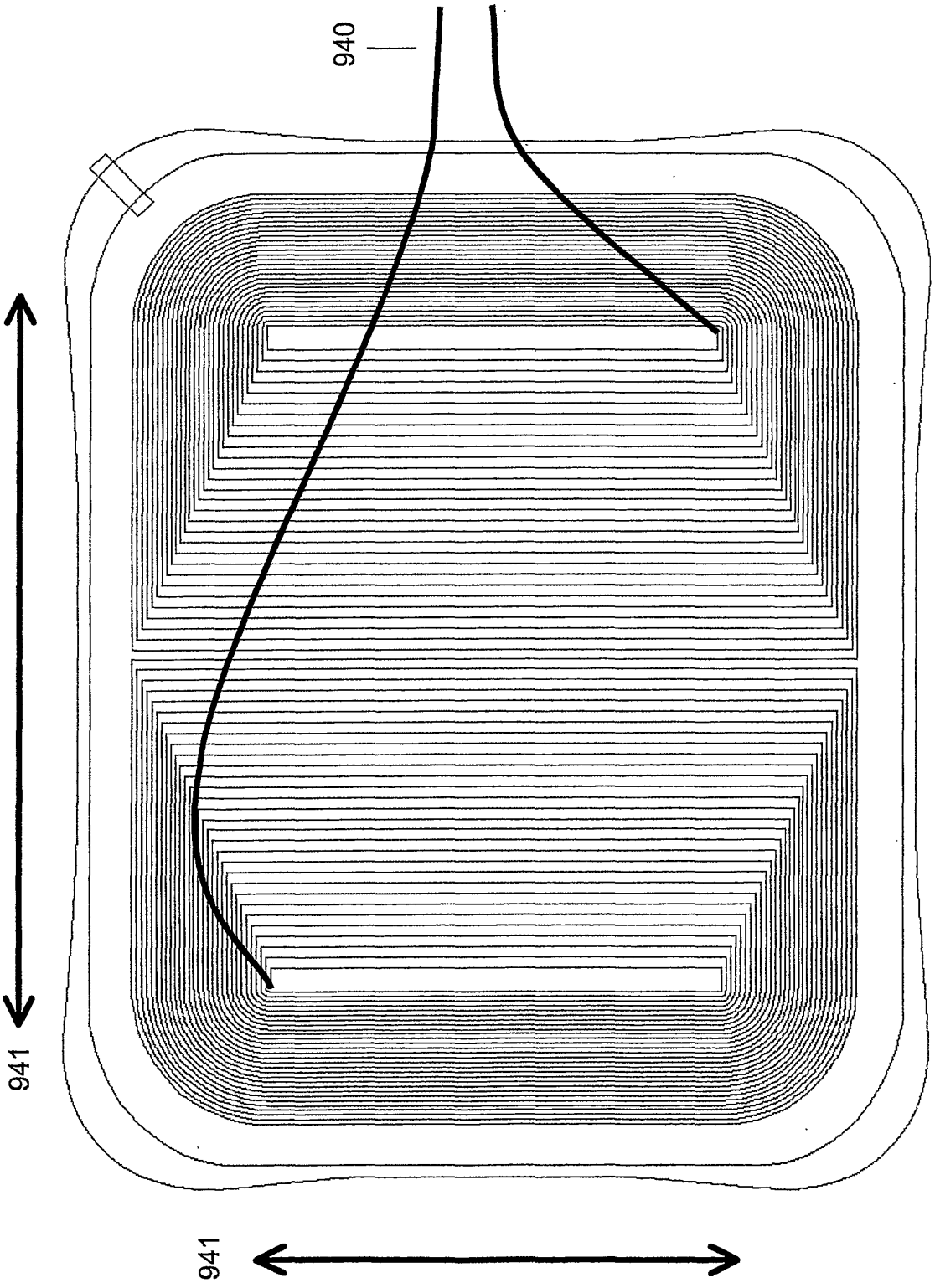


Figure 12a

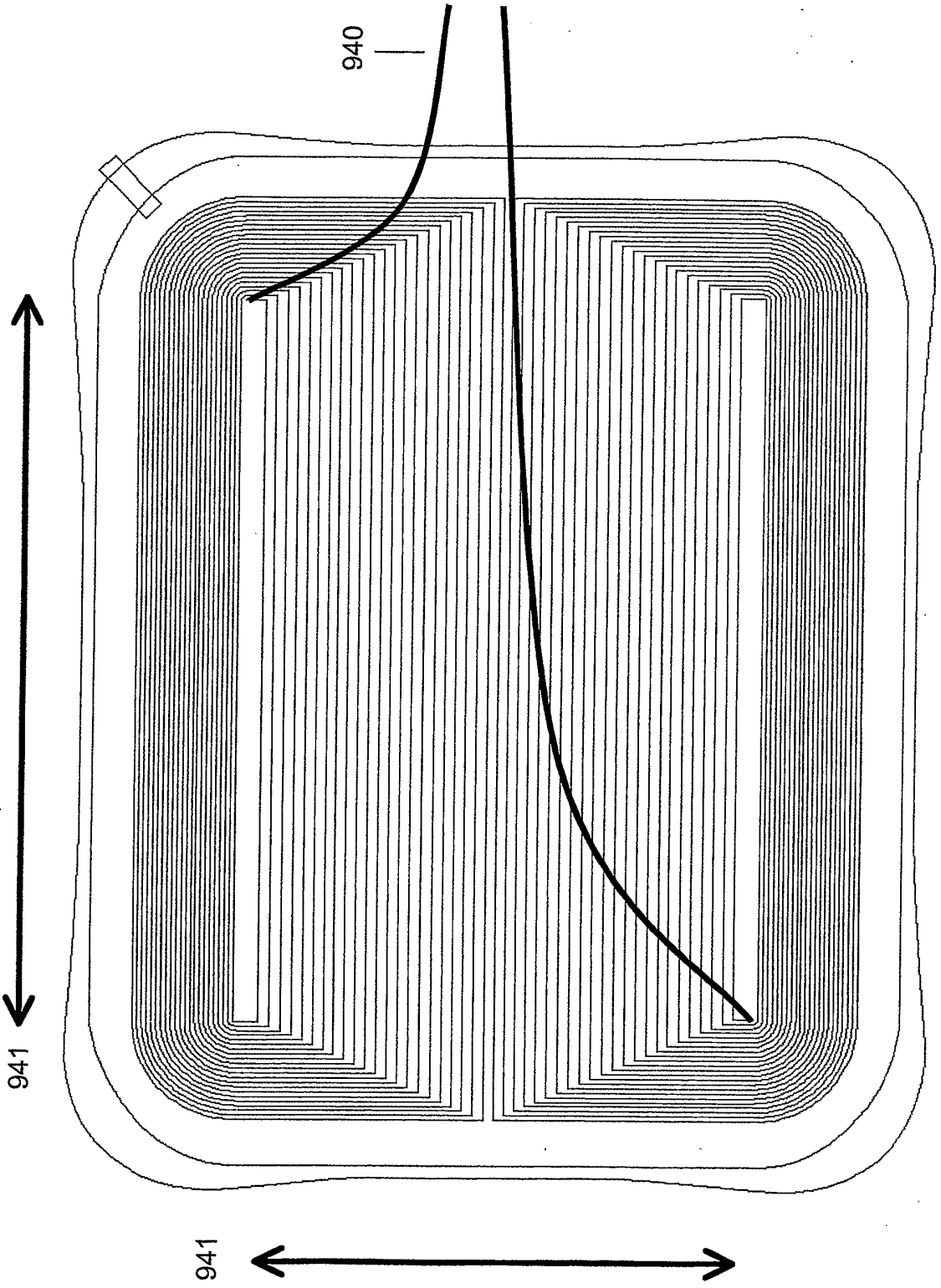
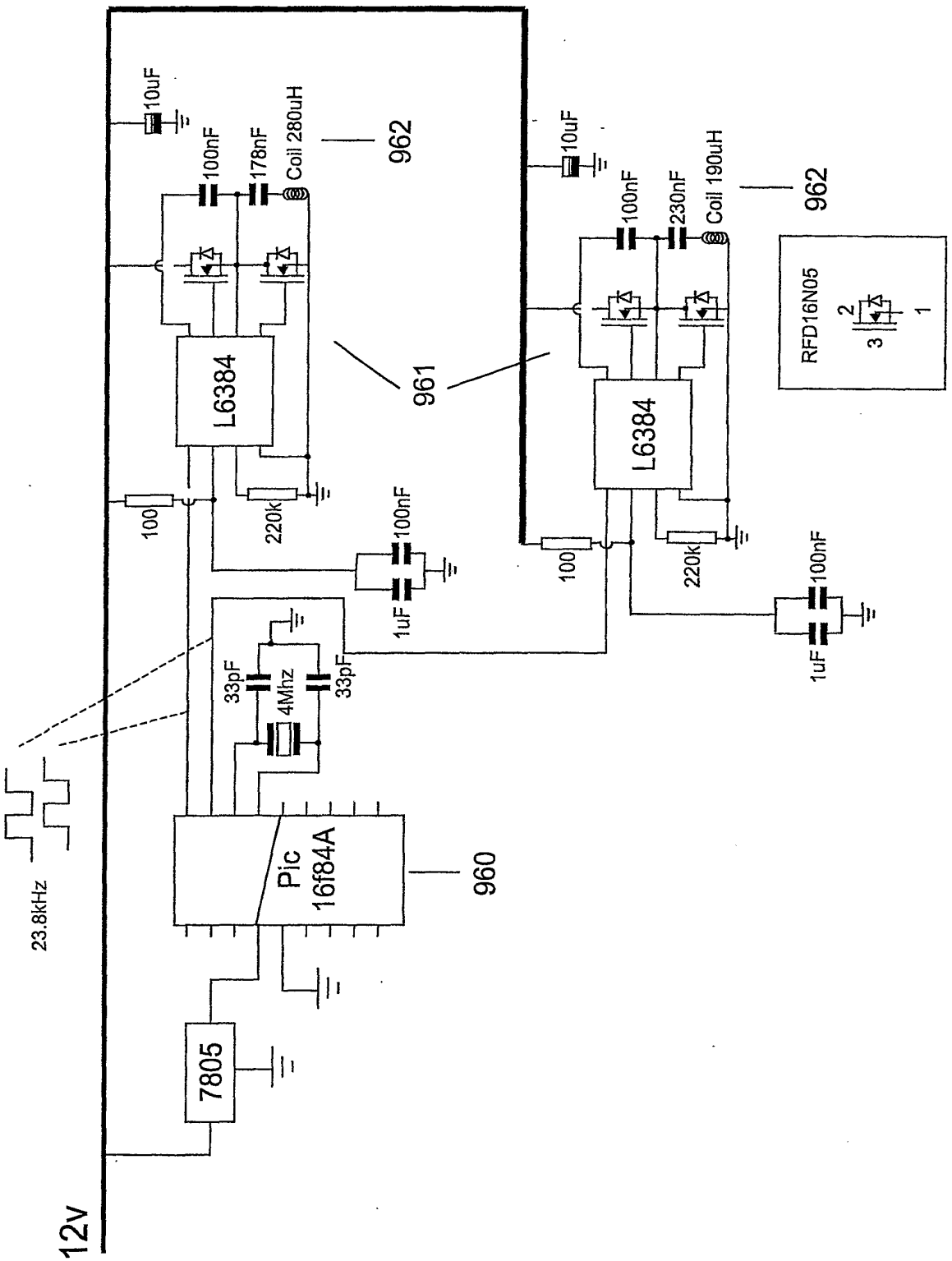


Figure 12b


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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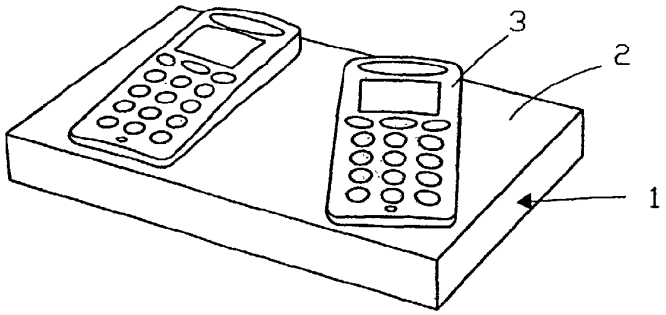
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(54) Title: PLANAR INDUCTIVE BATTERY CHARGER



(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.

WO 03/105308 A1

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.

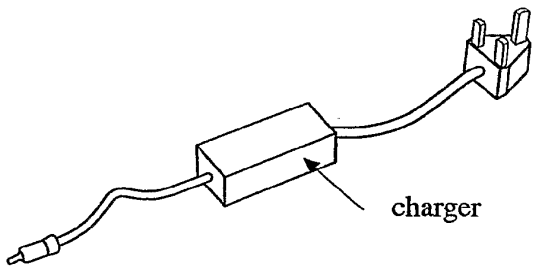


FIG.1 (PRIOR ART)

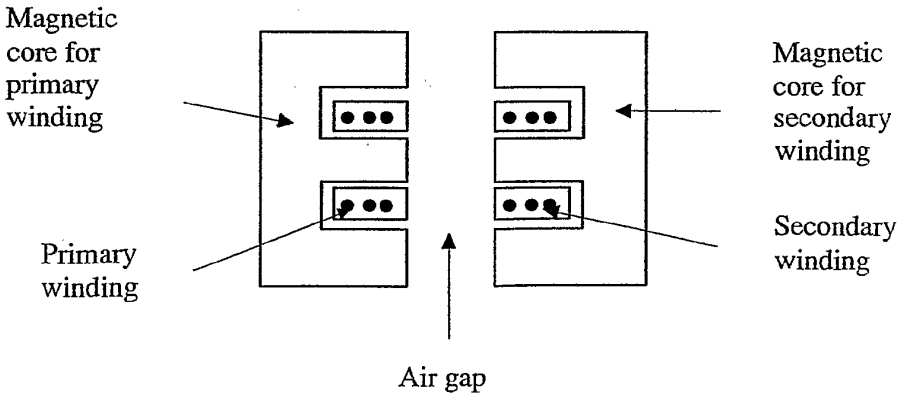


FIG.2 (PRIOR ART)

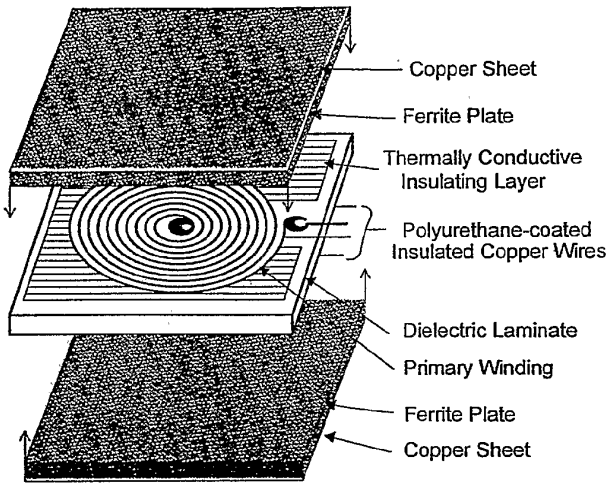


FIG.3 (PRIOR ART)

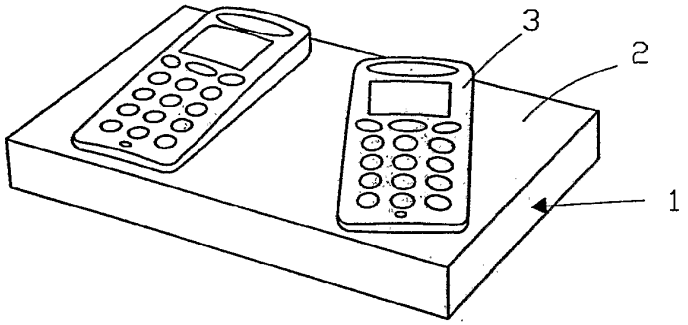


FIG.4(a)

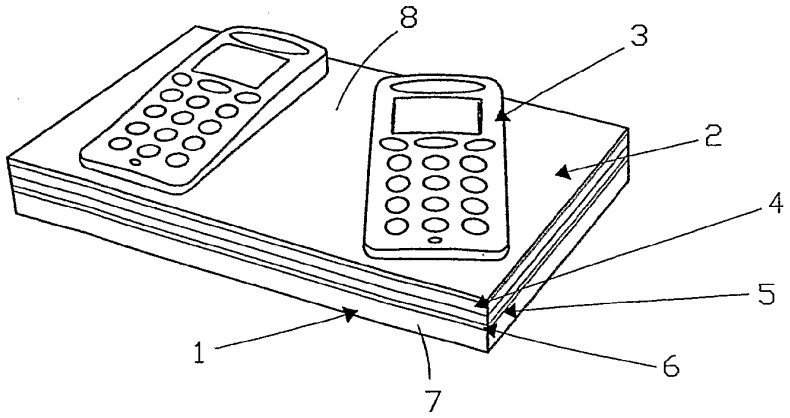


FIG.4(b)

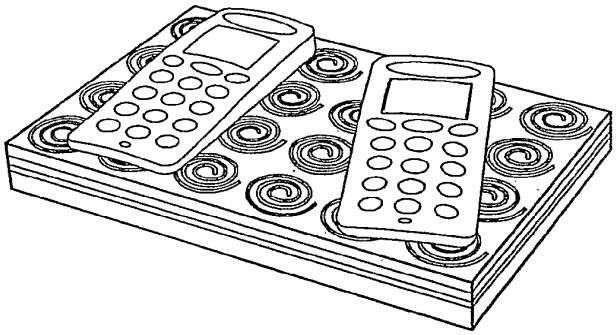


FIG.4(c)

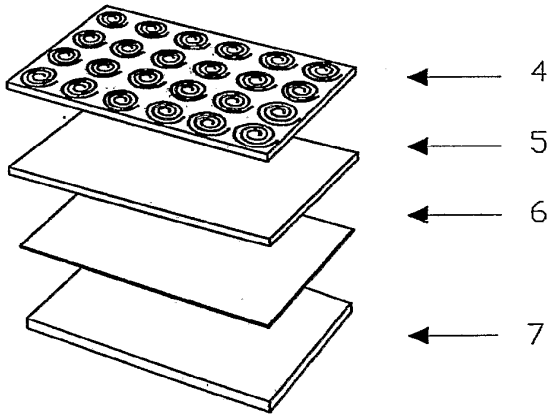


FIG.5(a)

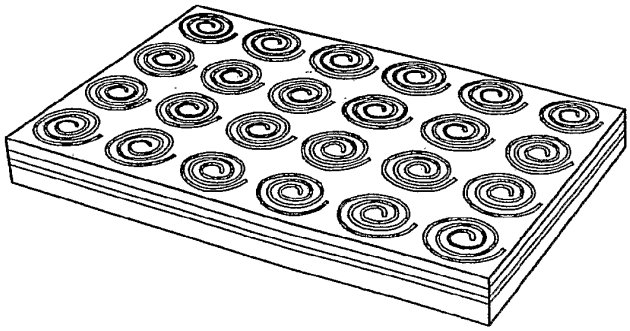


FIG.5(b)

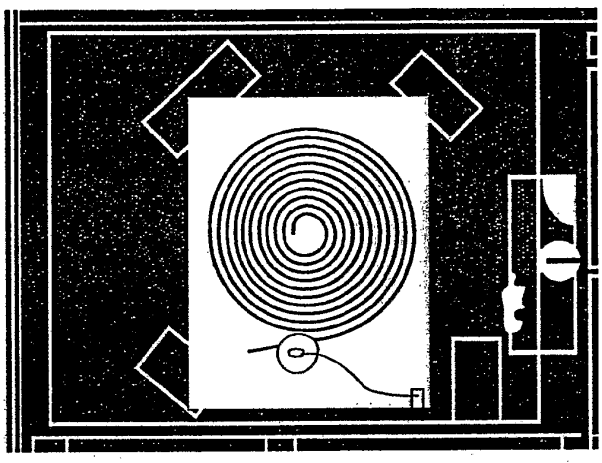


FIG.6(a)

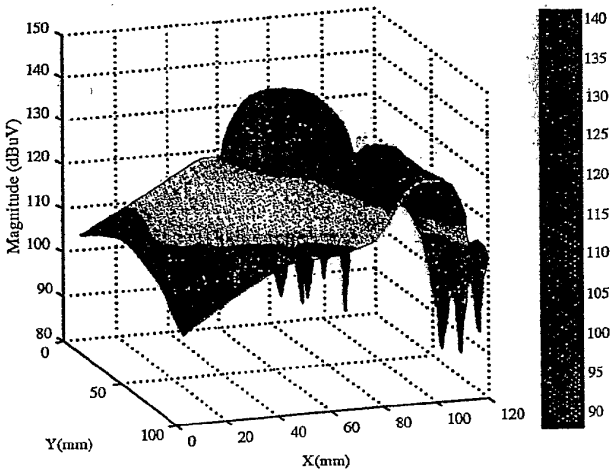

Magnitude (dBuV)
150
140
130
120
110
100
90
80
0
50
100
Y(mm)
0
20
40
60
80
100
120
X(mm)
140
135
130
125
120
115
110
105
100
95
90

FIG.6(b)

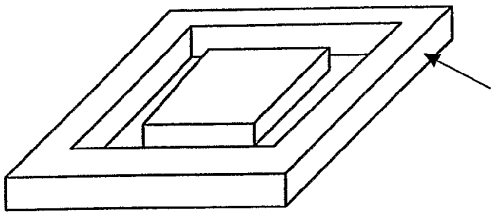


FIG.7(a)

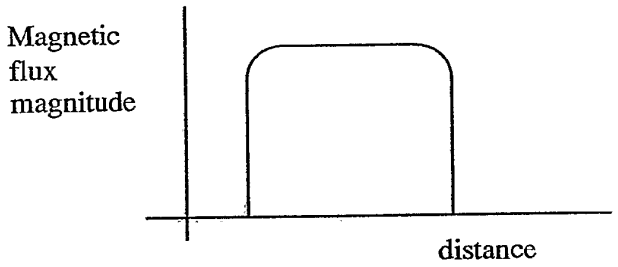


FIG.7(b)

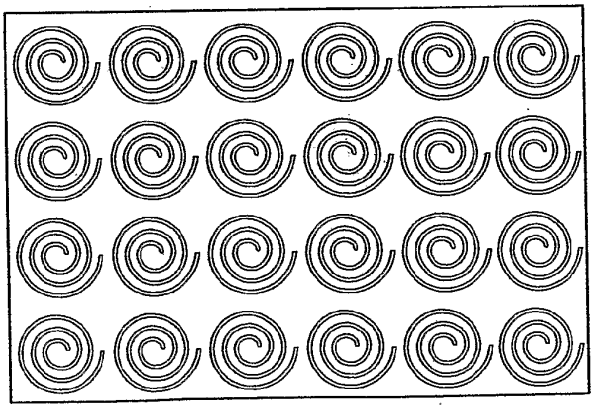


FIG.8

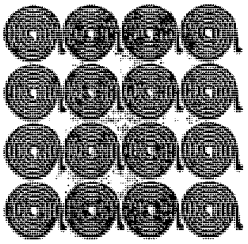


FIG.9(a)

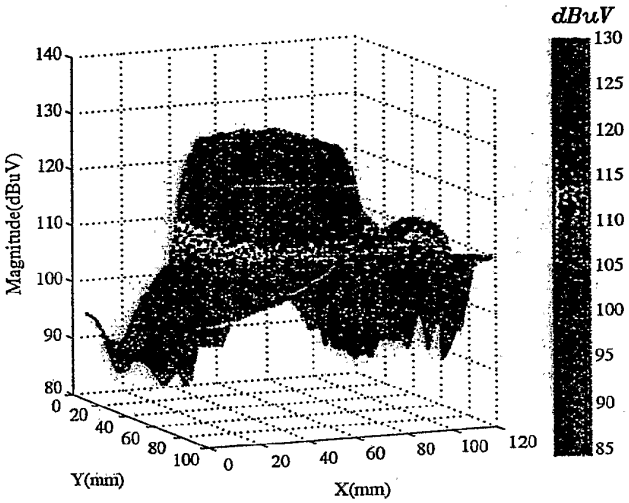

dBuV
130
125
120
115
110
105
100
95
90
85
Magnitude(dBuV)
140
130
120
110
100
90
80
0
20
40
60
80
100
Y(mm)
0
20
40
60
80
100
120
X(mm)

FIG.9(b)

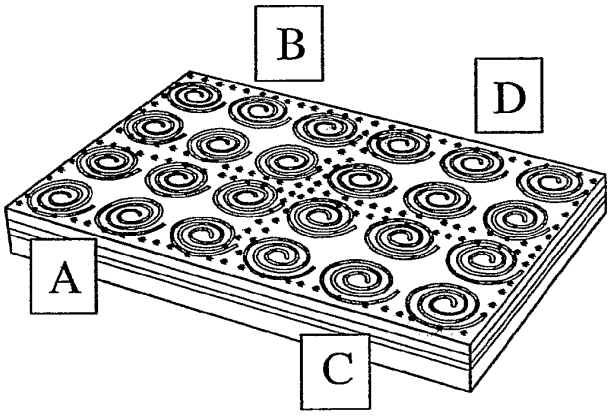


FIG.10(a)

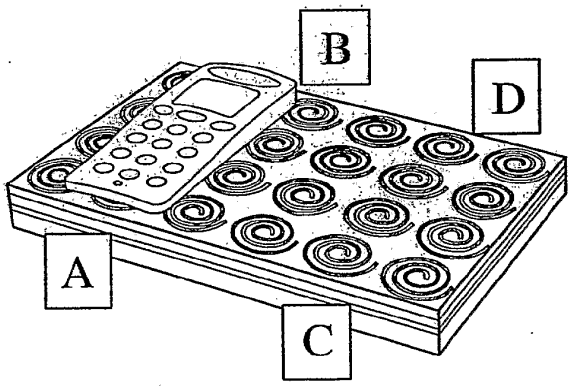


FIG.10(b)

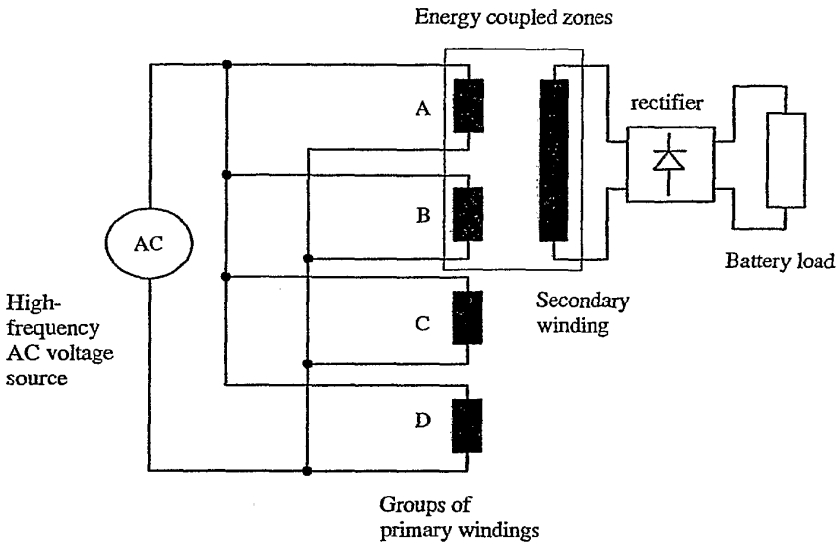


FIG.10(c)

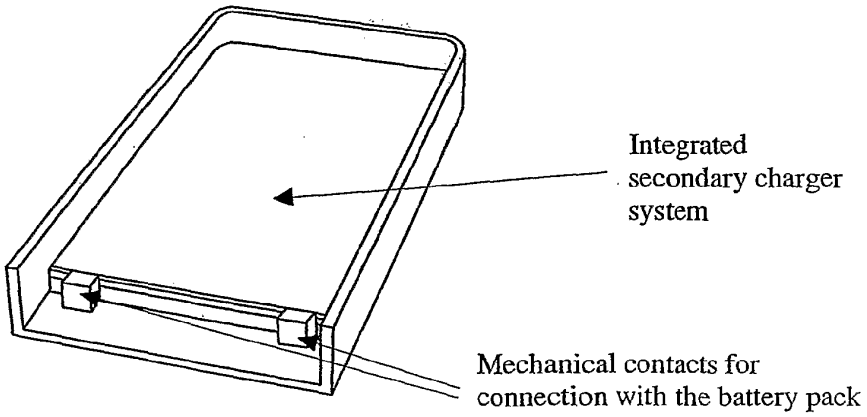


FIG.11

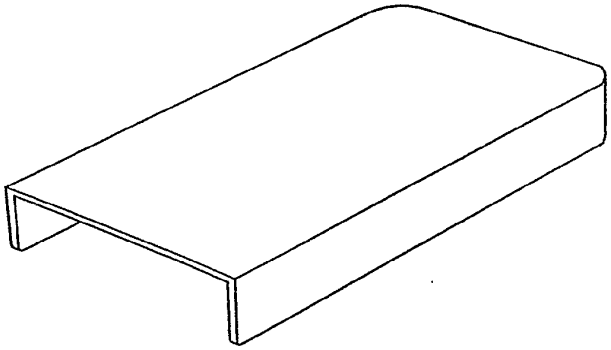


FIG.12(a)

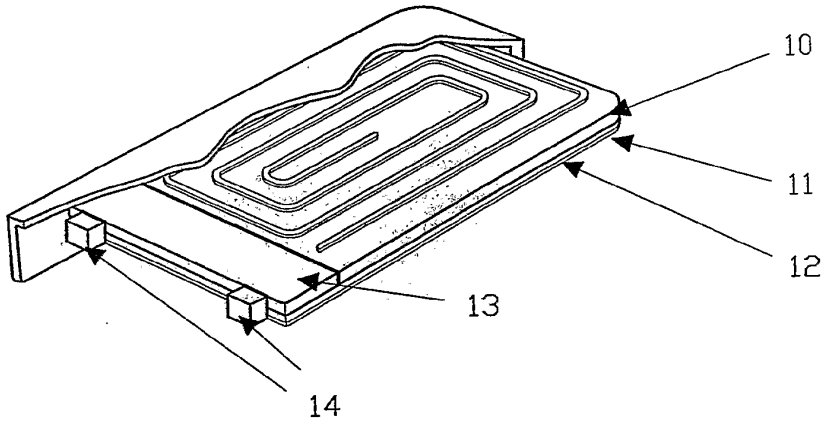


FIG.12(b)

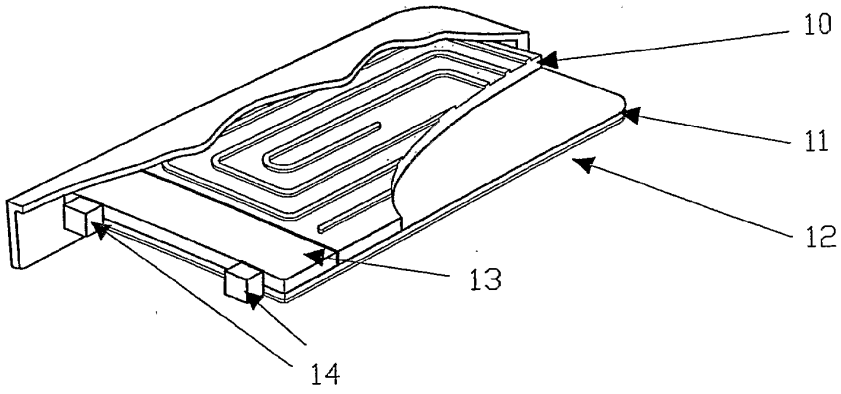


FIG.12(c)

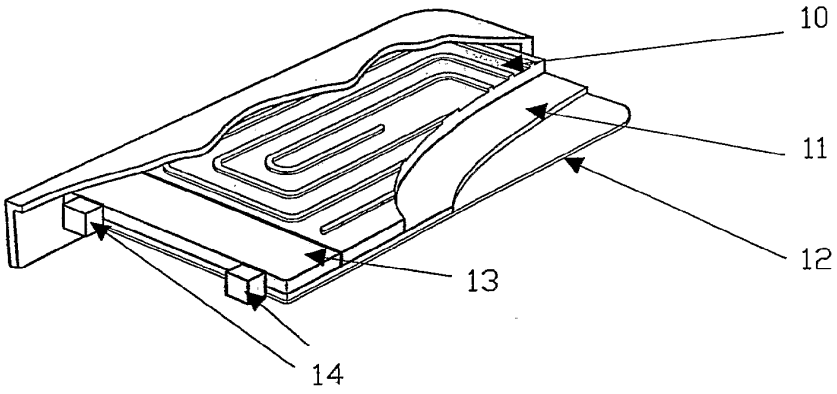


FIG.12(d)

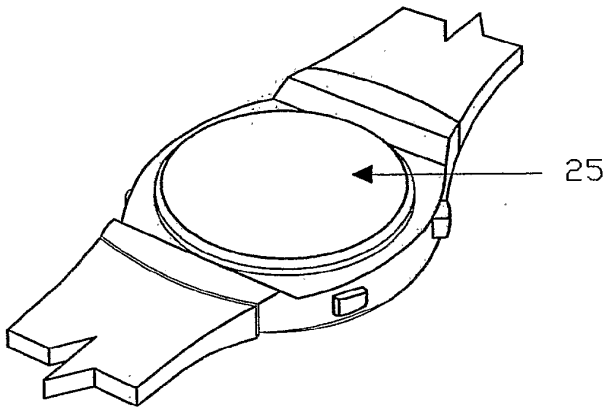


FIG.13(a)

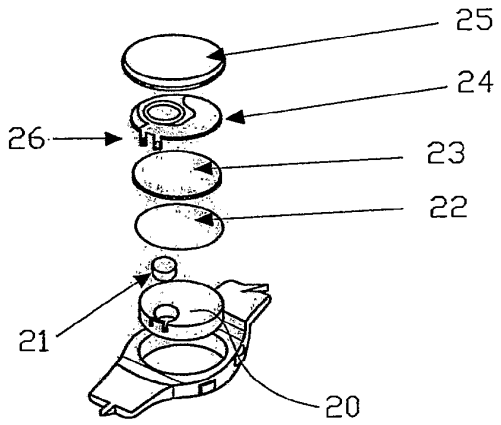


FIG.13(b)

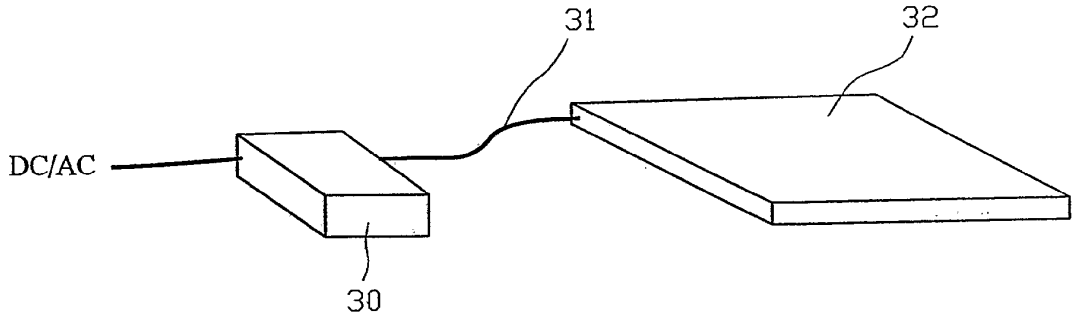


FIG.14

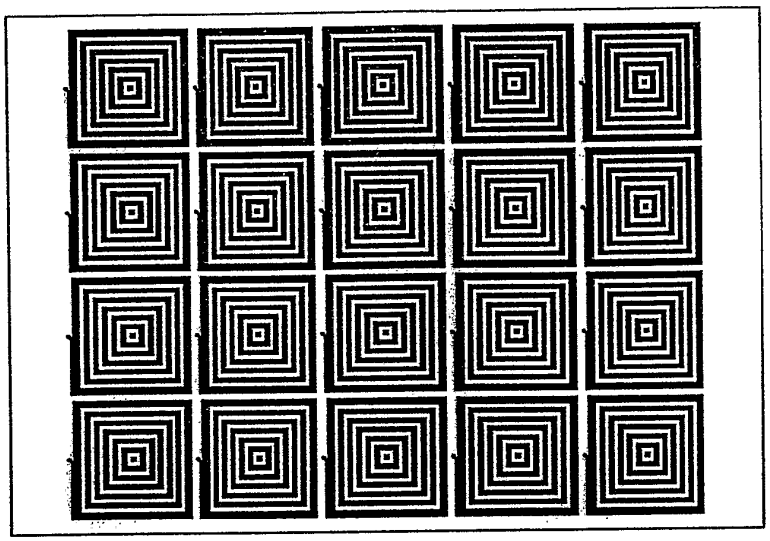


FIG.15

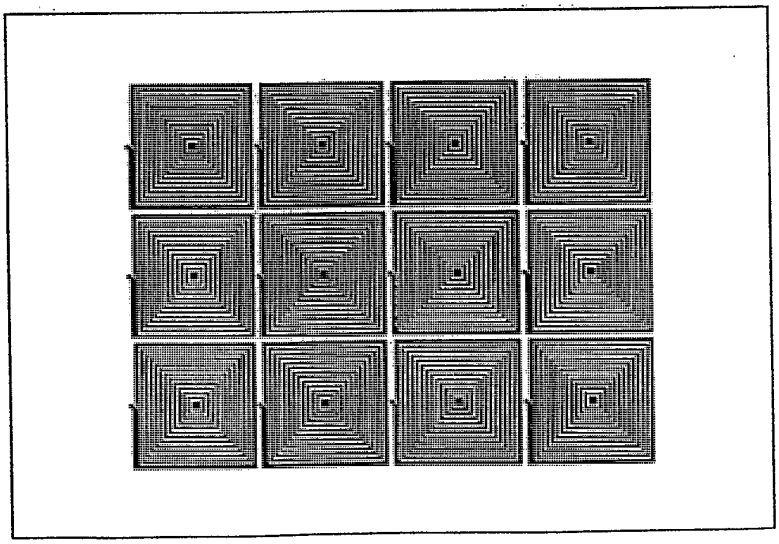


FIG.16

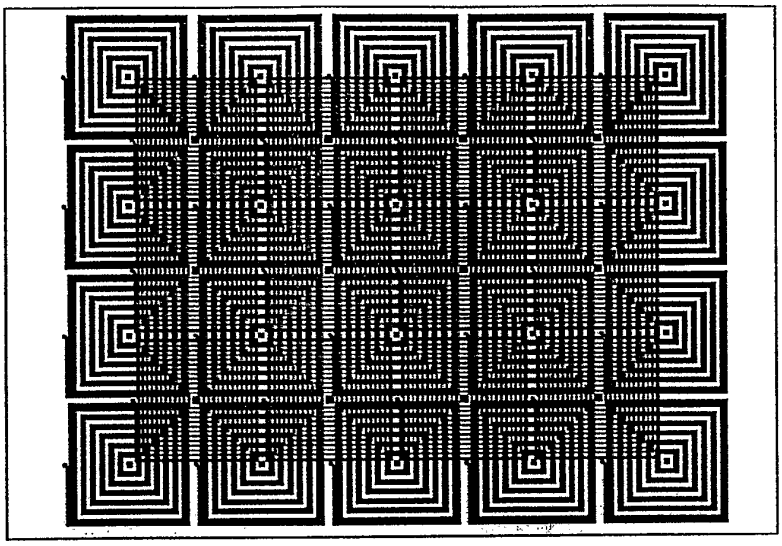


FIG.17

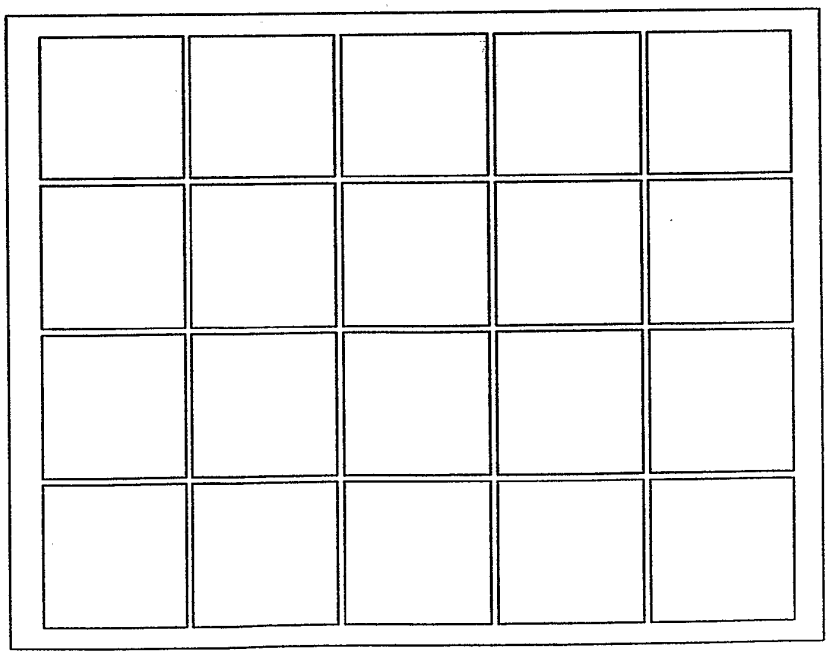


FIG.18

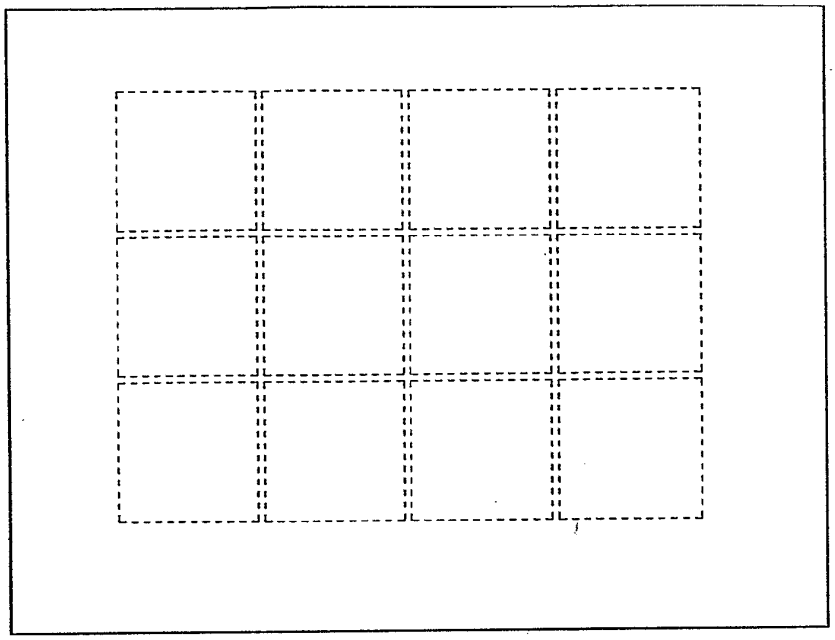
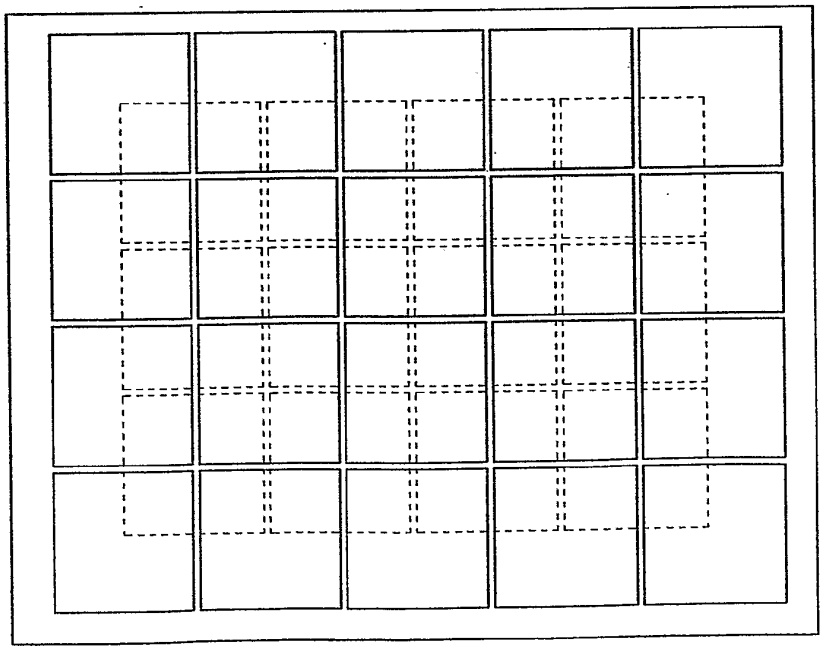


FIG.19



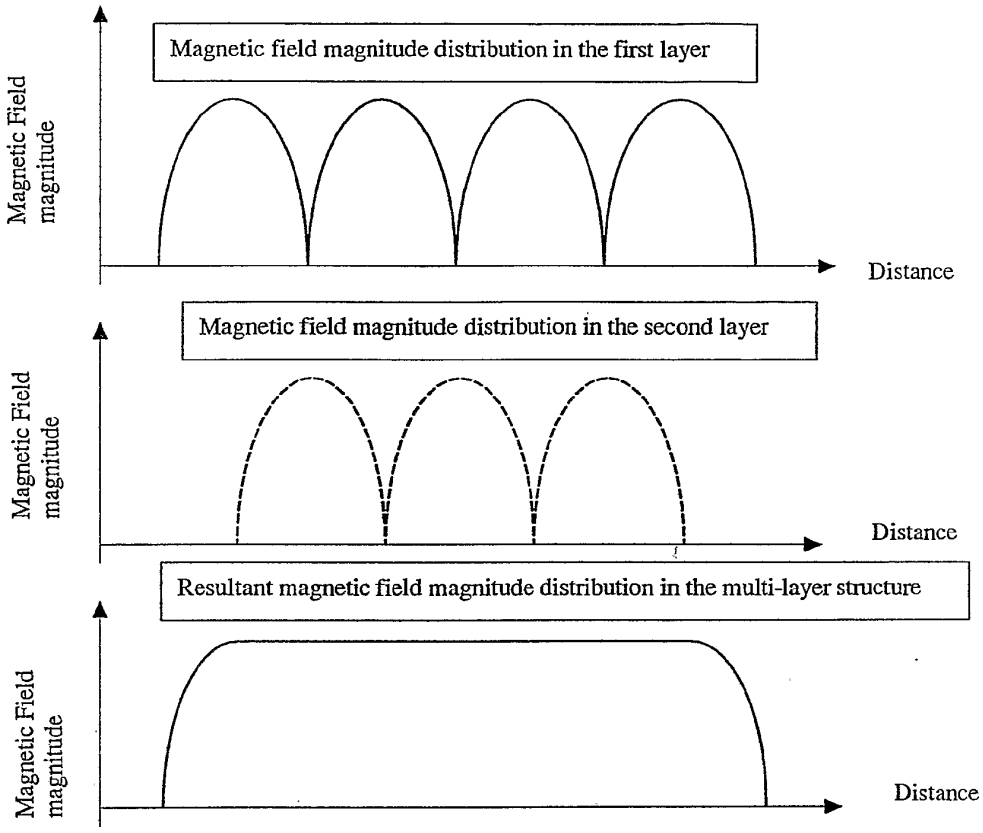


FIG.21

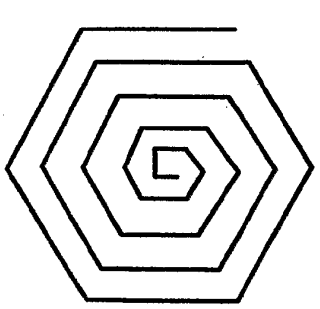


FIG.22

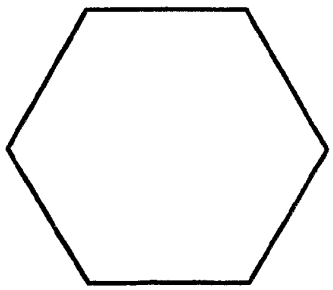


FIG.23

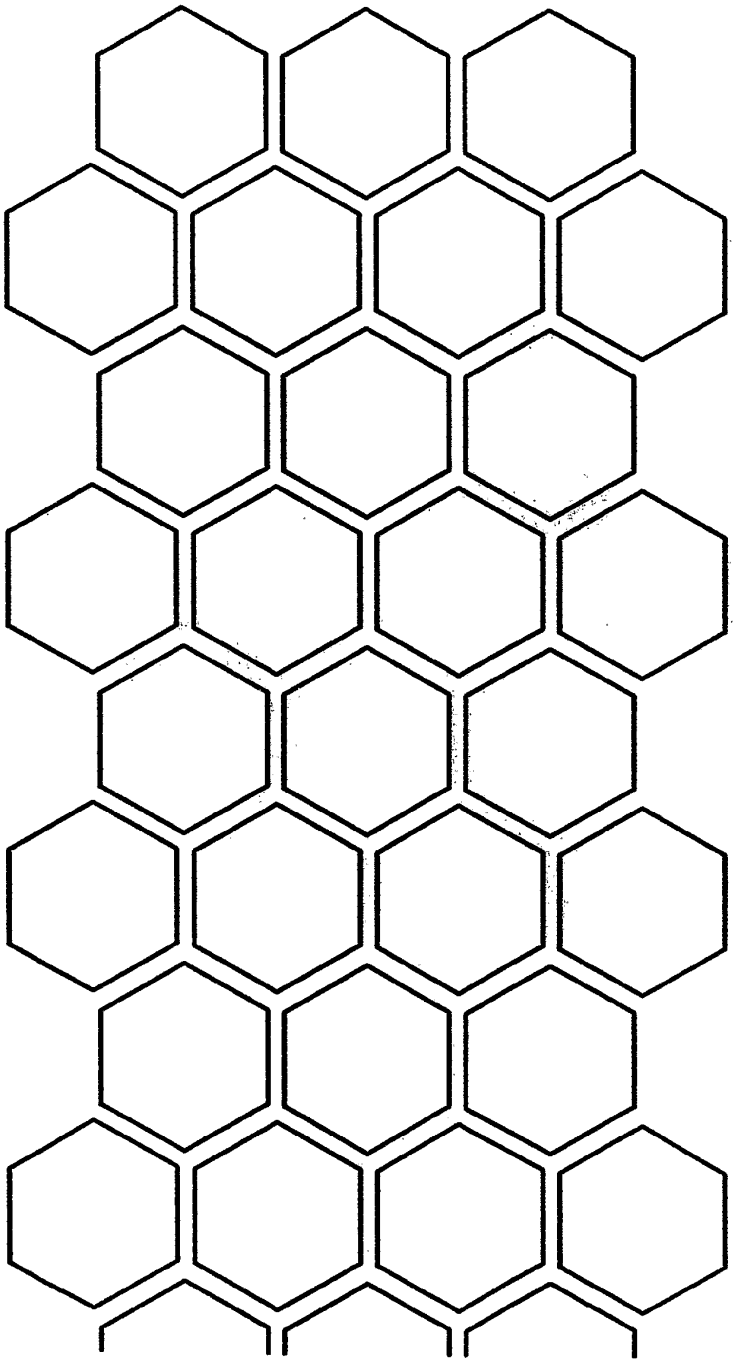


FIG.24

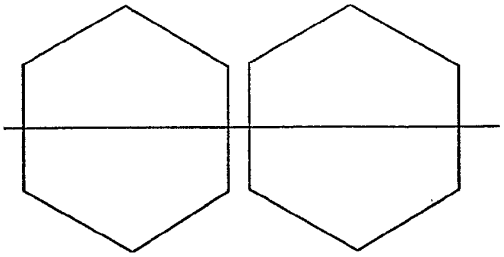


FIG.25

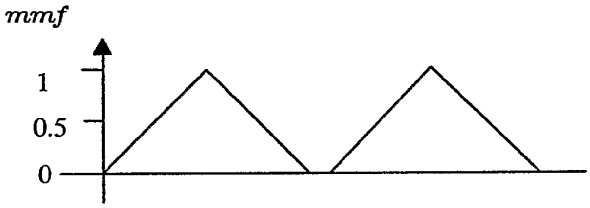


FIG.26

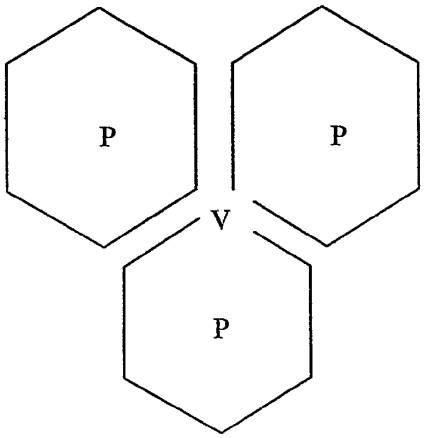


FIG.27

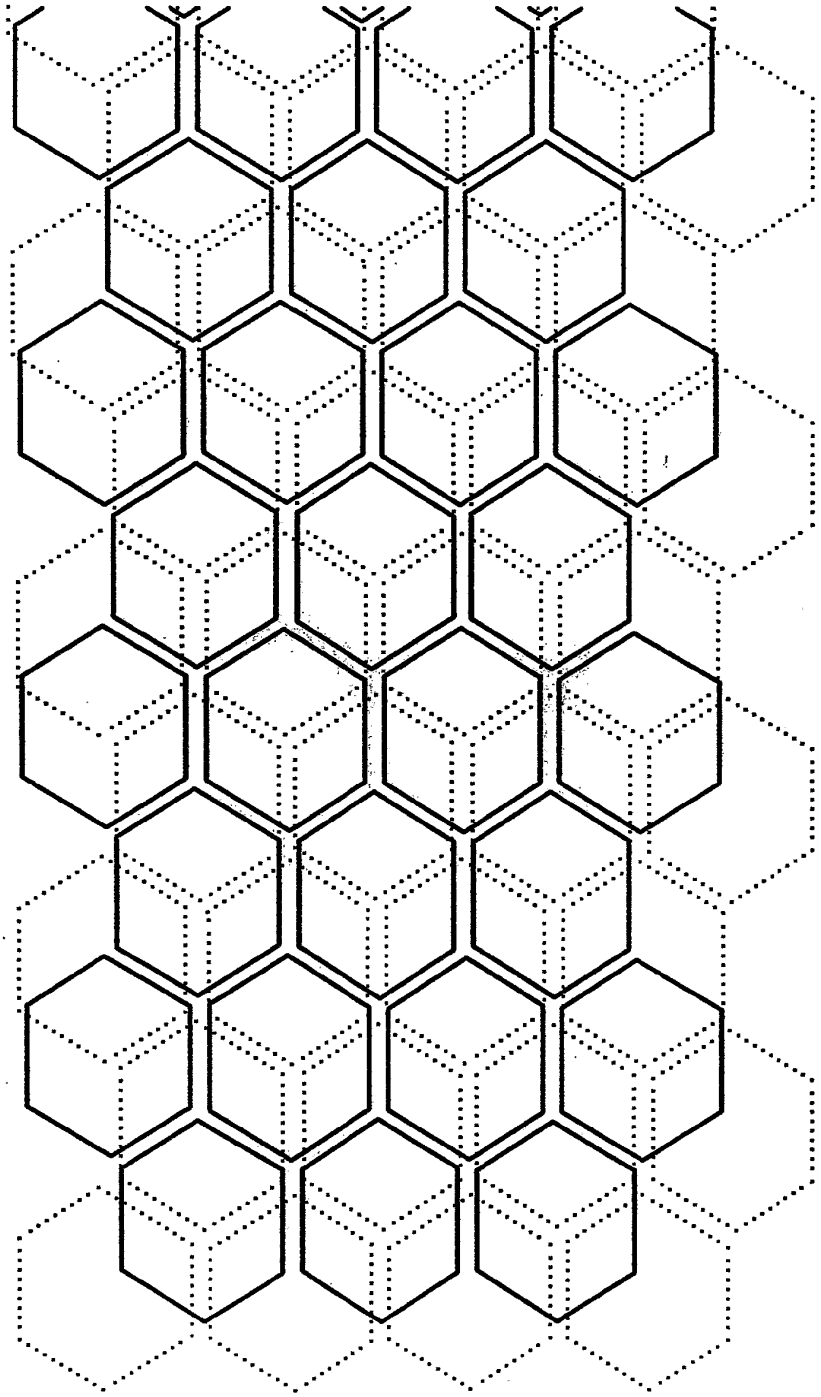


FIG.28

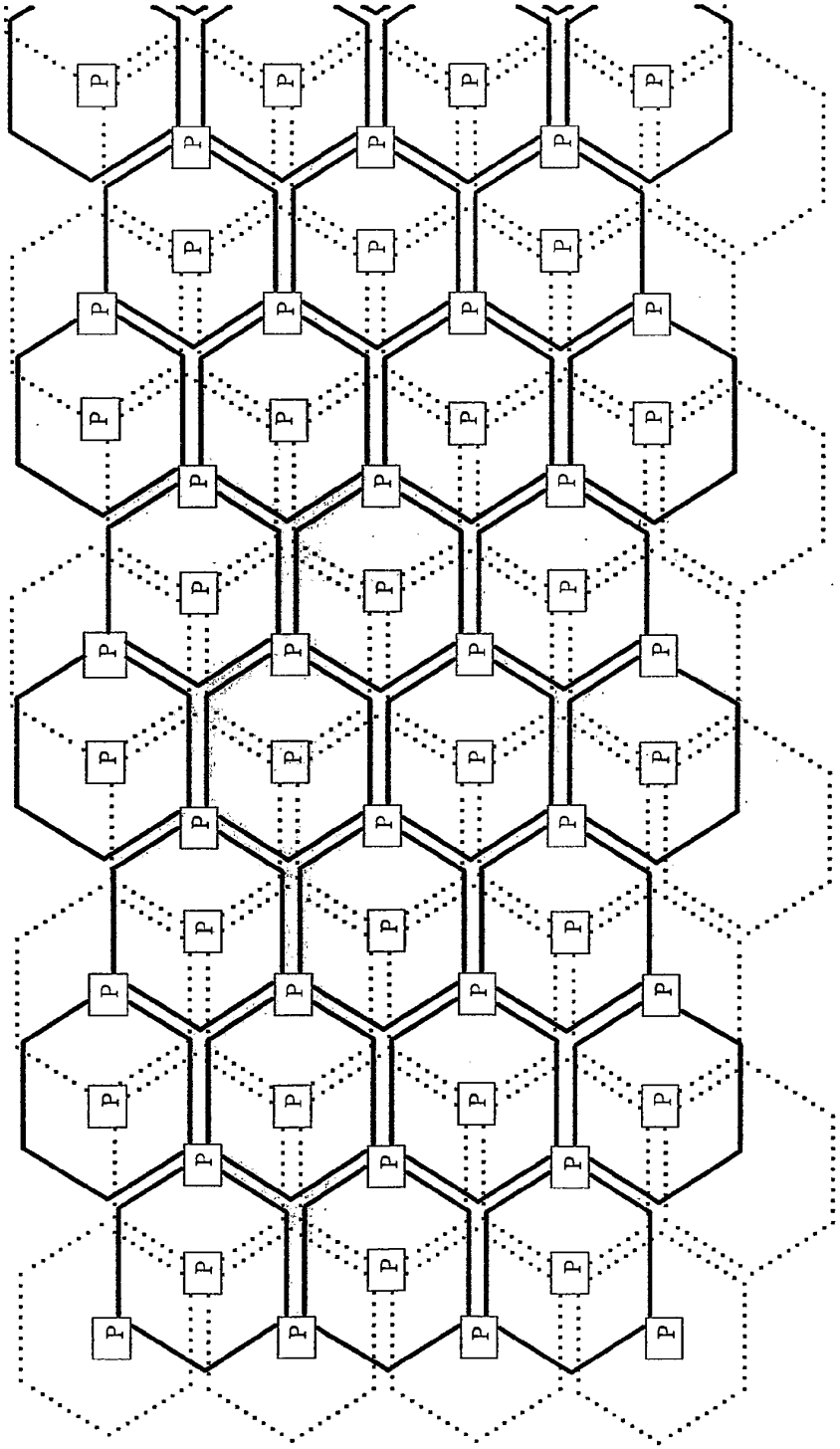


FIG.29

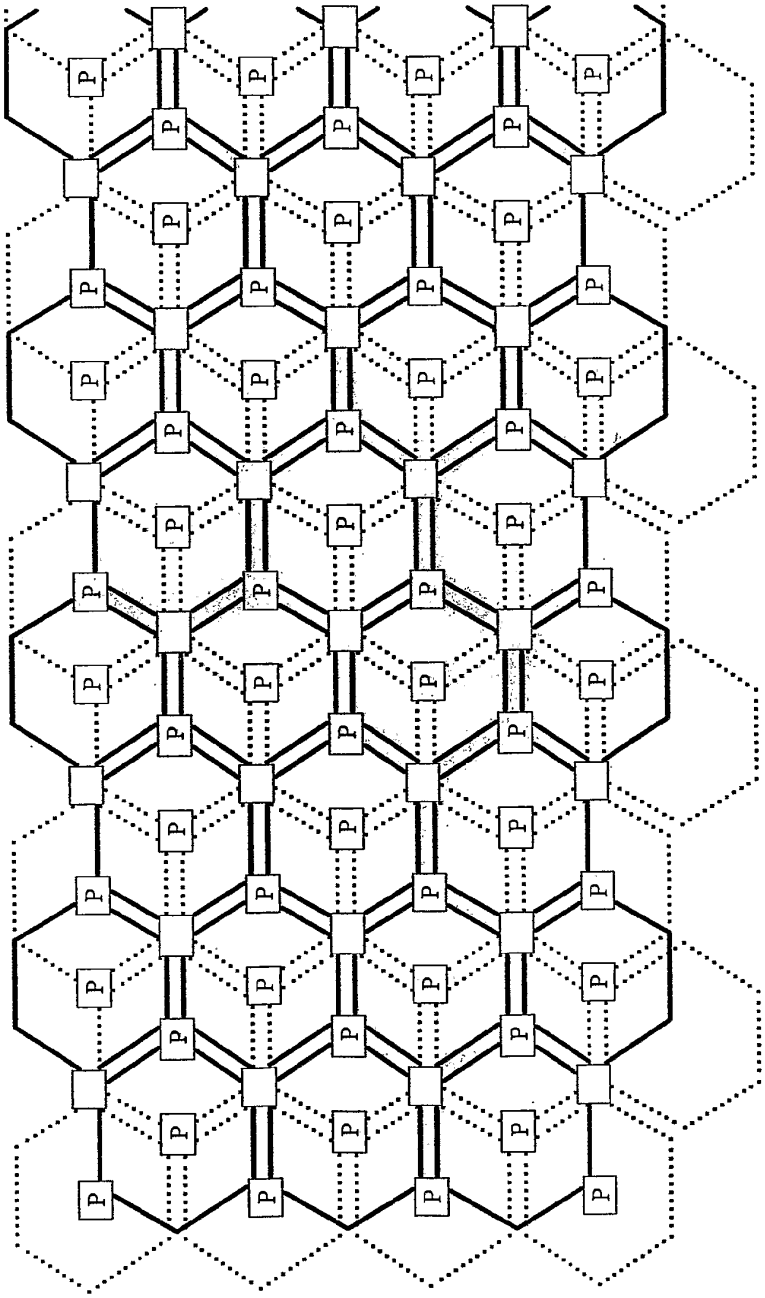


FIG.30

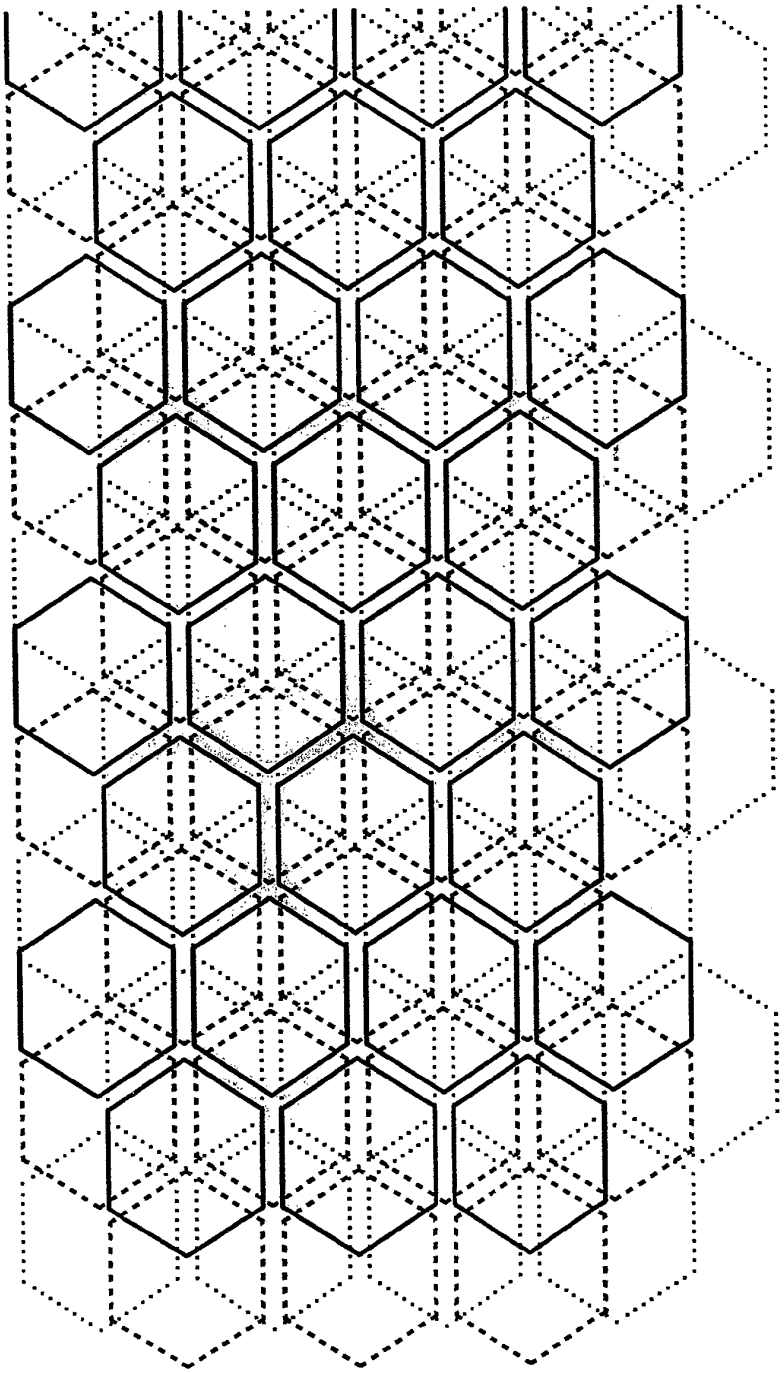


FIG.31

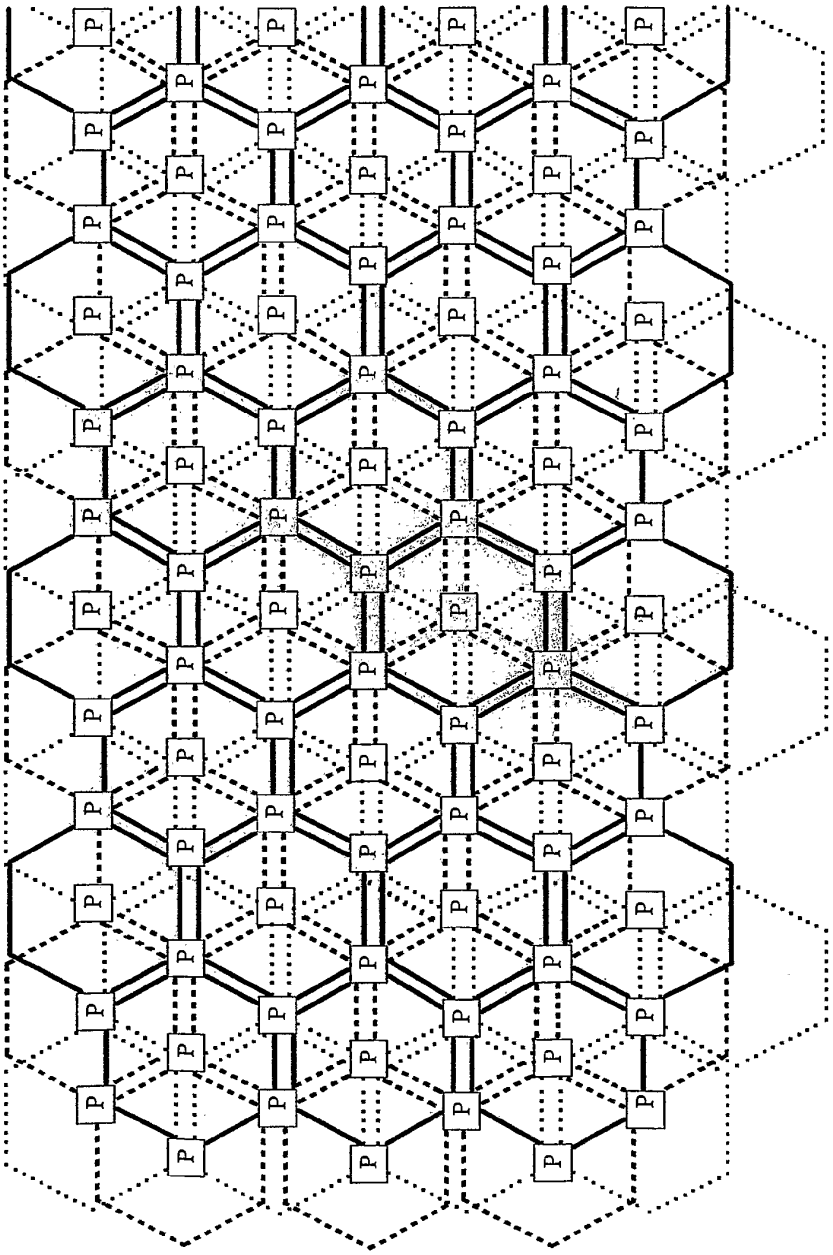


FIG.32

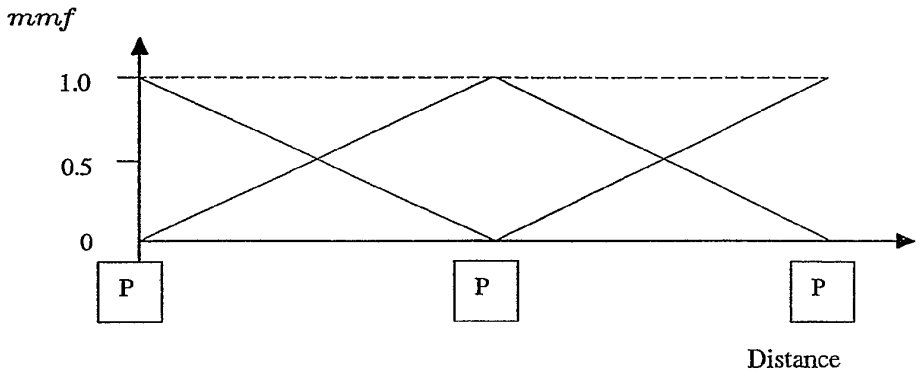


FIG.33

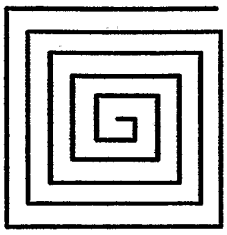


FIG.34

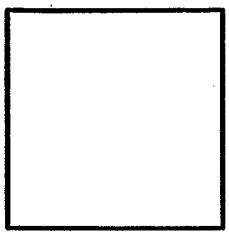


FIG.35

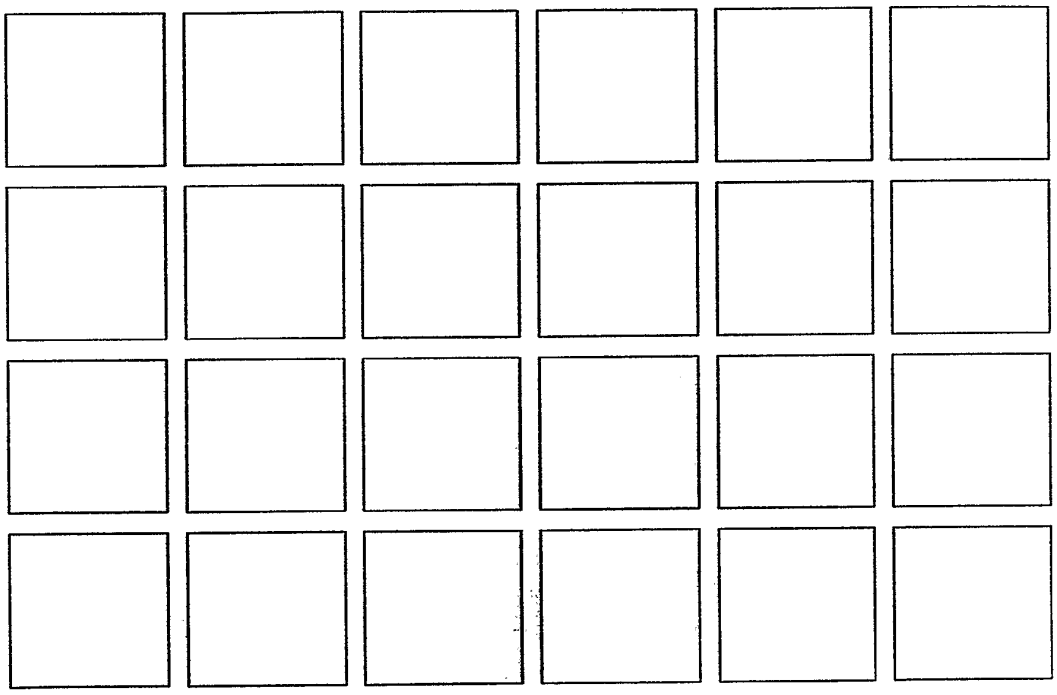


FIG.36

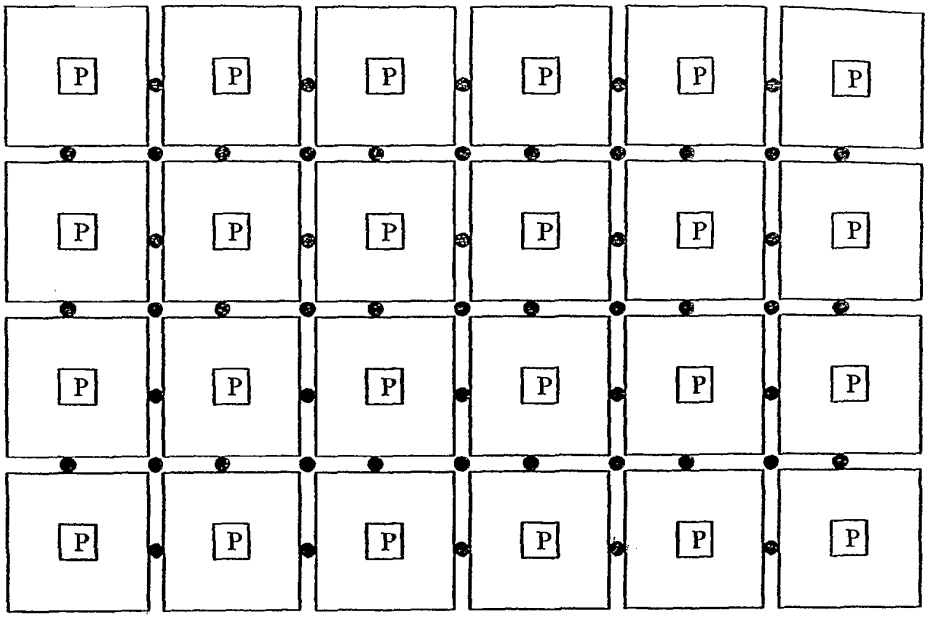


FIG.37

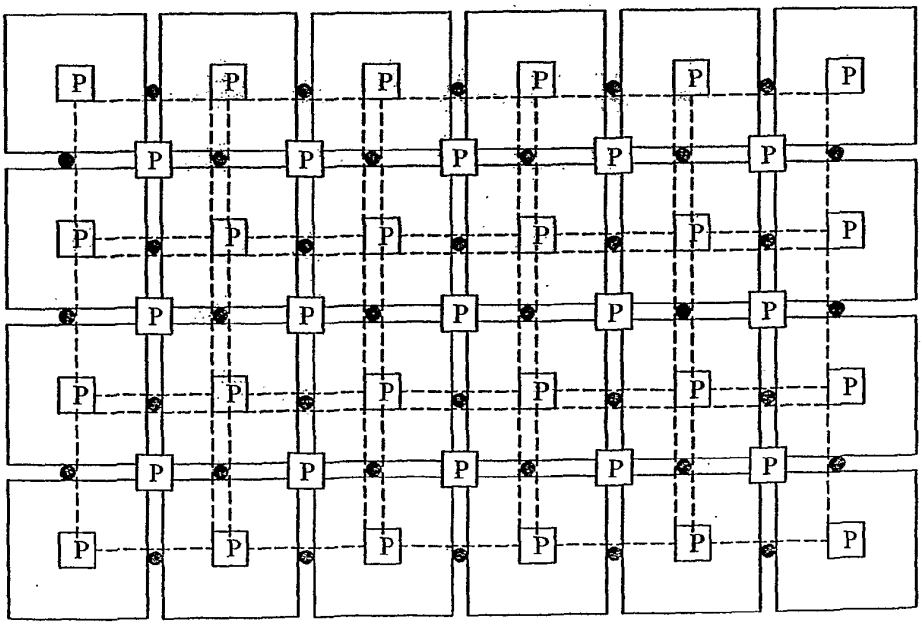


FIG.38

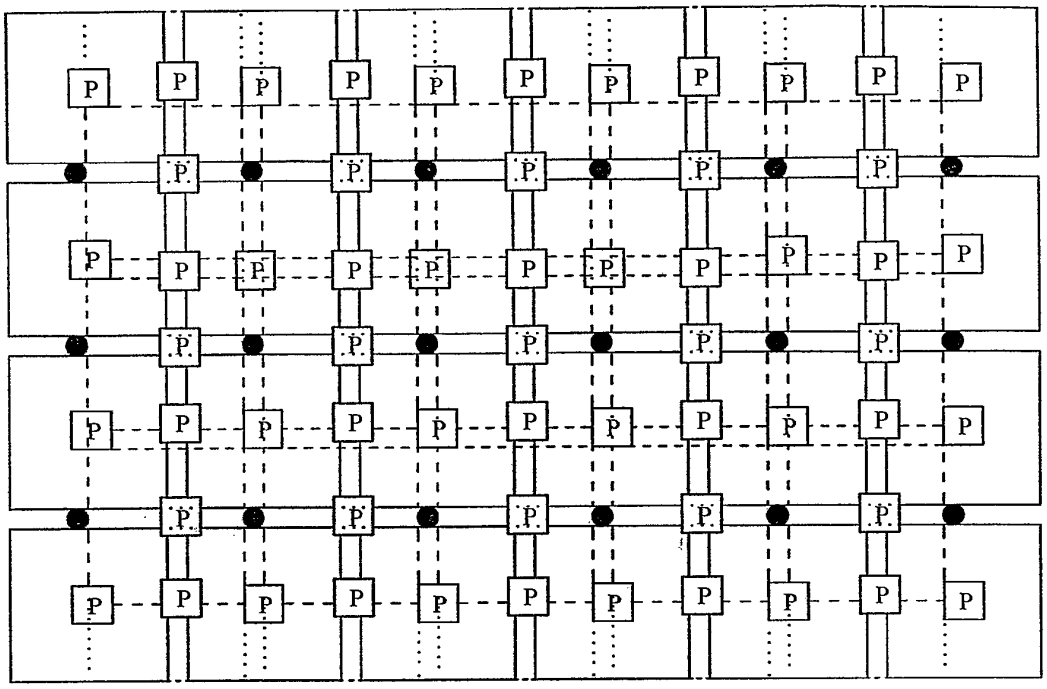


FIG.39

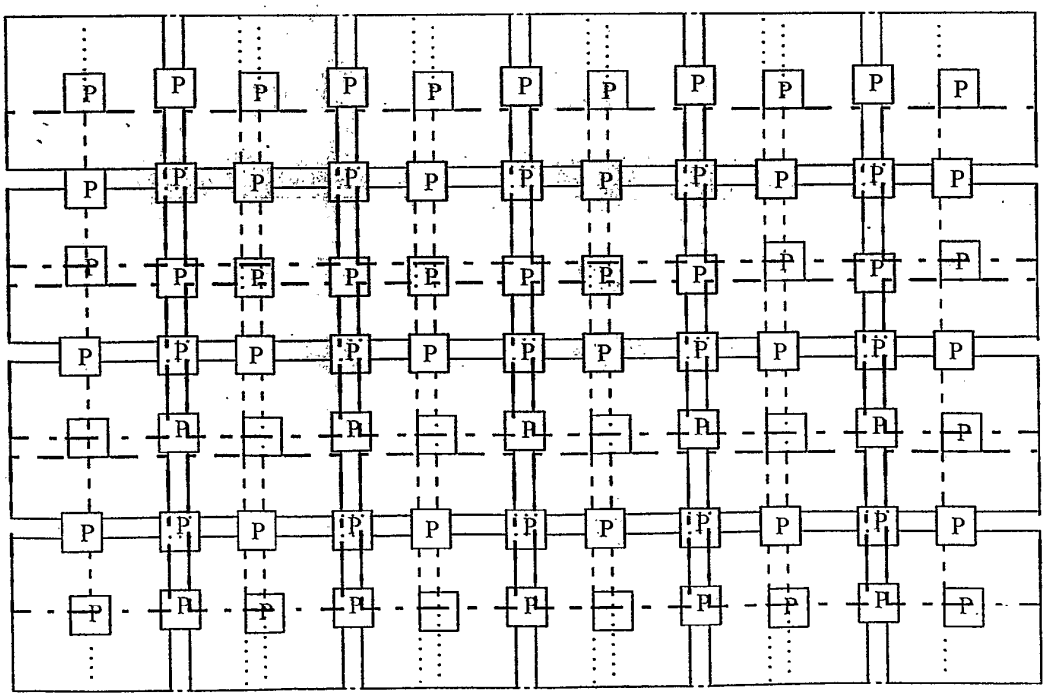


FIG.40

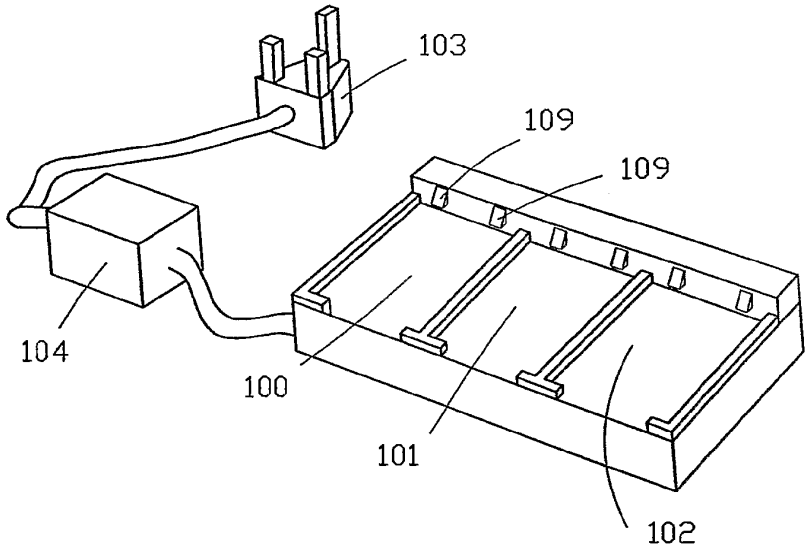


FIG.41

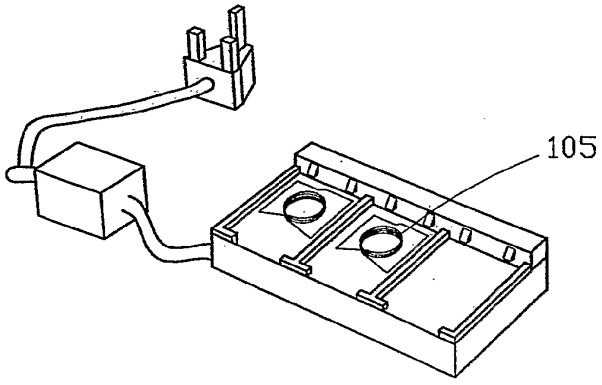


FIG.42

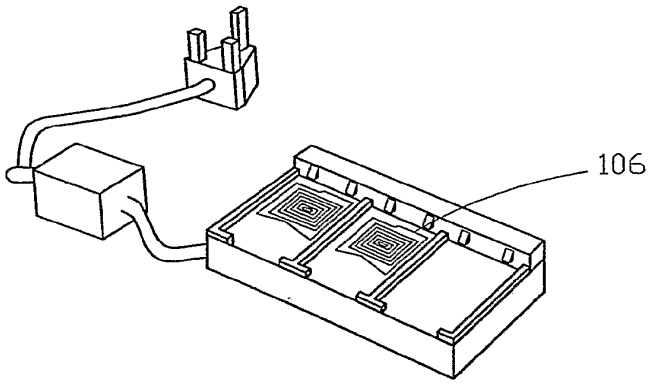


FIG.43

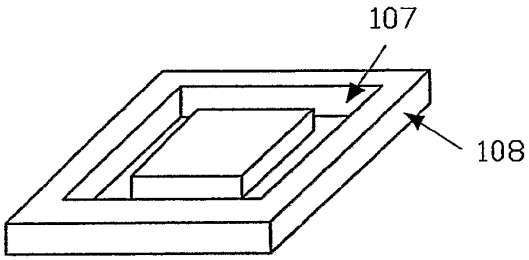


FIG.44(a)

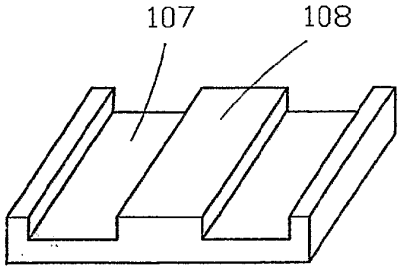


FIG.44(b)

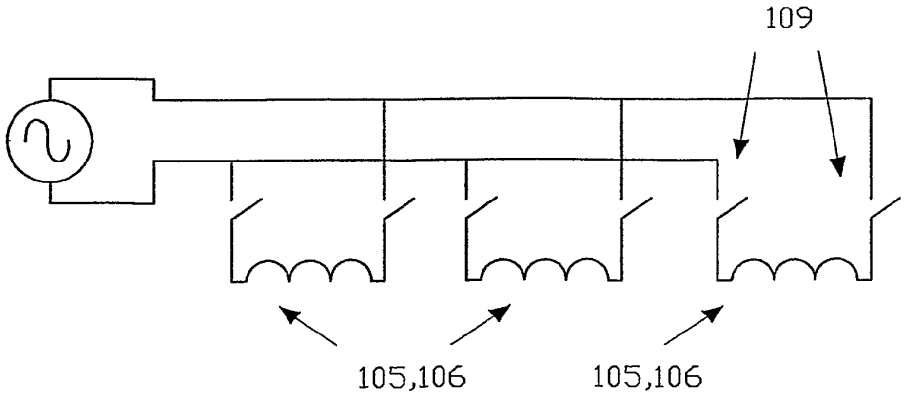


FIG.45

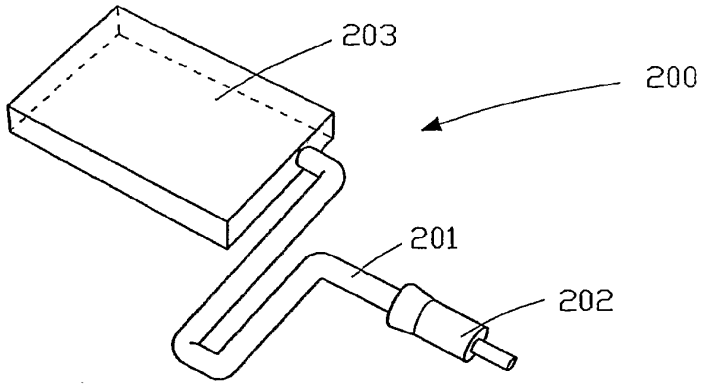


FIG.46

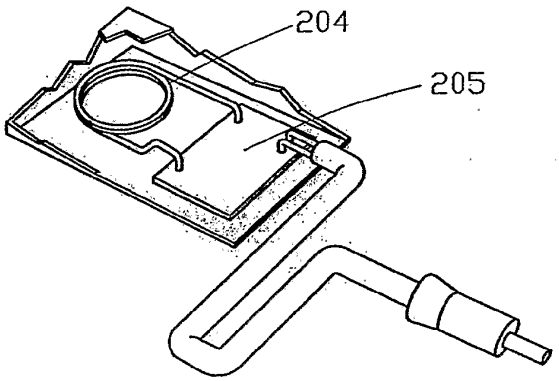


FIG.47

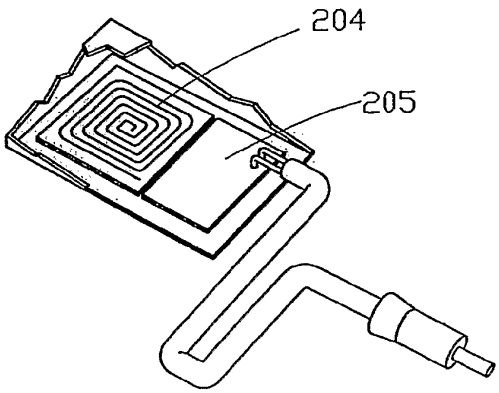


FIG.48

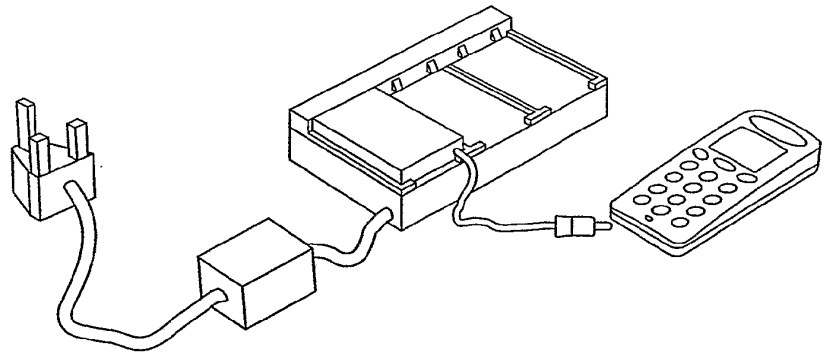


FIG.49

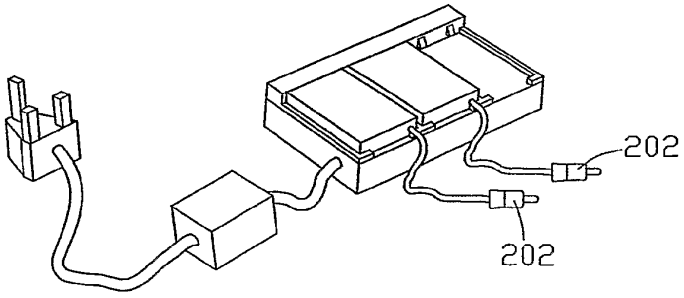


FIG.50

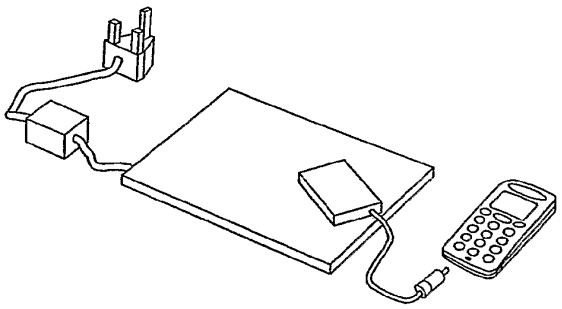


FIG.51

INTERNATIONAL SEARCH REPORT

International application No.
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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

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"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)

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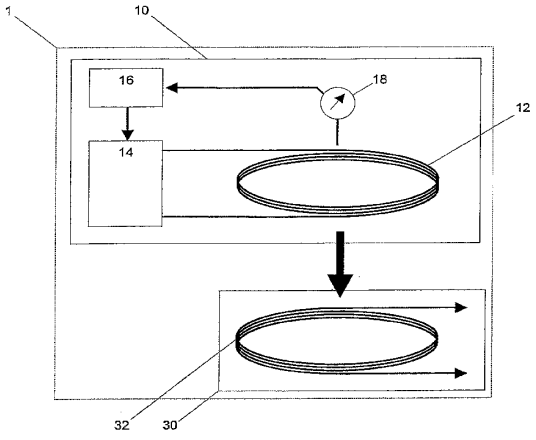
(74) Agent: **HITCHING, Peter, Matthew**; Haseltine Lake, 5th Floor, Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).

(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.

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[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.

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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.

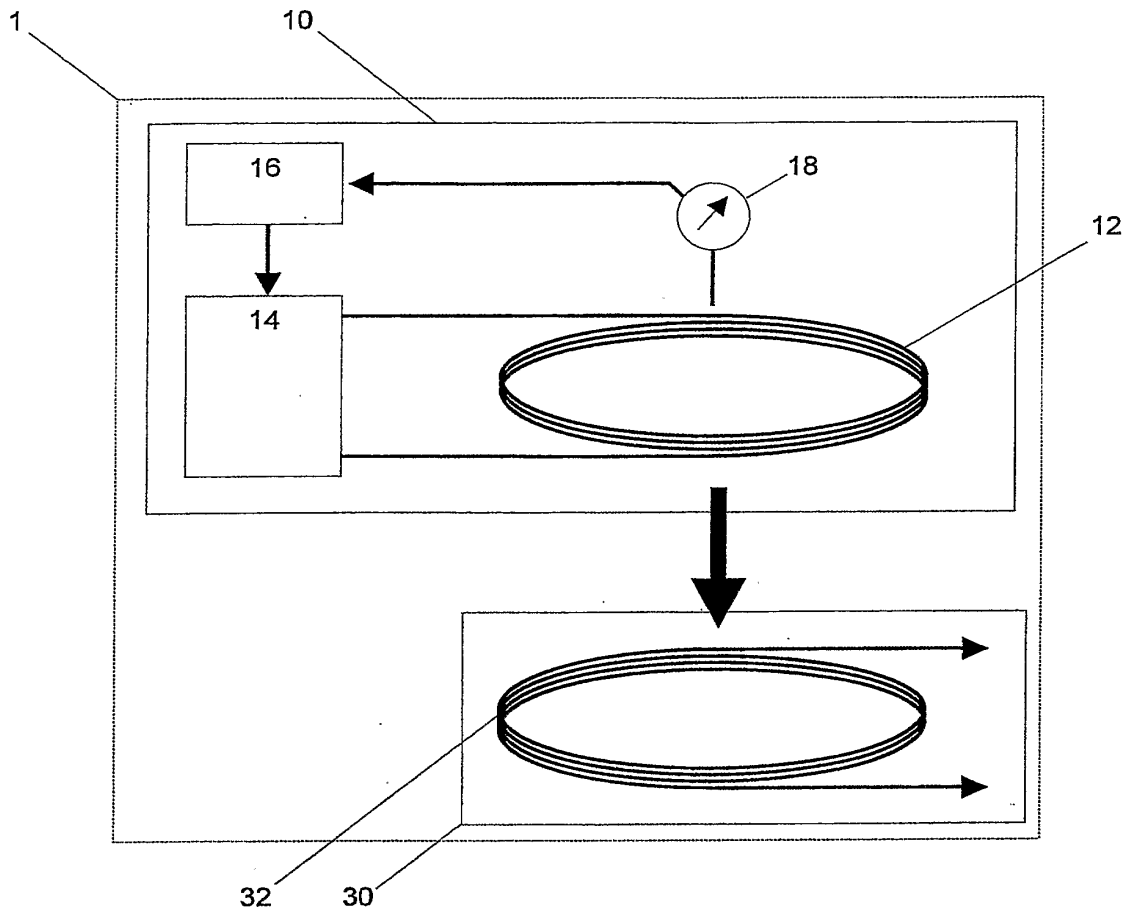


Figure 1

Figure 2(A)

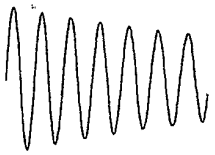
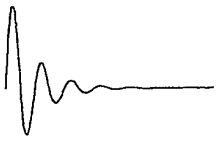


Figure 2(B)



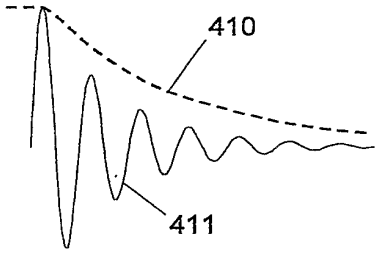


Figure 3

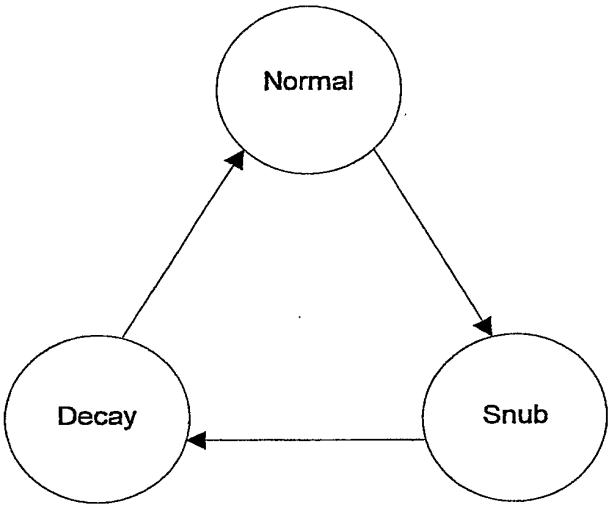


Figure 5

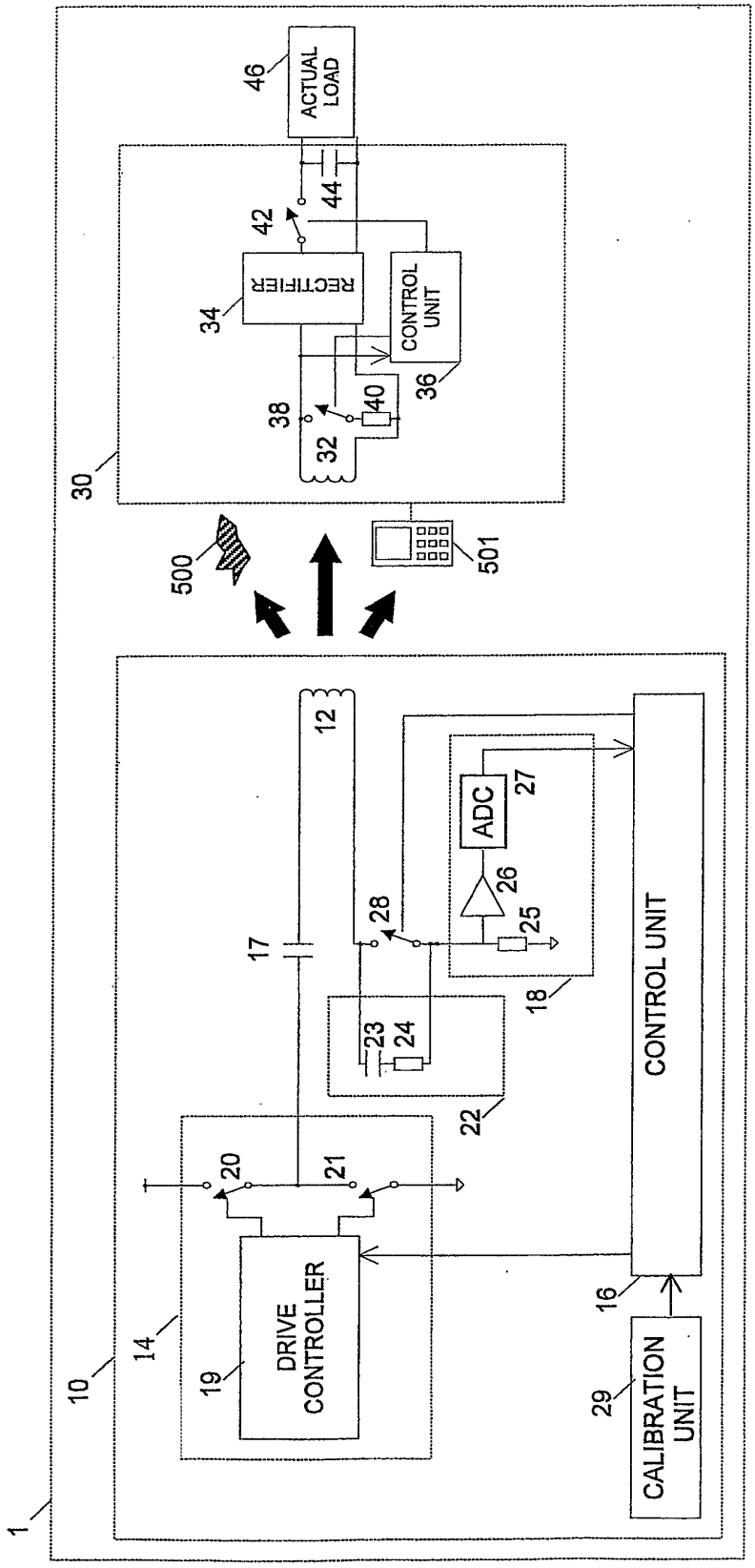

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ACTUAL LOAD
RECTIFIER
CONTROL UNIT
ADC
DRIVE CONTROLLER
CONTROL UNIT
CALIBRATION UNIT

Figure 4

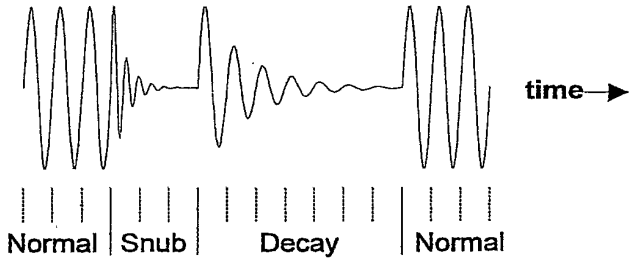


Figure 6



Figure 7

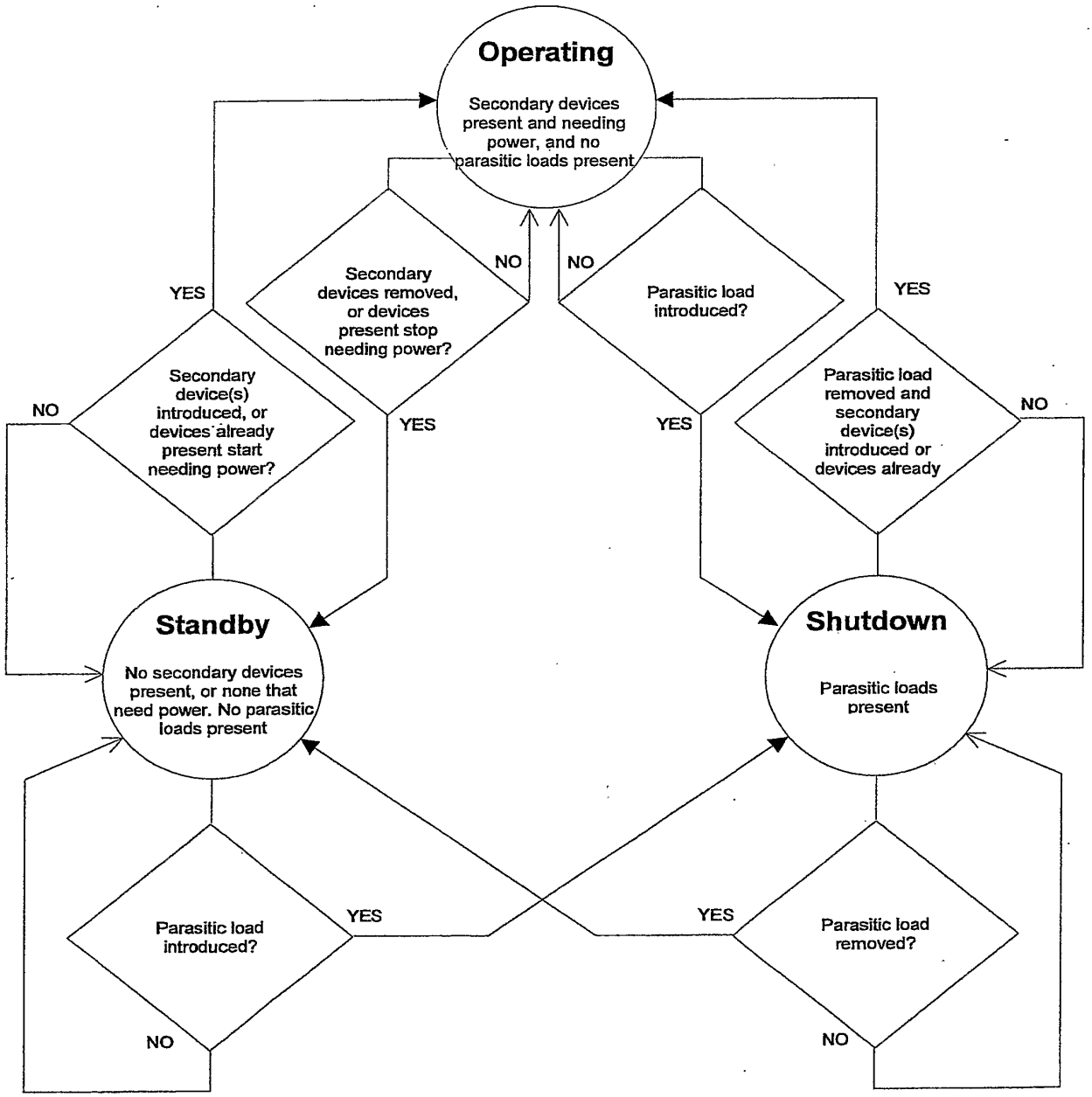

Operating
Secondary devices present and needing power, and no parasitic loads present
Secondary devices removed, or devices present stop needing power?
NO
YES
Parasitic load introduced?
NO
YES
Secondary device(s) introduced, or devices already present start needing power?
NO
YES
Parasitic load removed 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

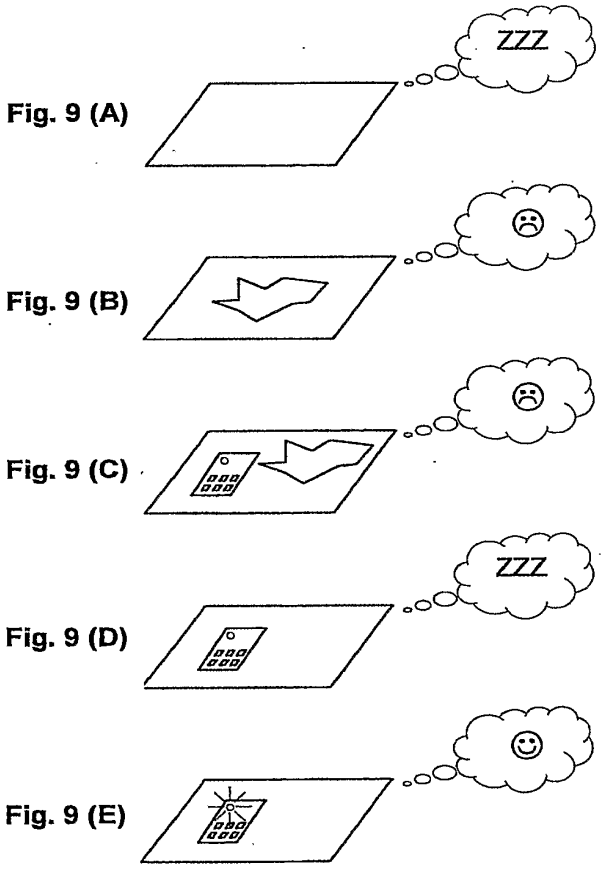


Figure 9

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 :

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"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

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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
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		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

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	03/29/2011	7915857	AFPA-01001US1	2001

23910 7590 03/09/2011

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

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;
Michael Sears, Ben Lomond, CA;

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

23910 7590 03/02/2011

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14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER	
RAMADAN, RAMY O	
ART UNIT	**PAPER NUMBER**
2858	

NOTIFICATION DATE	DELIVERY MODE
03/02/2011	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

Supplemental Notice of Allowability	**Application No.** 11/757,067	**Applicant(s)** PARTOVI ET AL.	
	Examiner RAMY RAMADAN	**Art Unit** 2858	

-- 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 *02/18/2011*.

2. ☒ The allowed claim(s) is/are *1,2,5-9,11,12,20-26,28,29 and 31-36*.

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

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 02/18/2011
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Edward Tso/
Primary Examiner, Art Unit 2858

DETAILED ACTION

Information Disclosure Statement

1. The Information Disclosure Statement dated February 18, 2011 has been acknowledged by the examiner and the cited references have been considered in the examination of the pending claims. As required by M.P.E.P 609 C (2), a copy of the Information Disclosure Statement initiated and dated by the examiner is attached.

Allowable Subject Matter

2. Claims 1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36 are allowed.

3. The following is an examiner's statement of reasons for allowance:

With respect to claim 1 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that decreases harmonics in that activated primary coil; and selectively switch, using their associated switching circuits to activate, only those one or more primary coils which are determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

With respect to claim 20 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, one or more capacitive or other components that decreases harmonics in the activated primary coil, and selectively switch, using their associated switching circuits to activate, only those primary coils which are determined to be in general alignment with a receiver coil at the device and/or battery.

With respect to claims 31 and 34 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or

switching circuit includes a capacitive or other component that increases energy transfer efficiency by that activated primary coil; and selectively switch, using their associated switching circuits to activate, only that one or more primary coils which is determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

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."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAMY RAMADAN whose telephone number is (571) 272-9761. The examiner can normally be reached on Mon-Fri 7:30 am-5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, PATRICK ASSOUAD can be reached on (571) 272-2210. 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.

/Edward Tso/
Primary Examiner, Art Unit 2858

/Ramy Ramadan/
Examiner
Art Unit 2858

/RR/

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	11757067
Filing Date	2007-06-01
First Named Inventor	Afshin Partovi
Art Unit	2858
Examiner Name	Ramy O. Ramadan
Attorney Docket Number	AFPA-01001US1

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/R.R./	1	2008-137996	WO		2008-11-13	Mojo Mobility, Inc.		☐
/R.R./	2	10-0836634	KR		2008-06-10	Hanrim Postech Co., Ltd.		☐

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Receipt date: 02/18/2011	Application Number	11757067 11757067 - GAU: 2858
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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]
/R.R./	1	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.	☐

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EXAMINER SIGNATURE

Examiner Signature	/Ramy Ramadan/	Date Considered	02/26/2011

*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.

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
Fliesler Meyer LLP
650 California Street, 14th Floor
San Francisco, CA 94108

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.

Karl F. Kenna	(Depositor's name)
/Karl F. Kenna/	(Signature)
February 18, 2011	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	6/1/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
NONPROVISIONAL	YES	$755	$300	$1055	02/18/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAMADAN, RAMY O	2858	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 Fliesler Meyer LLP
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): SUNNYVALE, CALIFORNIA (US)

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 enclosed:
☑ Issue Fee
☑ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies

4b. Payment of Fee(s):
☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☑ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1325.

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Karl F. Kenna/ Date February 18, 2011

Typed or printed name Karl F. Kenna Registration No. 45445

This collection of information 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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application		PATENT APPLICATION	
Inventors:	Afshin Partovi, et al.		
Appl. No.:	11/757,067	Art Unit:	2858
Confirm. No.:	2001	Examiner:	Ramy O. Ramadan
Filed:	June 1, 2007		
Title:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	**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:

✓ Information Disclosure Statement by Applicant (PTO/SB/08a), 4 pages. 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 of the International Searching Authority, Korean Intellectual Property Office, in re International Application No. PCT/US2010/032845 dated December 13, 2010, 10 pages.

___ 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: February 18, 2011

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

Customer No. 23910
FLIESLER MEYER LLP
650 California Street, 14th Floor
San Francisco, California 94108
Telephone: (415) 362-3800

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	11757067
Filing Date	2007-06-01
First Named Inventor	Afshin Partovi
Art Unit	2858
Examiner Name	Ramy O. Ramadan
Attorney Docket Number	AFPA-01001US1

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					

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
	1	20080258679		2008-10-23	Manico	

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]
	1	2008-137996	WO		2008-11-13	Mojo Mobility, Inc.		☐
	2	10-0836634	KR		2008-06-10	Hanrim Postech Co., Ltd.		☐

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

NON-PATENT LITERATURE DOCUMENTS Remove

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11757067
	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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 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.	☐

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	11757067
	Filing Date	2007-06-01
	First Named Inventor	Afshin Partovi
	Art Unit	2858
	Examiner Name	Ramy O. Ramadan
	Attorney Docket Number	AFPA-01001US1

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 F. Kenna/	Date (YYYY-MM-DD)	2011-02-18
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.

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

RECEIVED
DEC 20 2010
FLIESLER MEYER LLP

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) 13 DECEMBER 2010 (13.12.2010)

Fliesler Meyer LLP

Applicant's or agent's file reference AFPA1026WO0

File: AFPA-0100US1

FOR FURTHER ACTION See paragraphs 1 and 4 below

Action Item: Intl Search Report - ISR?

International application No PCT/US2010/032845

Date Due: Jan. 14 2011

Critical Date: March 13 2011

International filing date (day/month/year) 28 APRIL 2010 (28.04.2010)

Attorney Path: KFK

Docketed By: AMS

Applicant MOJO MOBILITY, INC. et al

A-Wole

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
Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

COMMISSIONER

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 : **HGM5R98I**

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)

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.

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 Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer 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

Form PCT/ISA/210 (patent family annex) (July 2009)

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. 1 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).

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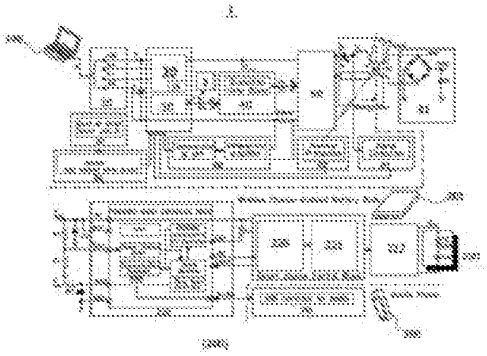
심사관 : 박대식

(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 빨어뜨릴 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 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 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 부츠트랩 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); 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)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 ID칩에서 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), 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)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(415), (-)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.

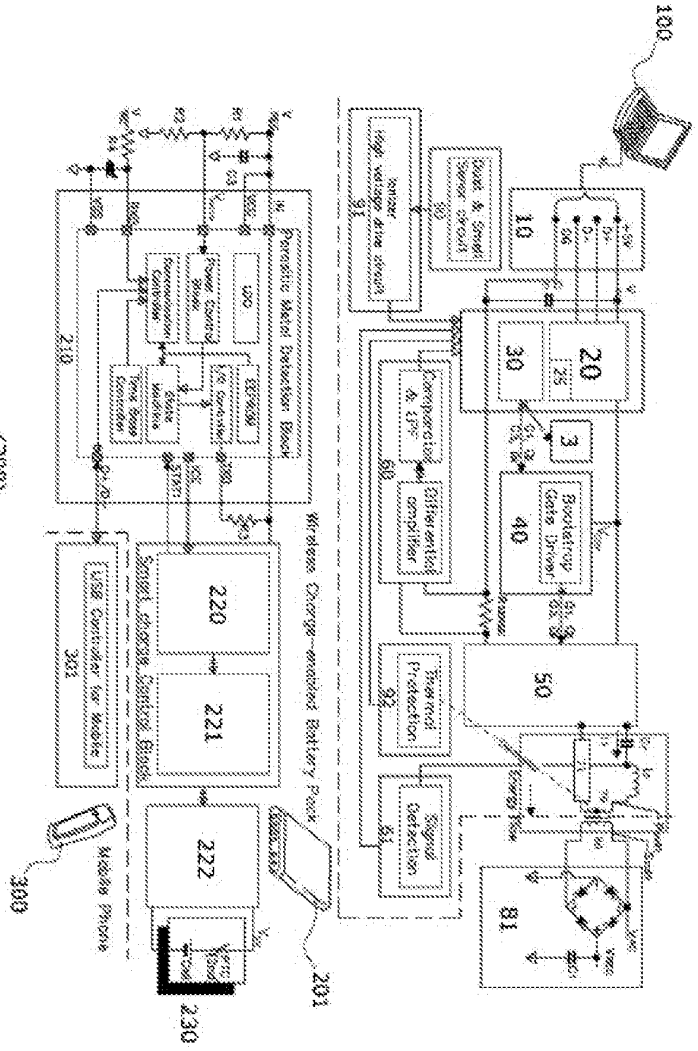
[0011] 도 11은 종래 기술에 따른 핸드폰용 충전장치에 대한 사용상태도이다.

[0012] <도면의 주요 부분에 대한 부호의 설명>

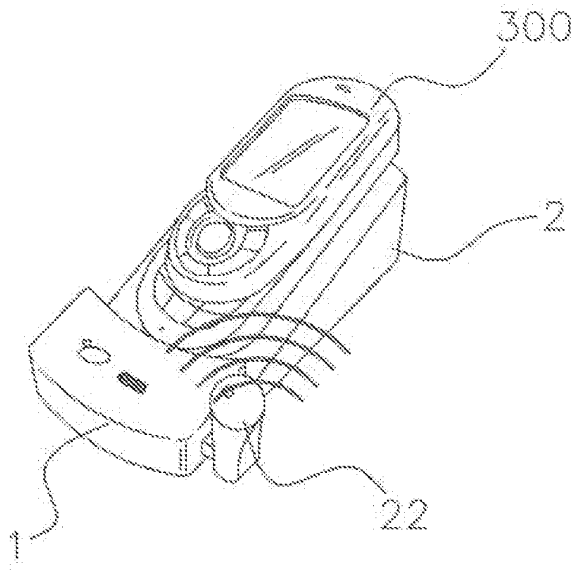
[0013]	1 : 무접점 충전장치	2 : 장치몸체
[0014]	10 : USB커넥터	10 : USB드라이버블록
[0015]	30 : MPU블록	50 : 직렬공진 컨버터
[0016]	60 : 전류센싱블록	
[0017]	70 : 1차코일	80 : 2차코일
[0018]	200 : 충전용 배터리팩	300 : 휴대용 단말기

도면

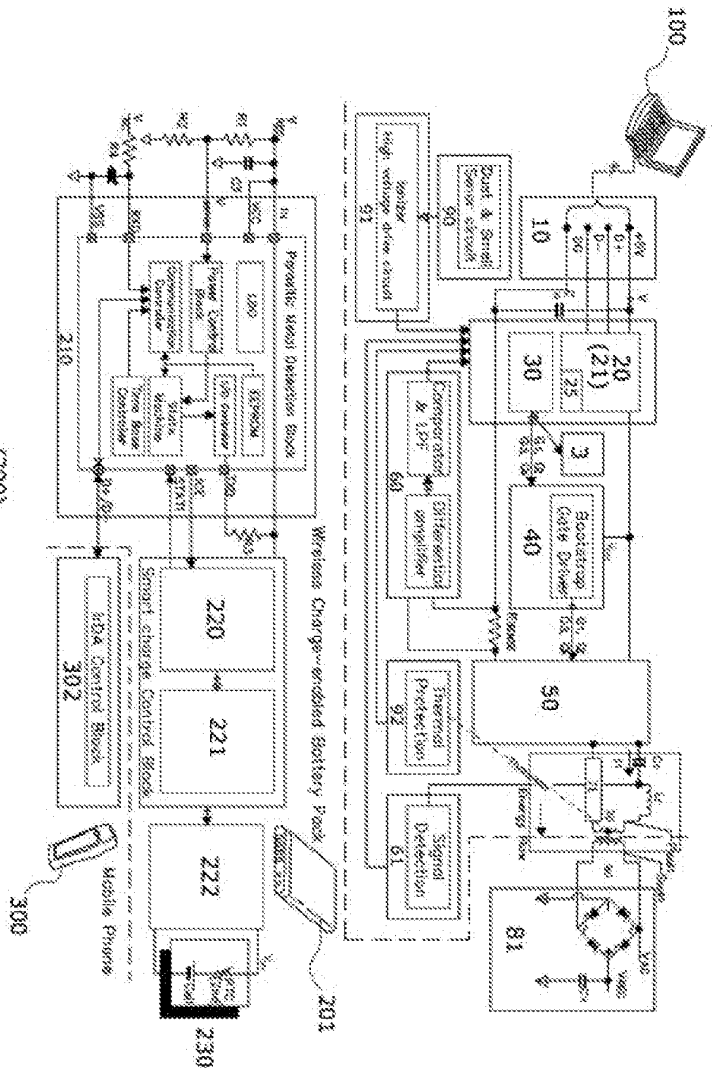
도면1


100
1
10
20
30
40
50
60
81
91
92
220
221
222
230
201
300
(200)
Wireless Charge-enabled Battery Pack
Smart Charge Control Block
Portable Metal Detection Block
Mobile Phone
USB Controller for Mobile
Inverter High voltage drive circuit
Short & Short Detect circuit
Bootstrap Gate Driver
Differential amplifier
Comparator & LPF
Thermal Protection
Signal Detection
Power Control
Temp Sense Controller
Buck Mode Controller
LDO
EEPROM
LED Control
Power Management
Power Switch
Full Bridge Rectifier
Resonant Tank
Primary Coil
Secondary Coil
Load

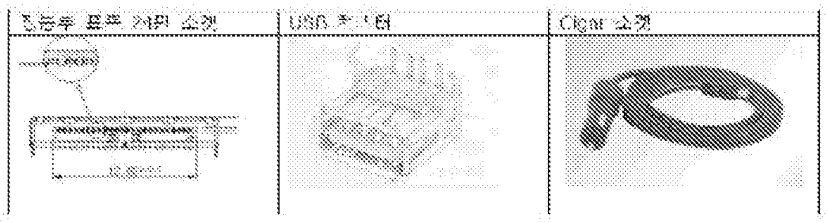
도면2



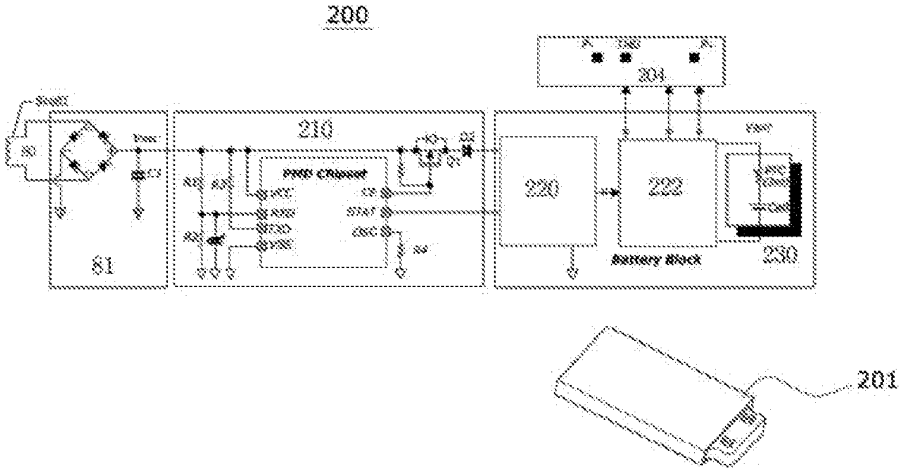
도면3


100
10
20
(21)
30
40
50
60
61
62
70
81
90
201
210
220
221
222
230
300
302
(200)
Wireless Charge-enabled Battery Pack
Smart charge Control Block
Portable Waist Detection Block
Mobile Phone
BMS Control Block
Signal Detection
Thermal Protection
Battery Pack
Power Control
Boost & Small Power circuit
Switching Box

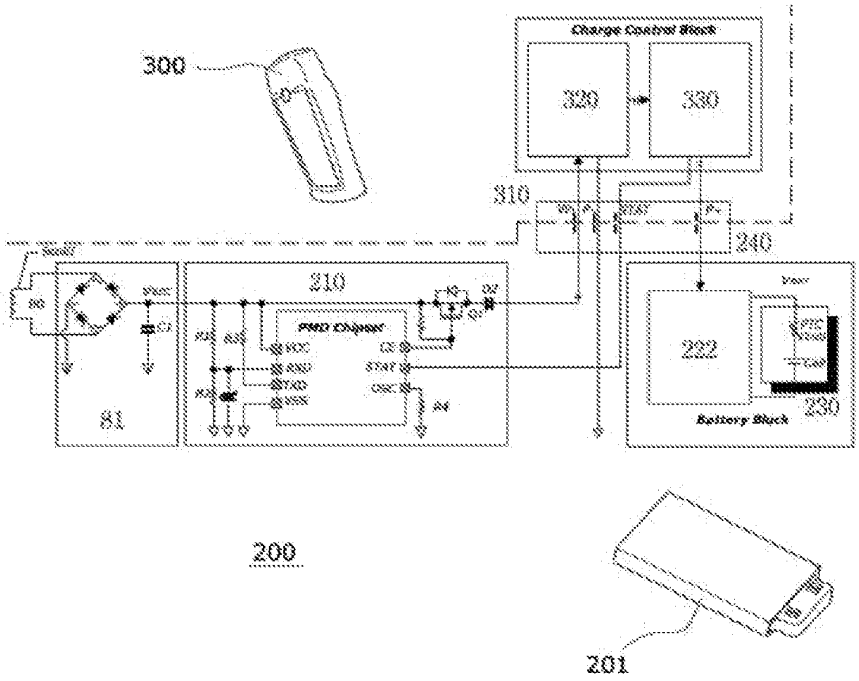
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USB 케이블
Clean 소켓

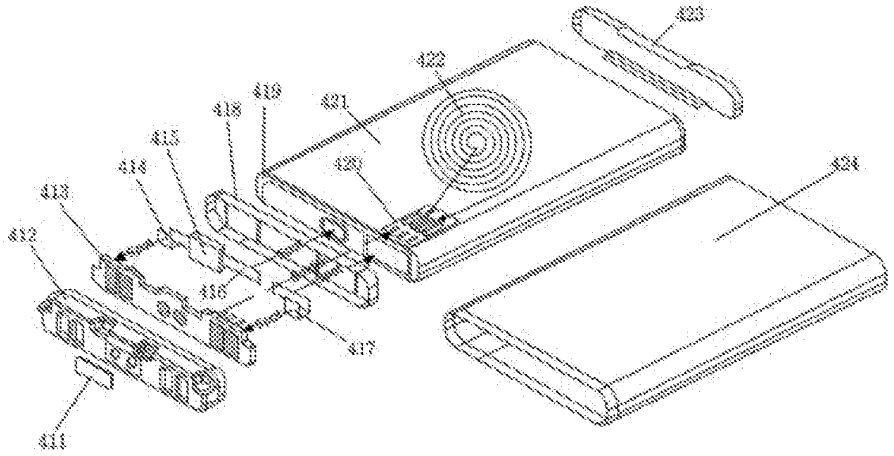
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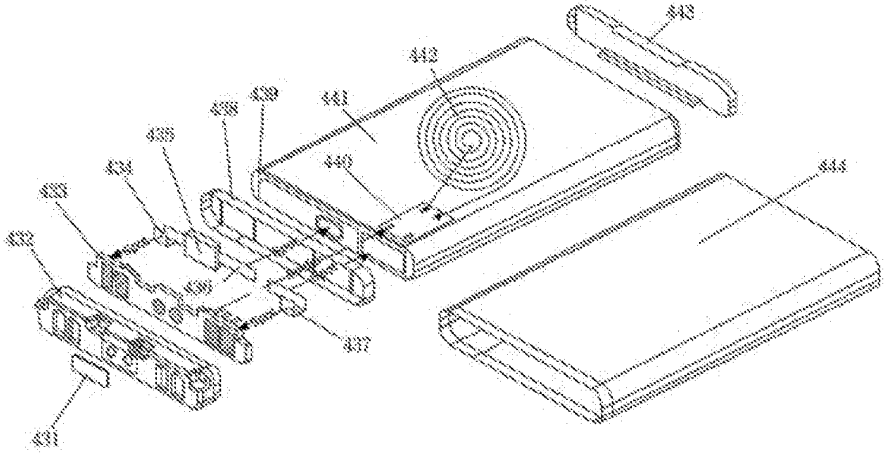
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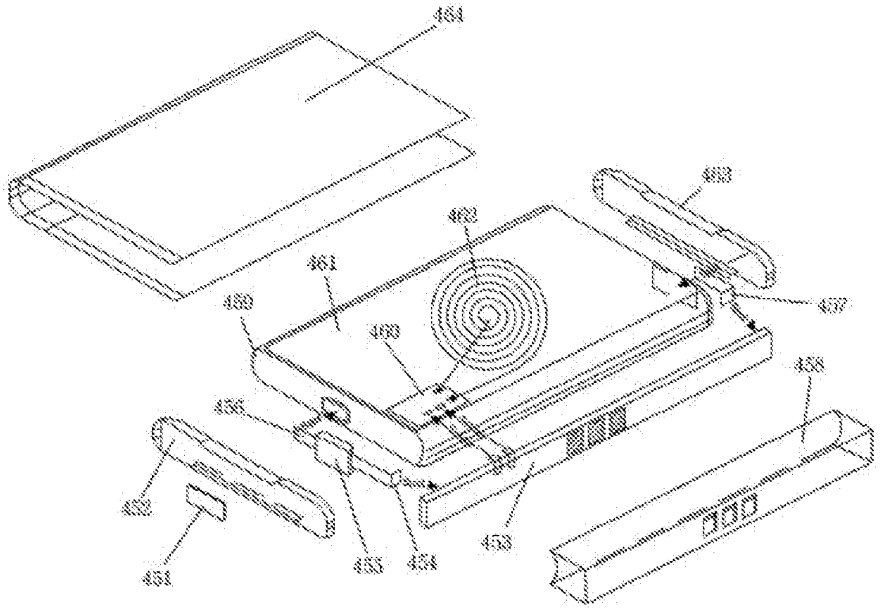
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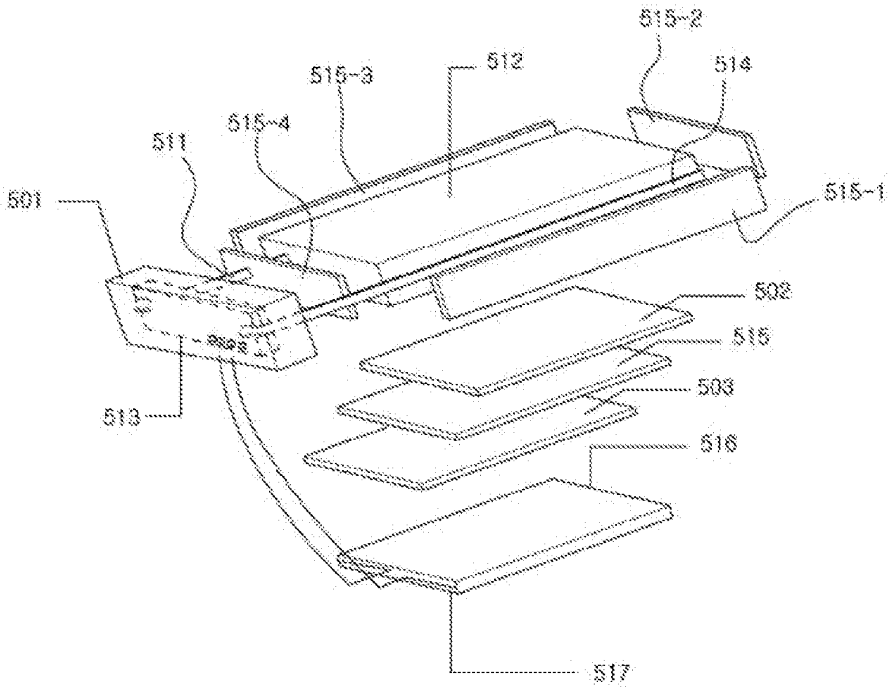
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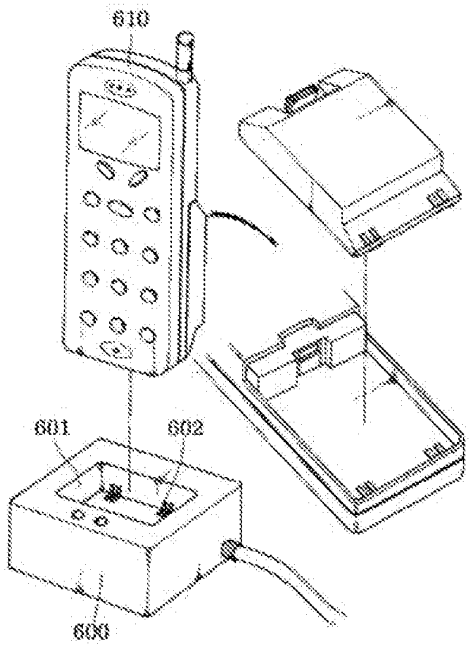
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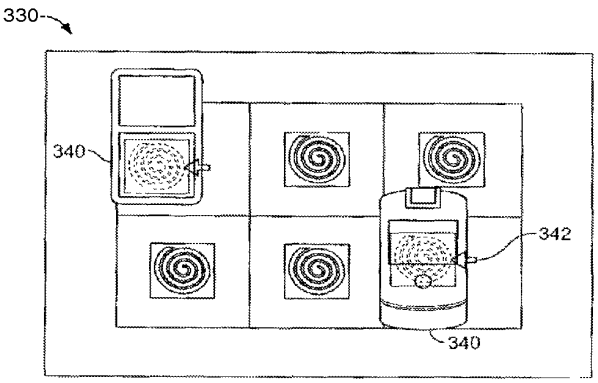
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[Continued on next page]

(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.

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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 paraiiei 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 bow!. 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 minimal 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 coil 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 to each other are required.

[00159] 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, all the coils nearby (in and around the circle 328) will need to be turned on to achieve a uniform field in the desired location 326. While this approach solves the offset issue and can be used to 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 wall or physical barrier, or simply some tethering means with no physical walls but that otherwise restrict movement to 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 to the drive electronics placed 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 layers 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.

Effιεiency Enhancements through Coiℓ 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 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. 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.) are able to communicate through a wired connection.

Switching Wlode Power Supply with Wireless Communseat!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 10^9 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 coi! area. The magnet shown in Figure 73 comprises a ring that surrounds the coi! 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 coi! 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 b 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 coi! 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 pui! 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 coi! 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. ɜ 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.

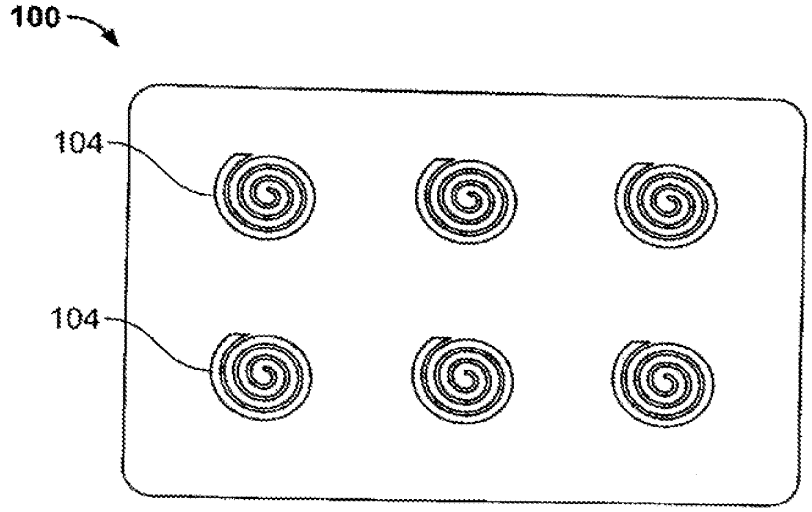

100
104
104

FIG. 1

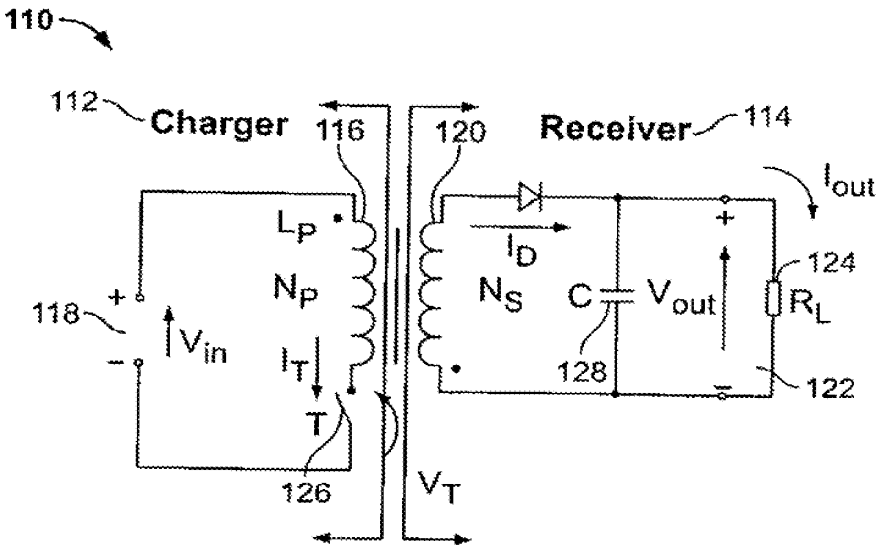

110
112
Charger
116
120
Receiver
114
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
124
R_L
118
+
V_{in}
−
I_T
T
128
122
126
V_T

FIG. 2

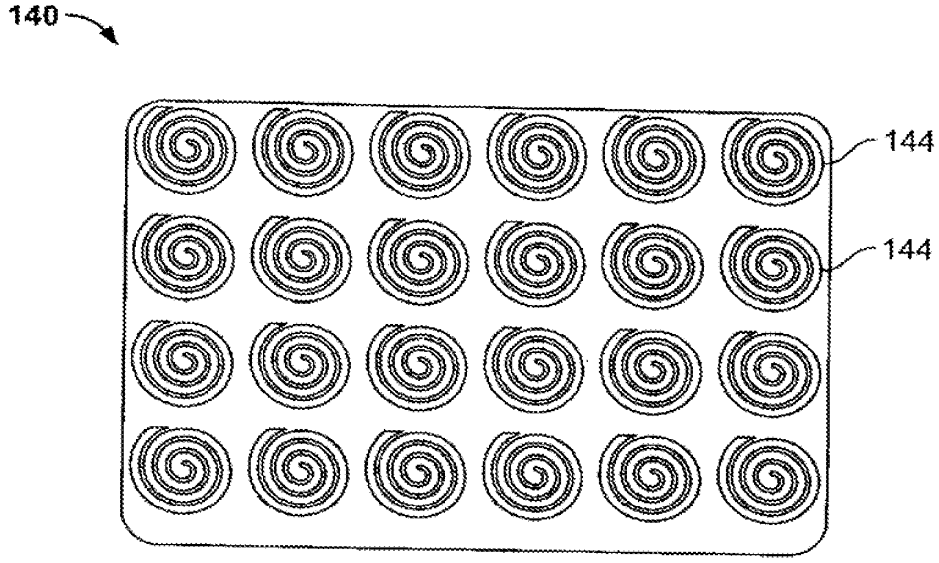


FIG. 3

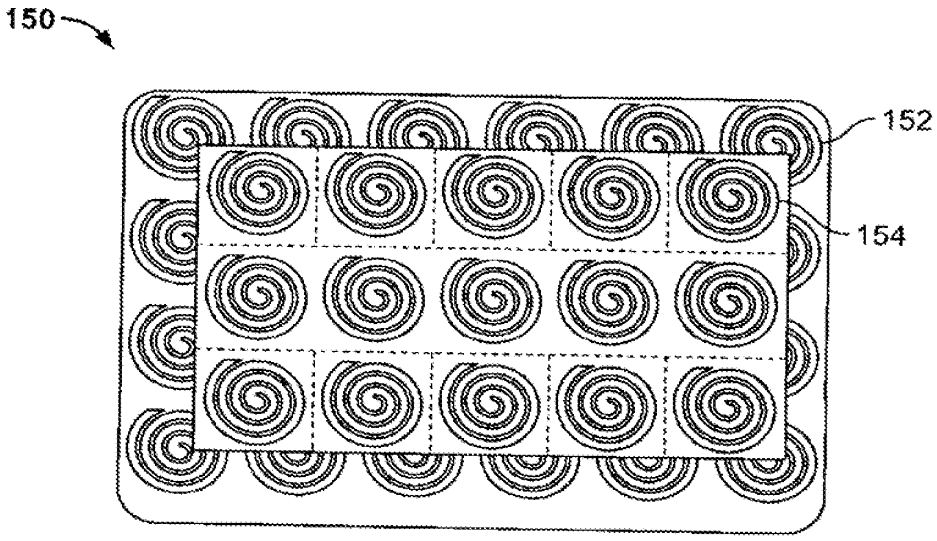


FIG. 4

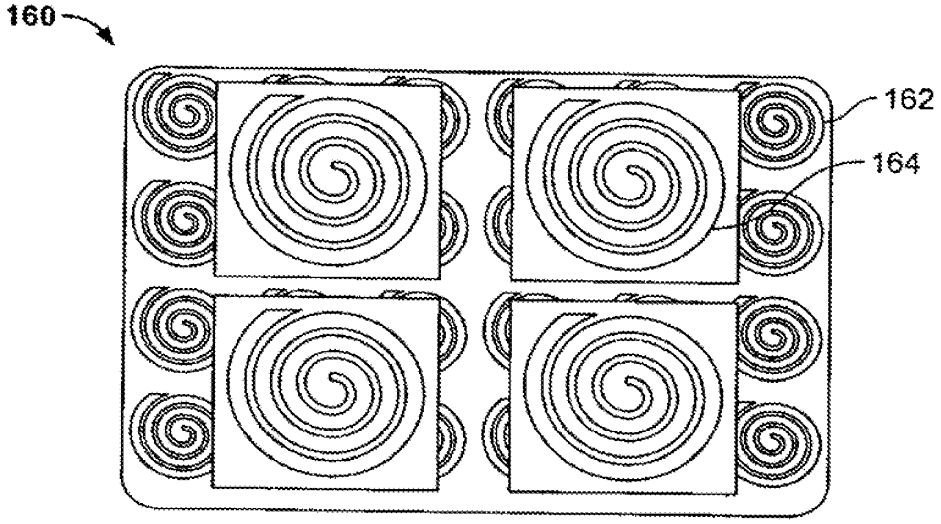

160
162
164

FIG. 5

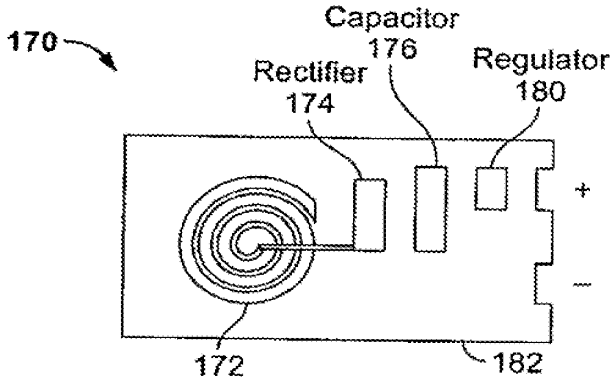

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

FIG. 6

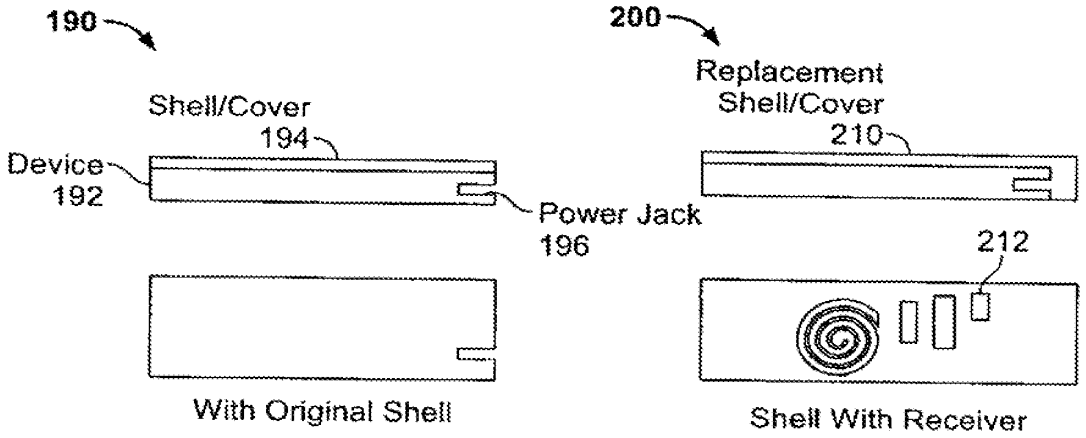

190
200
Shell/Cover
194
Device
192
Replacement
Shell/Cover
210
Power Jack
196
212
With Original Shell
Shell With Receiver

FIG. 7

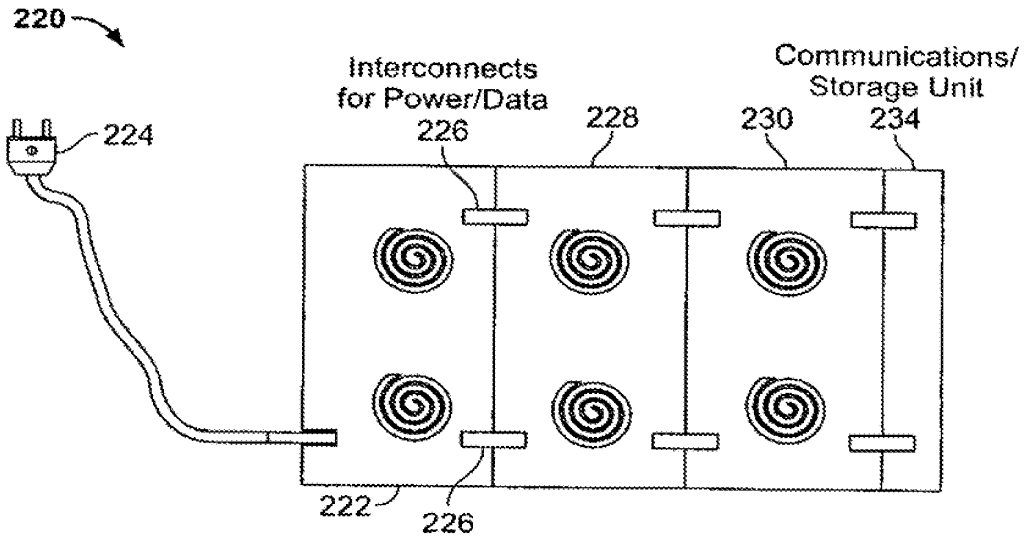

220
224
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
222
226

FIG. 8

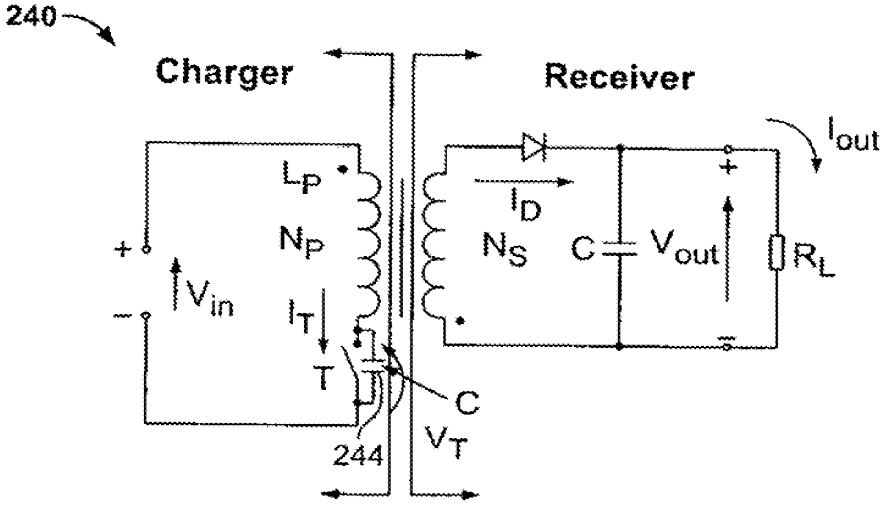

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
V_T
244

FIG. 9

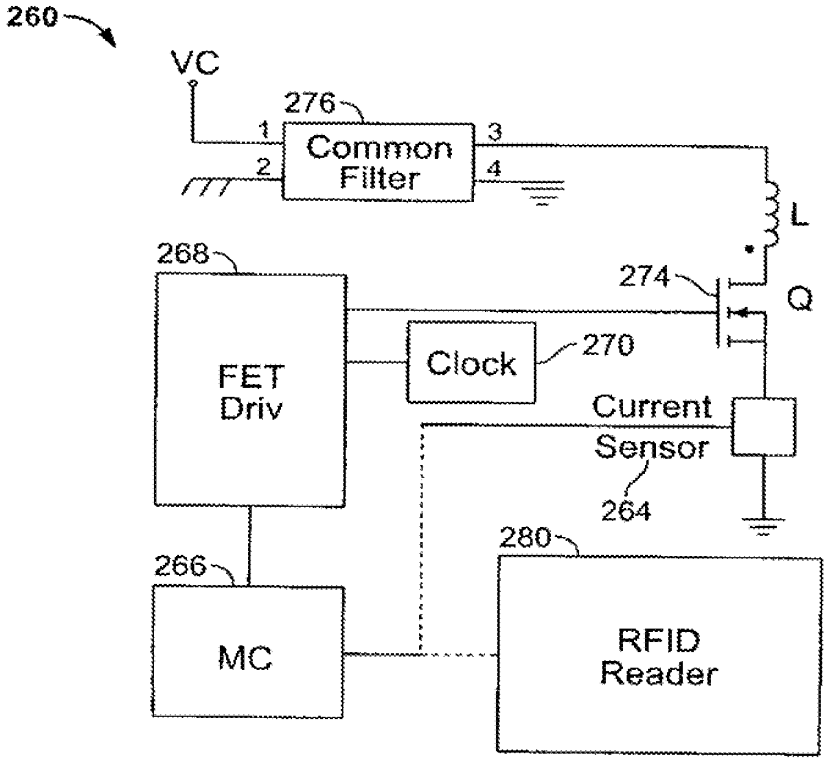

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

FIG. 10

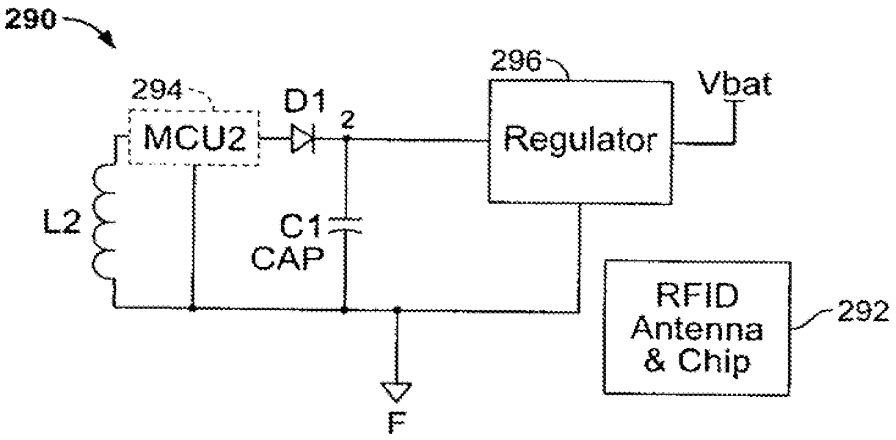

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

FIG. 11

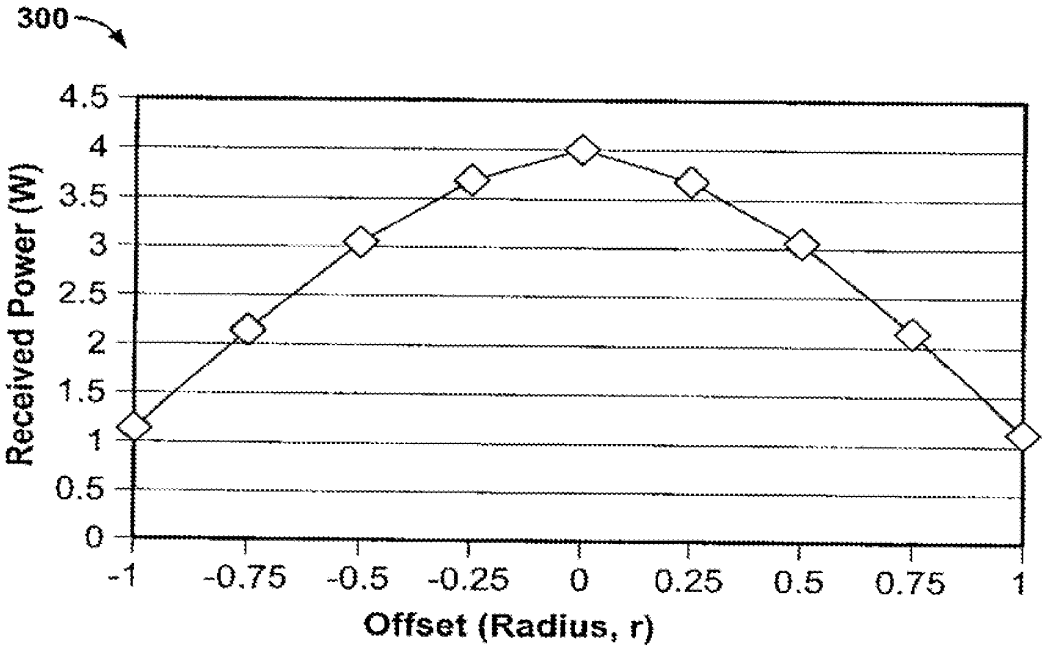

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

FIG. 12

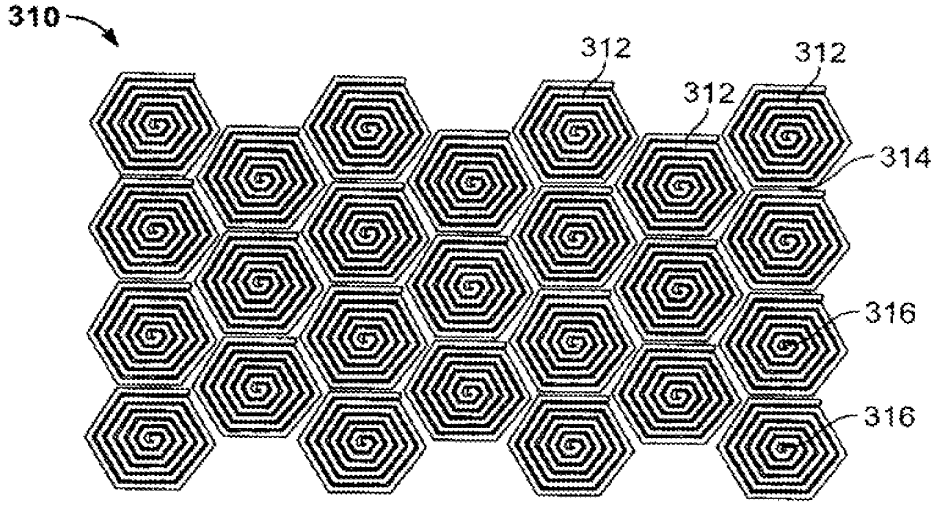


FIG. 13

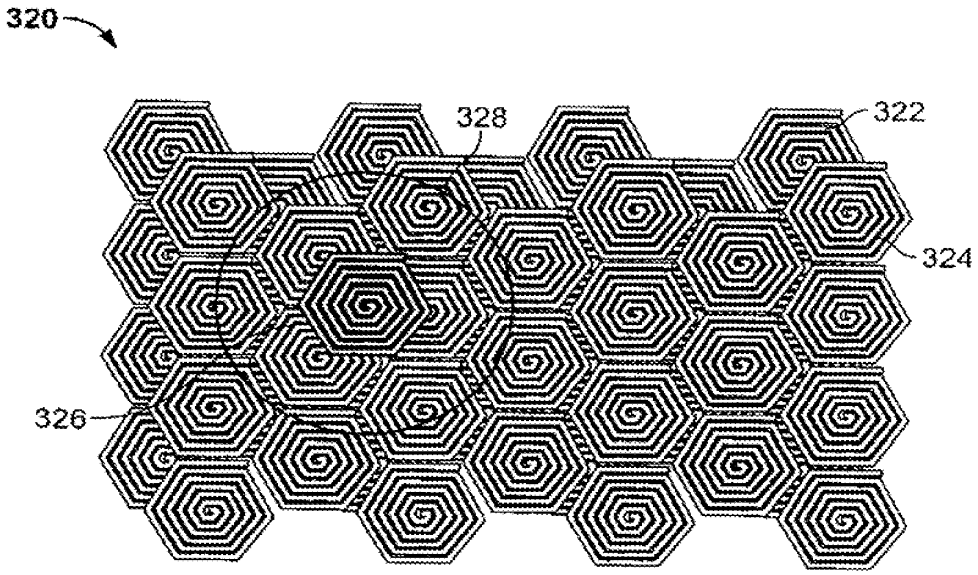


FIG. 14

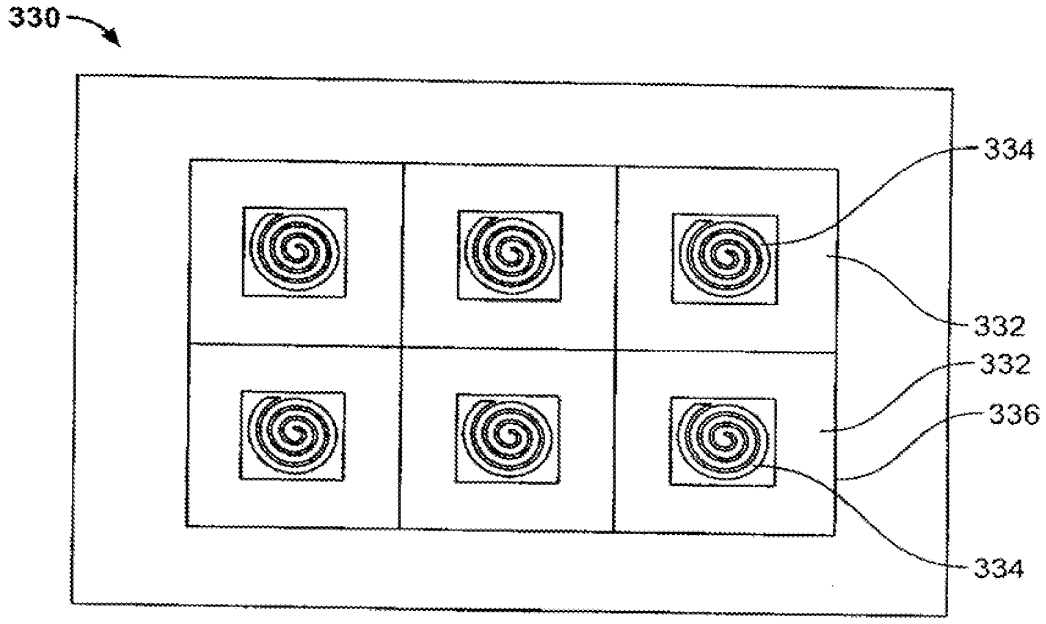


FIG. 15

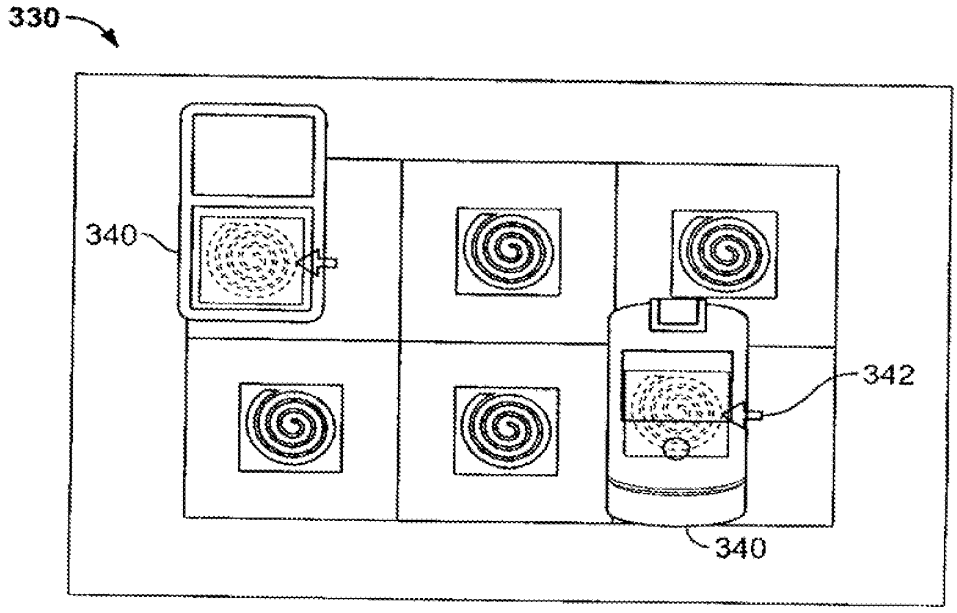


FIG. 16

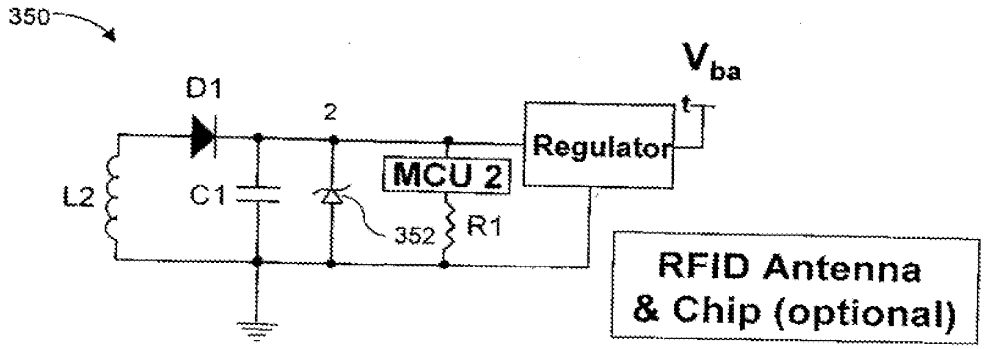

350
D1
2
V_{ba}
Regulator
MCU 2
L2
C1
352
R1
RFID Antenna
& Chip (optional)

FIG. 17

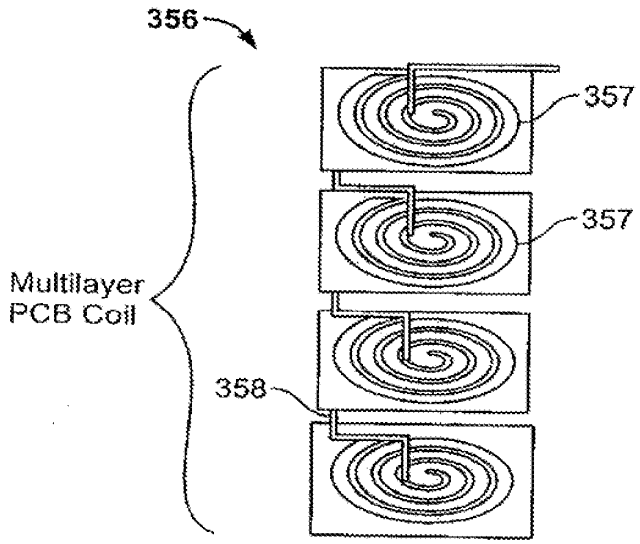

356
357
357
Multilayer
PCB Coil
358

FIG.18

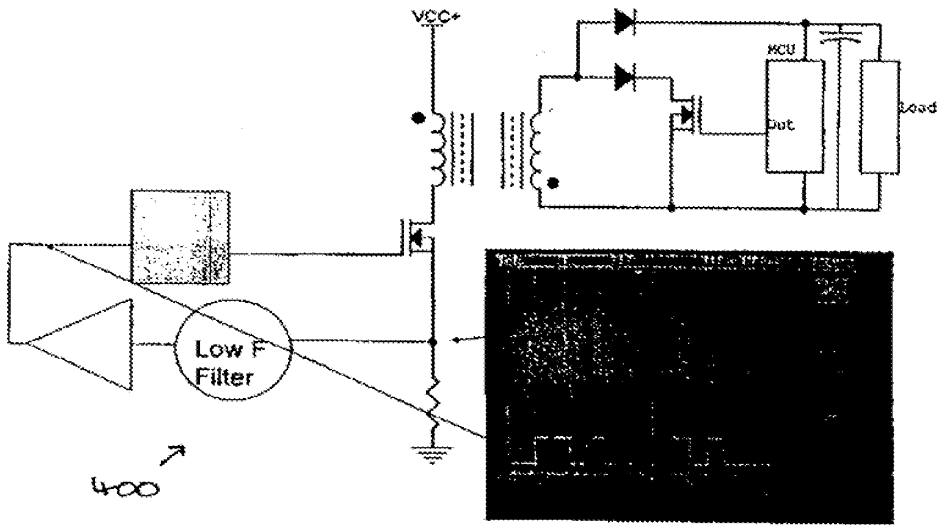


FIG. 19

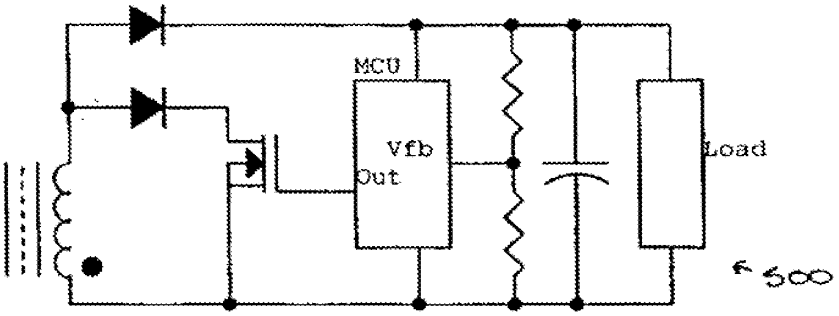


FIG. 23

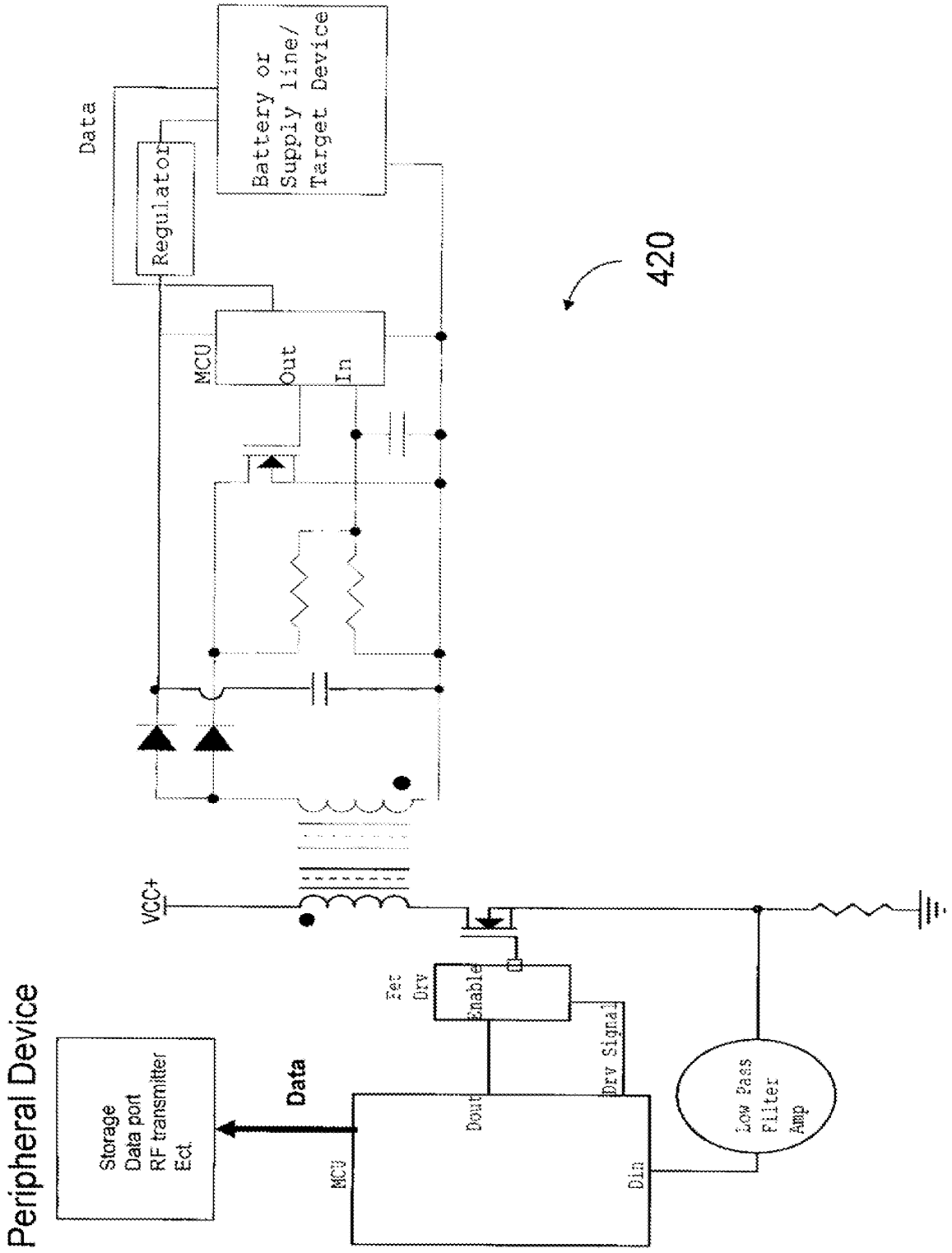

Peripheral Device
Storage
Data port
RF transmitter
Ect
Data
MCU
Dout
Din
Drv Signal
Enable
Rec
Drv
VCC+
Low Pass
Filter
Amp
MCU
Out
In
Regulator
Data
Battery or
Supply line/
Target Device
420

Figure 20

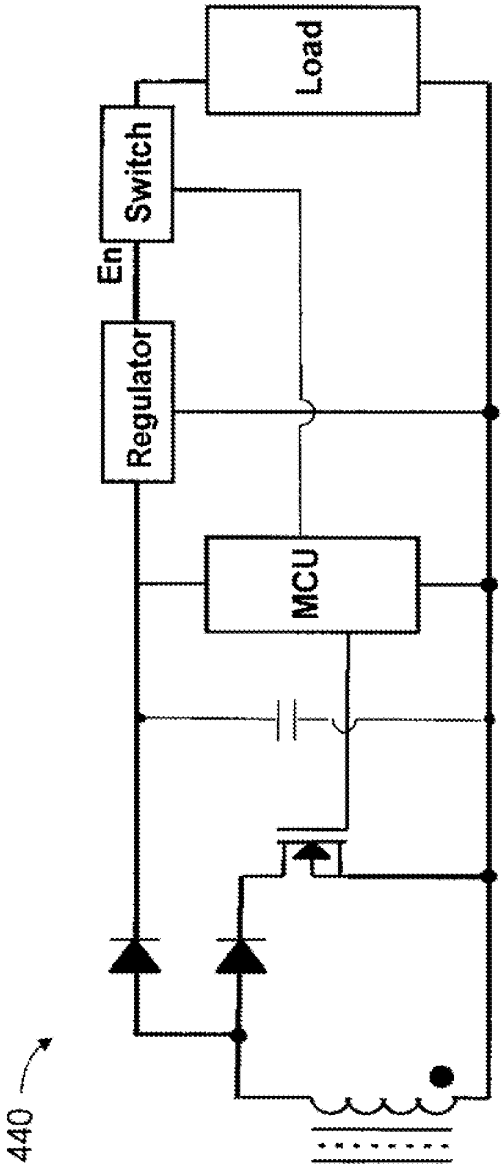


Figure 21

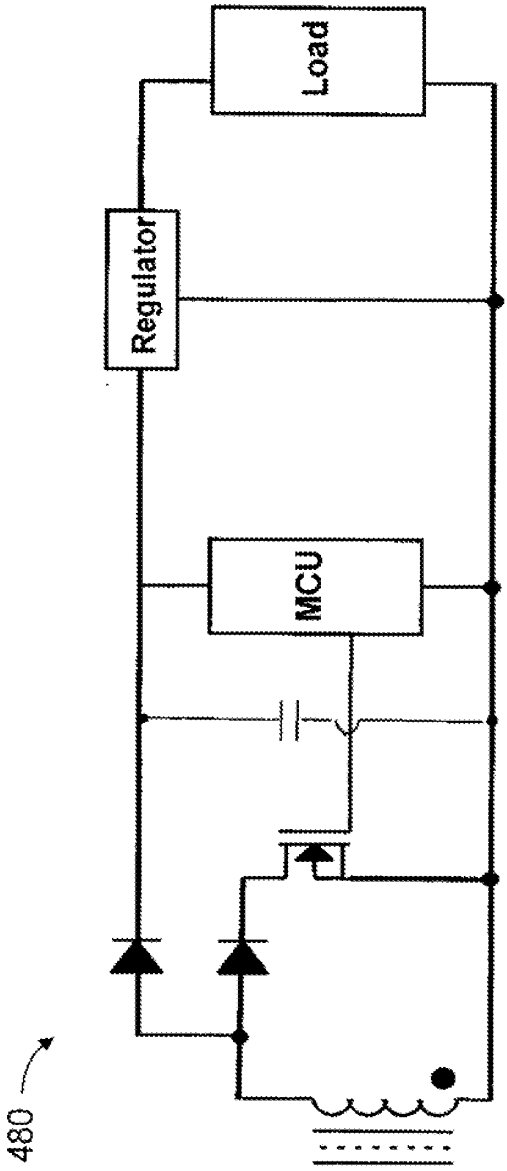


Figure 22

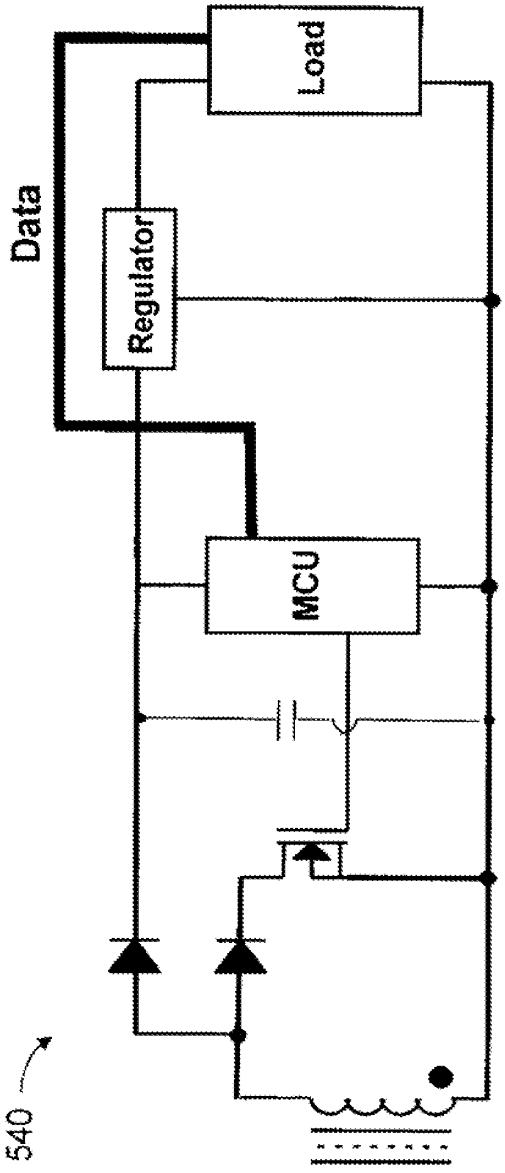


Figure 24

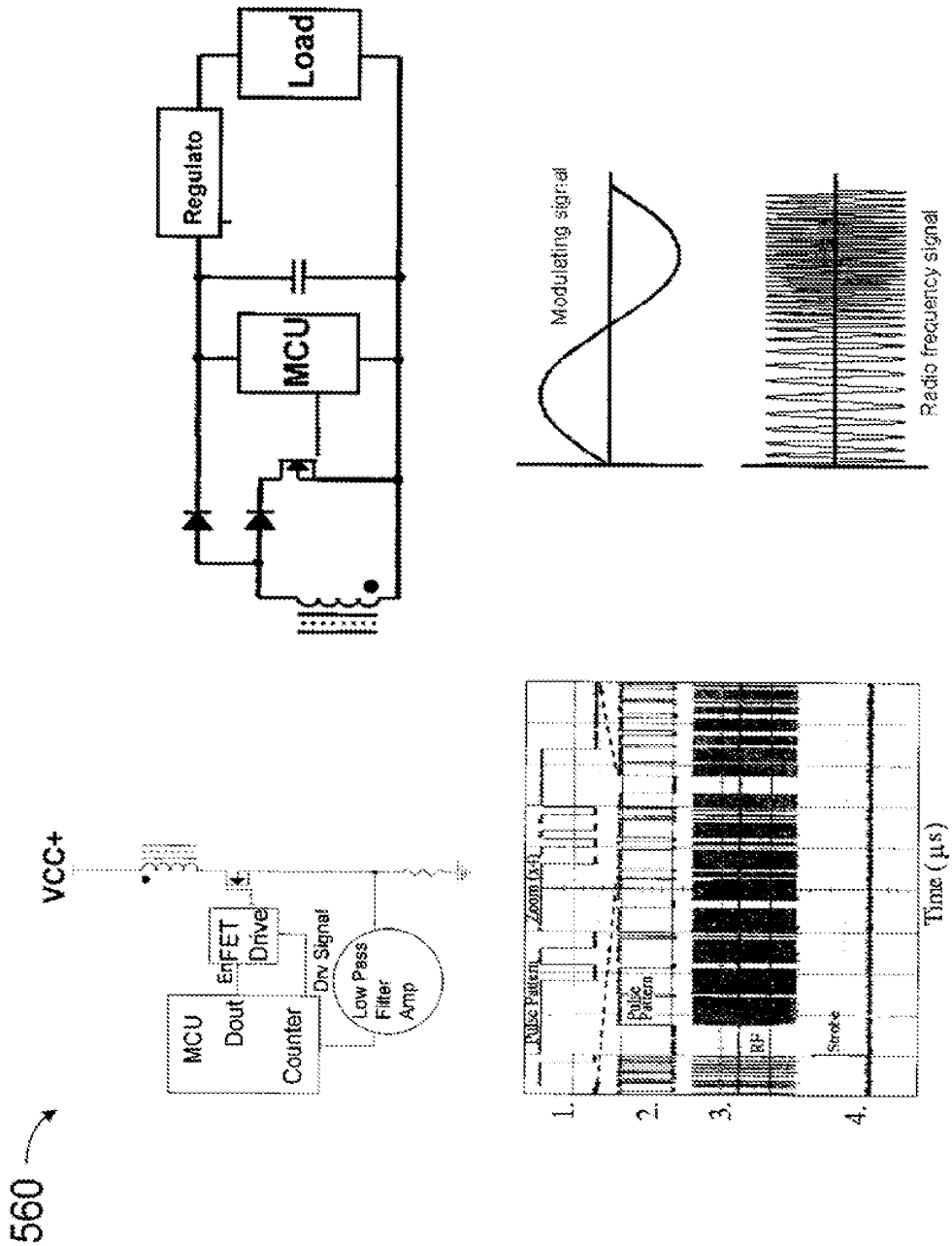

560
VCC+
MCU
Dout
Counter
EnFET
Drive
Drv Signal
Low Pass
Filter
Amp
Load
Regulato
MCU
Modulating signal
Radio frequency signal
Pulse Pattern
Zoom (x1)
Pulse Pattern
RF
Stroke
1.
2.
3.
4.
Time (µs)

Figure 25

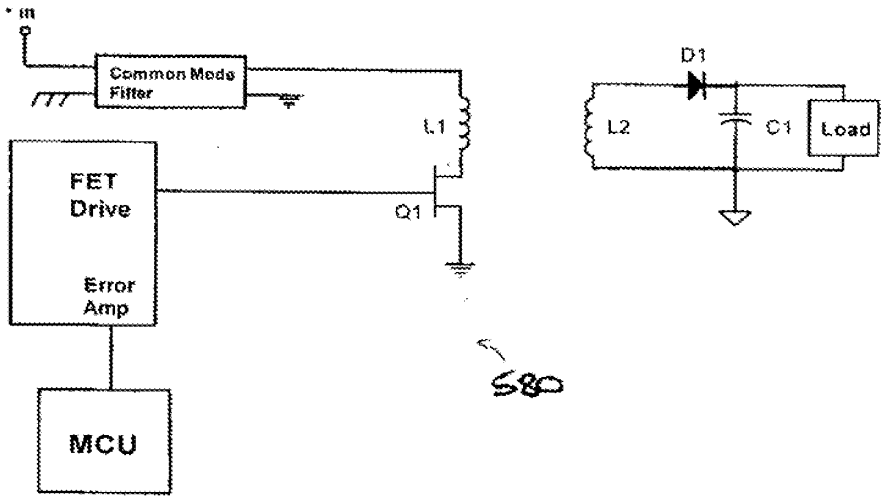

Common Mode Filter
L1
FET Drive
Q1
Error Amp
MCU
580
D1
L2
C1
Load

FIG. 26

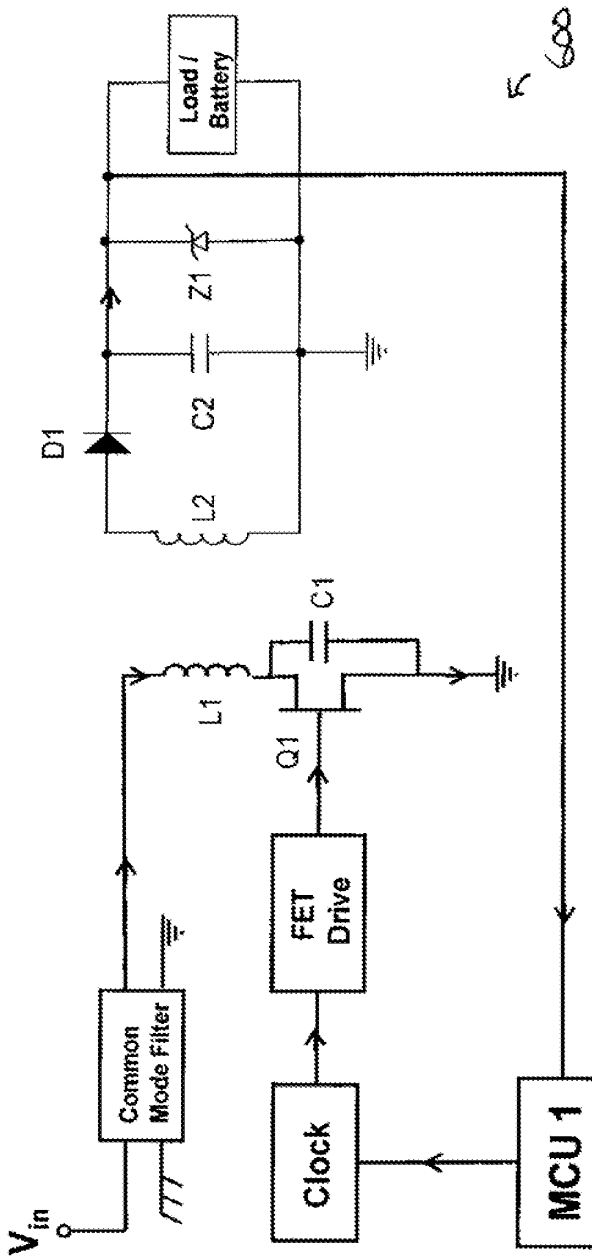

600
Load / Battery
Z1
C2
D1
L2
C1
L1
Q1
FET Drive
Common Mode Filter
Clock
MCU 1
V_{in}

Figure 27

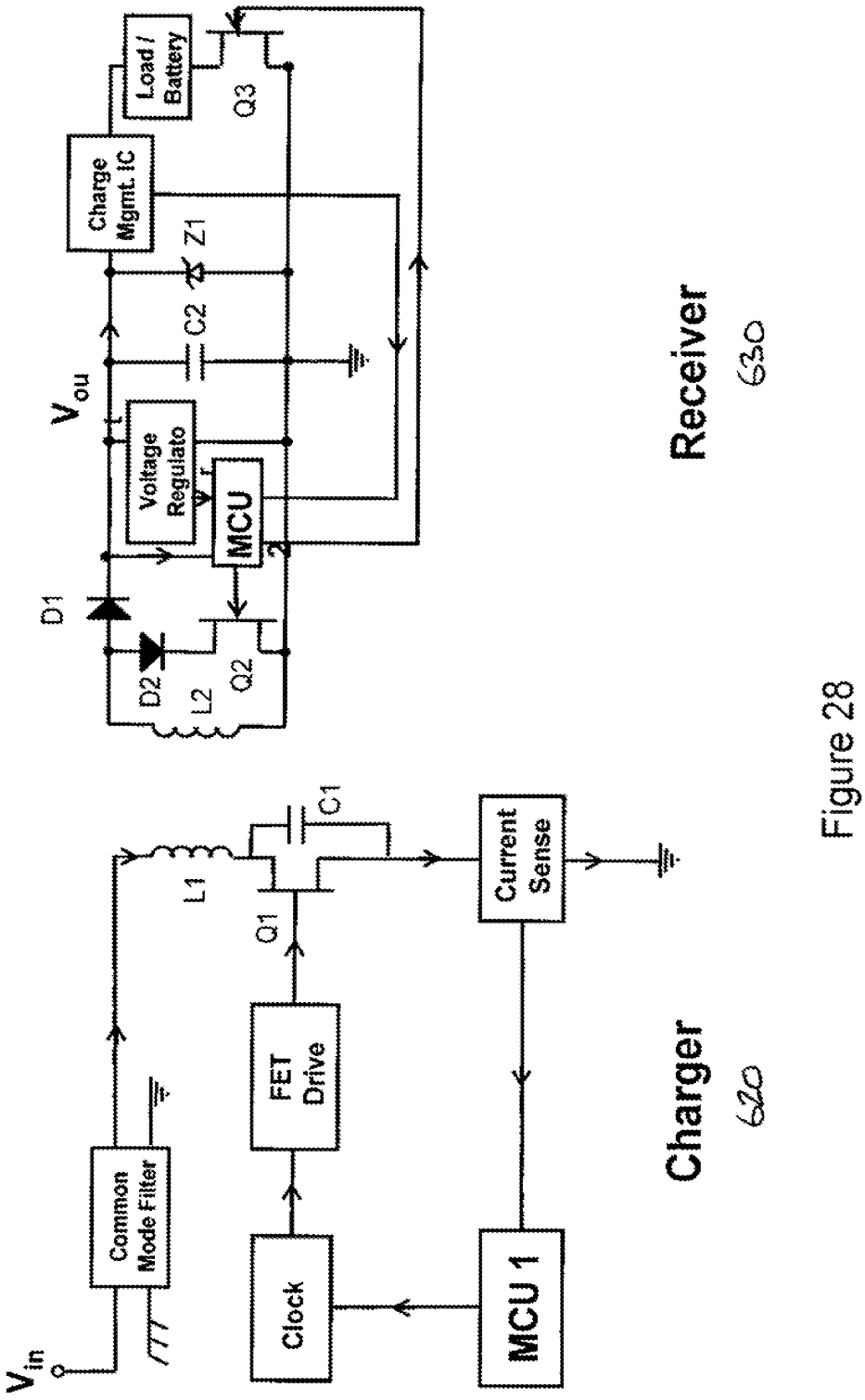
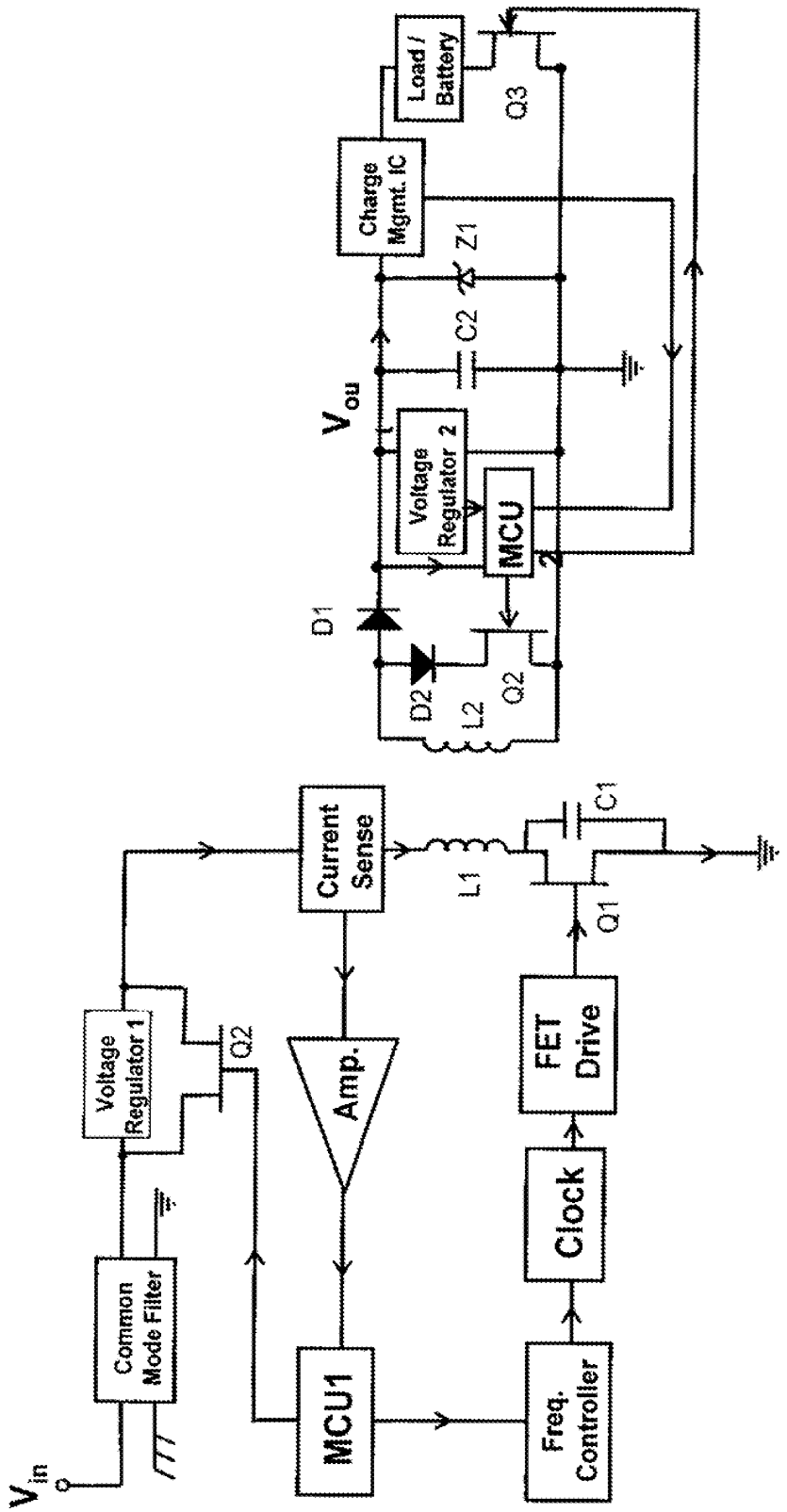

Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
V_{ou}
Voltage Regulato
MCU
D1
D2
L2
Q2
Receiver
630
C1
L1
Q1
Current Sense
FET Drive
Common Mode Filter
Clock
MCU 1
V_{in}
Charger
620

Figure 28


Receiver
Charger
640
Figure 29
Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
V_{out}
Voltage Regulator 2
MCU
D1
D2
L2
Q2
Current Sense
L1
C1
Q1
FET Drive
Clock
Amp.
Voltage Regulator 1
Q2
Common Mode Filter
MCU1
Freq. Controller
V_{in}

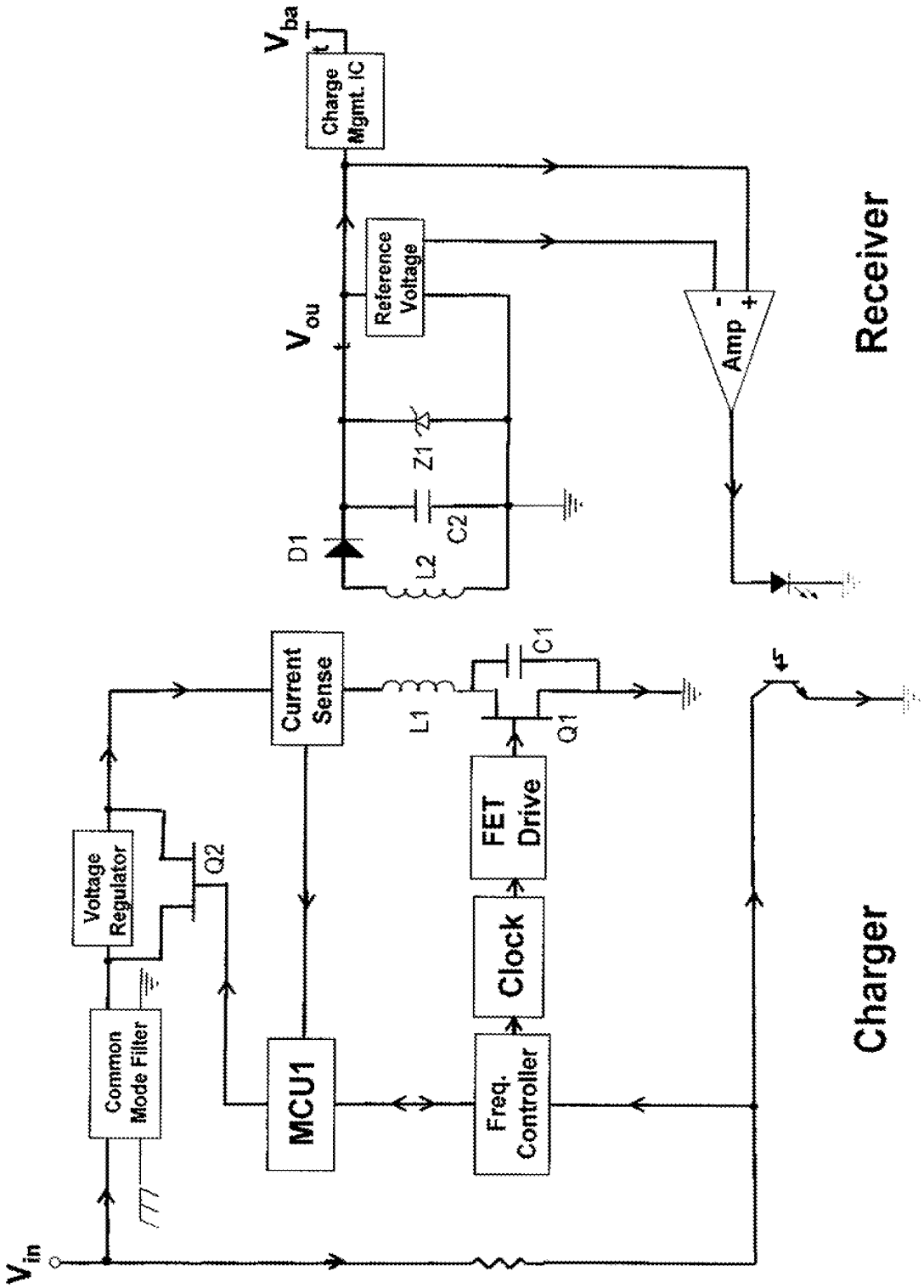

V_{ba}
Charge Mgmt. IC
V_{ou}
Reference Voltage
Amp
Receiver
650
Z1
C2
D1
L2
Current Sense
L1
C1
Q1
FET Drive
Clock
Voltage Regulator
Q2
Common Mode Filter
MCU1
Freq. Controller
Charger
V_{in}

Figure 30

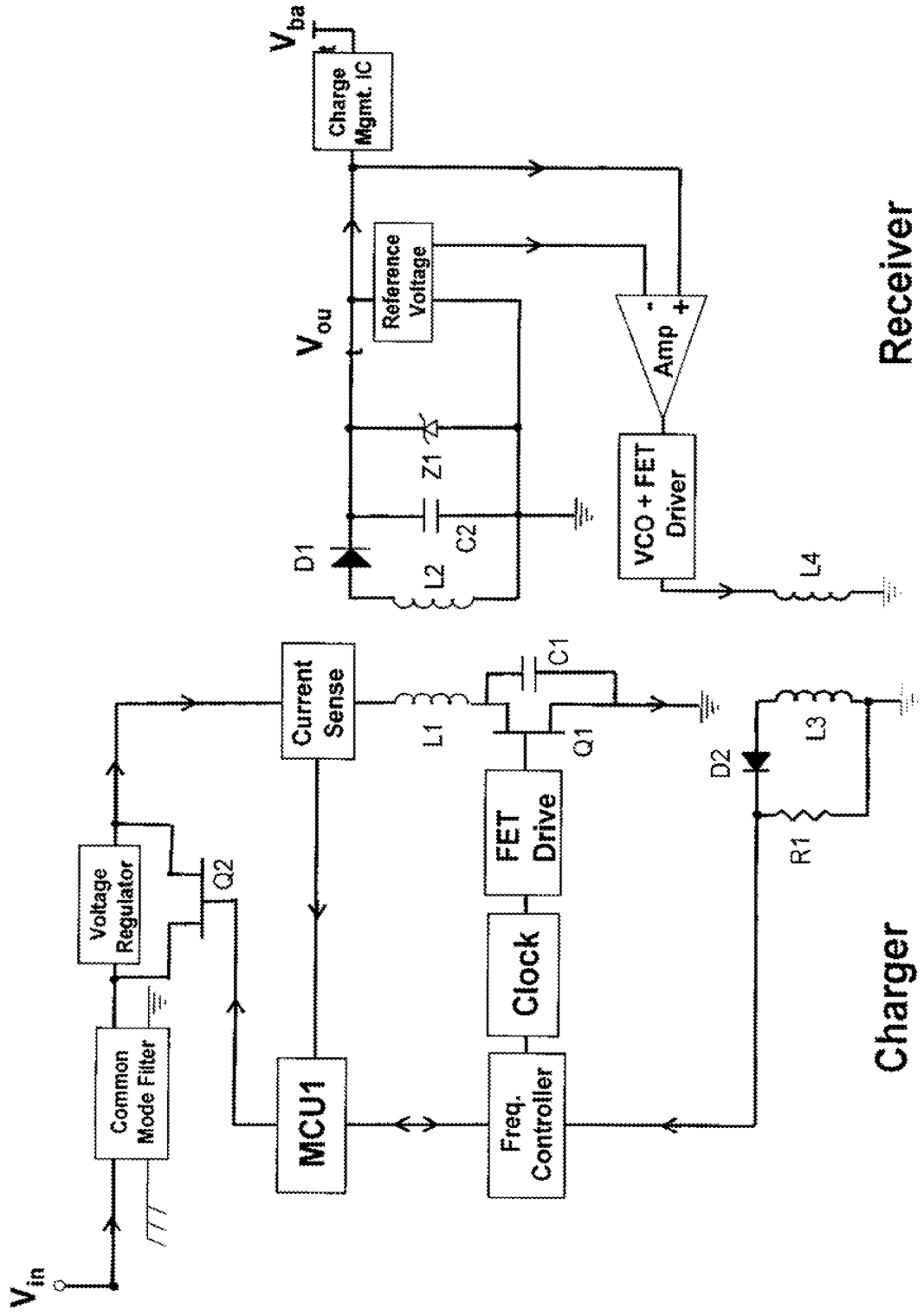

V_ba
Charge Mgmt. IC
V_ou
Reference Voltage
Amp
Receiver
Z1
C2
D1
L2
VCO + FET Driver
L4
660
Current Sense
L1
C1
Q1
D2
L3
R1
FET Drive
Clock
Freq. Controller
MCU1
Voltage Regulator
Q2
Common Mode Filter
V_in
Charger

Figure 31

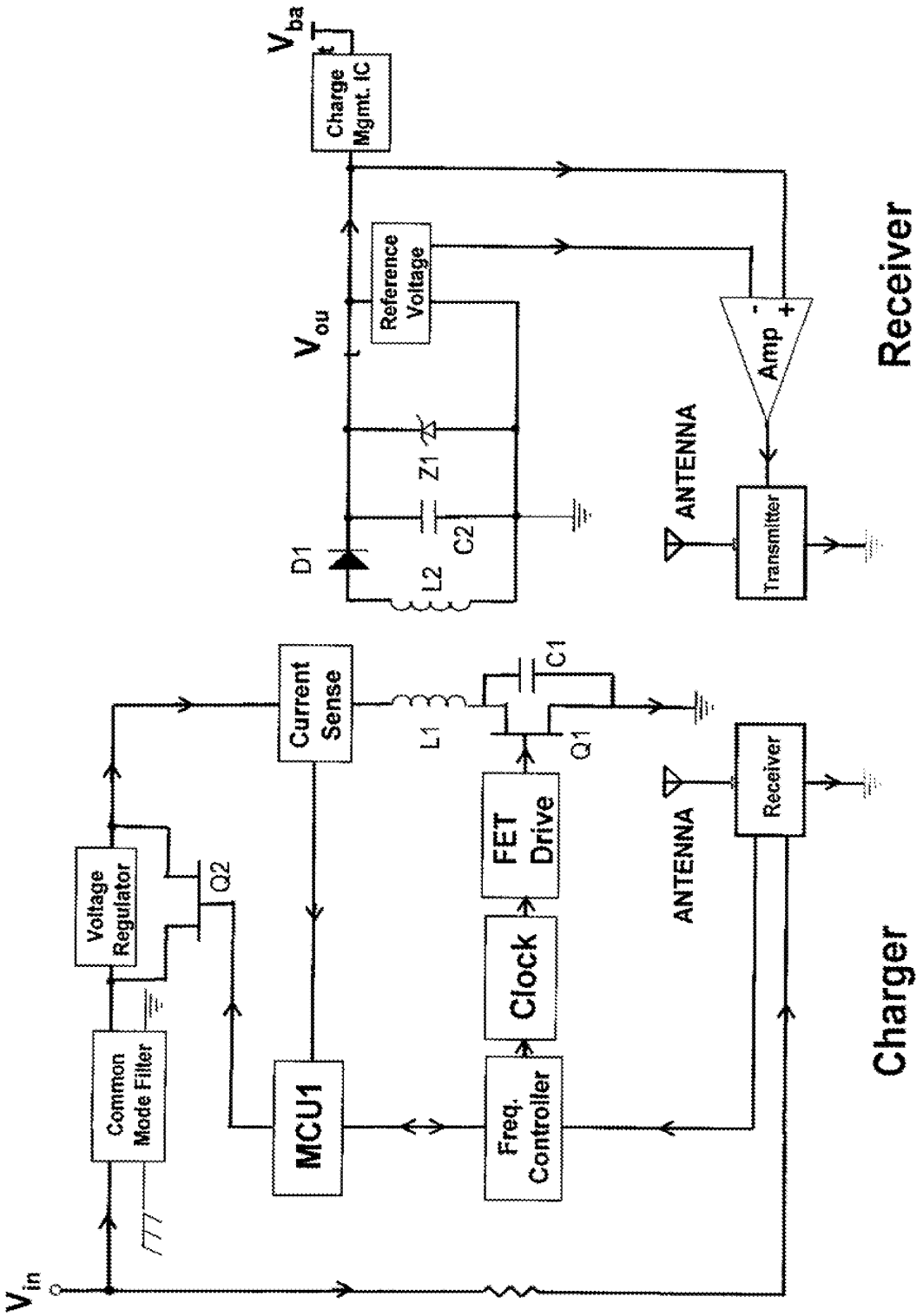

Charger
Receiver
V_{in}
V_{ba}
V_{ou}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
C1
Q1
FET Drive
Clock
Freq. Controller
ANTENNA
Receiver
Charge Mgmt. IC
Reference Voltage
D1
L2
C2
Z1
Amp
ANTENNA
Transmitter
670

Figure 32

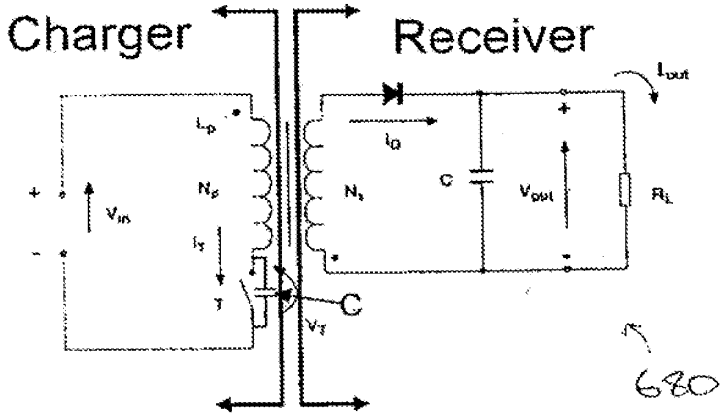


FIG. 33

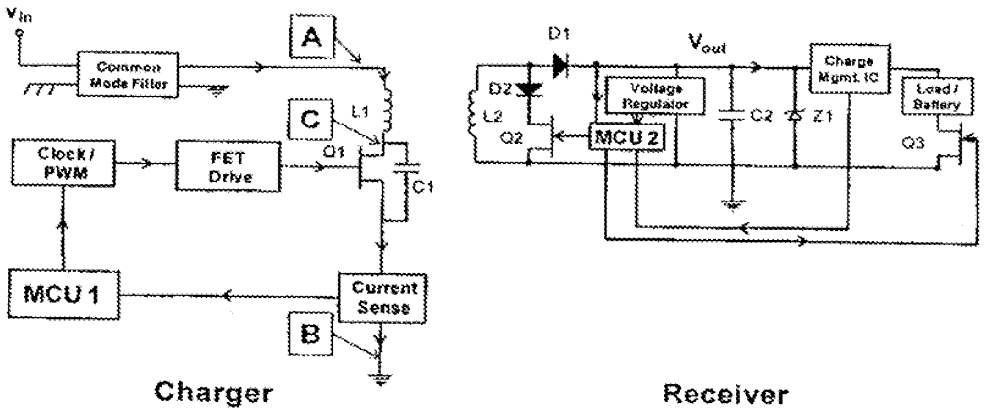


FIG. 34

700

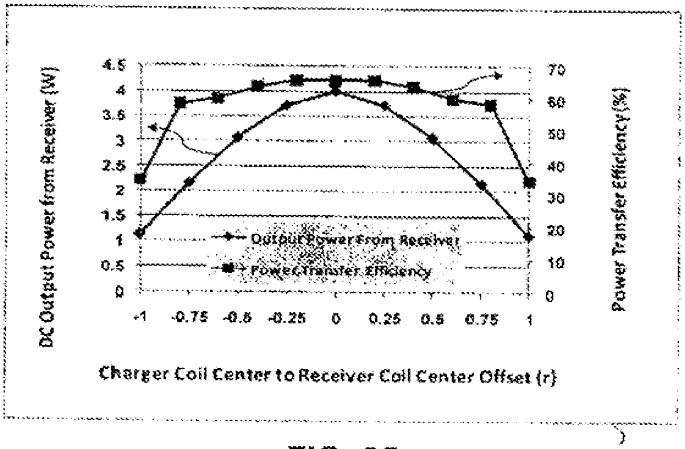


FIG. 35

720

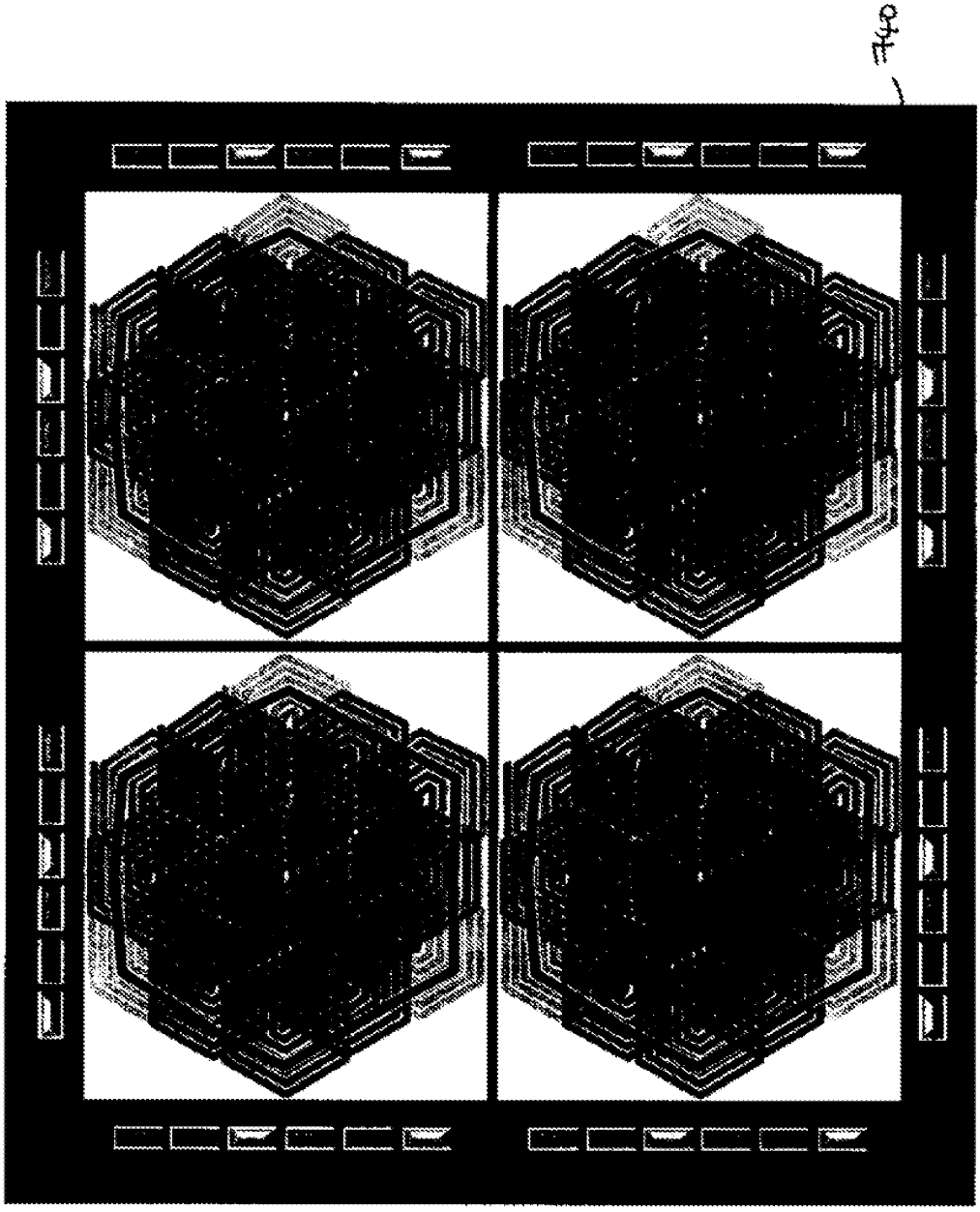


Figure 36

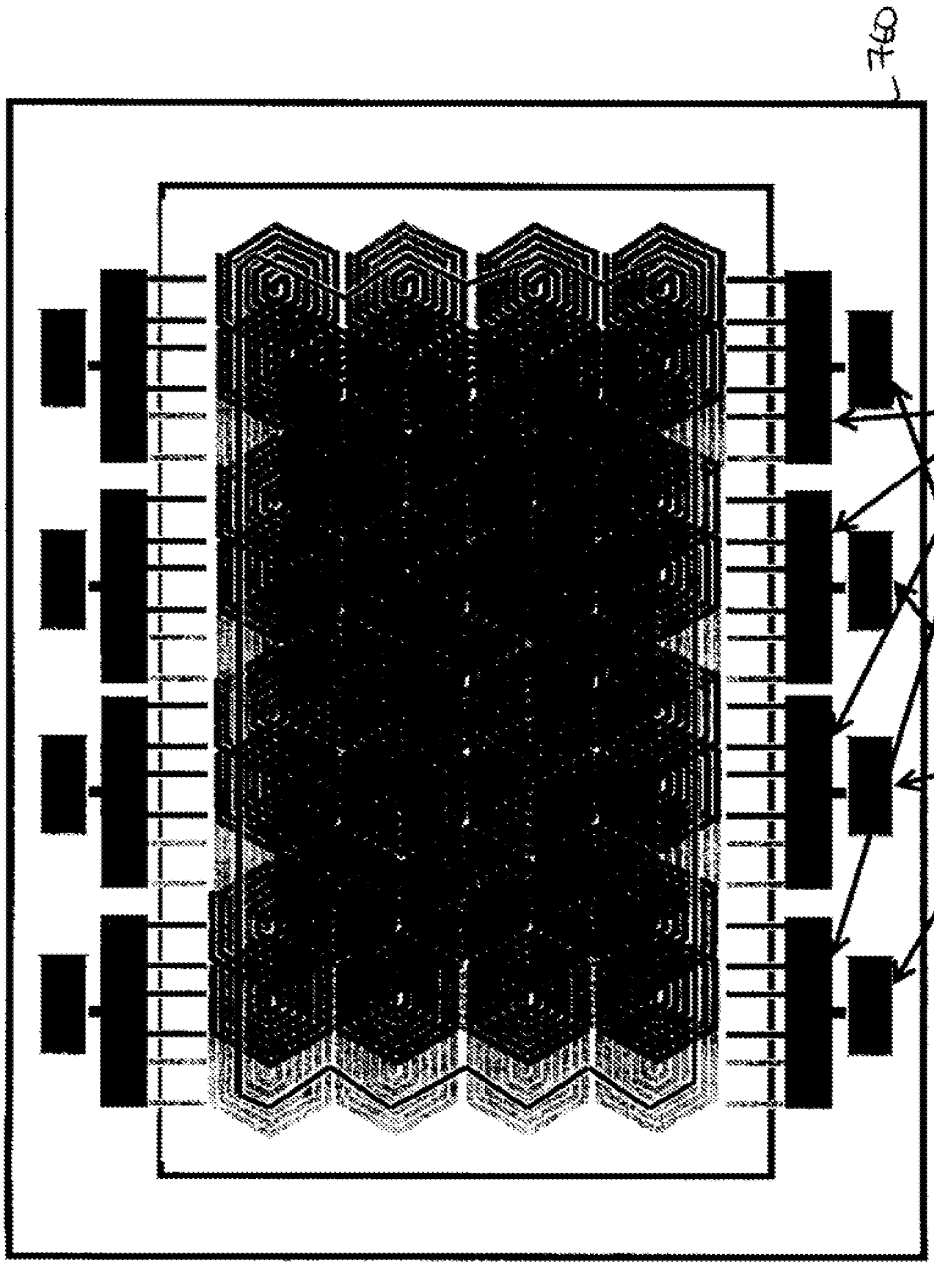


Figure 37

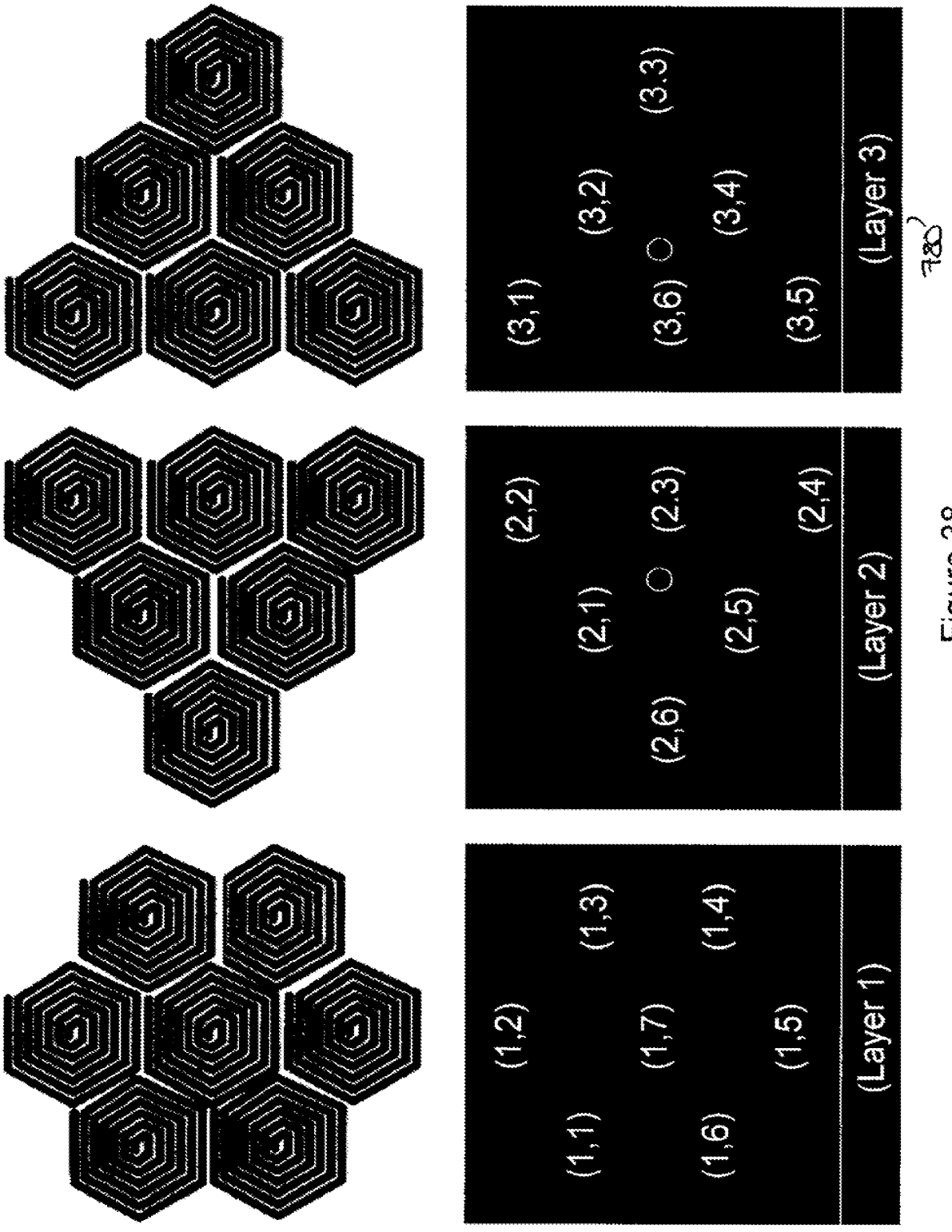

(1,1)
(1,2)
(1,3)
(1,4)
(1,5)
(1,6)
(1,7)
(Layer 1)
(2,1)
(2,2)
(2,3)
(2,4)
(2,5)
(2,6)
(Layer 2)
(3,1)
(3,2)
(3,3)
(3,4)
(3,5)
(3,6)
(Layer 3)
780

Figure 38

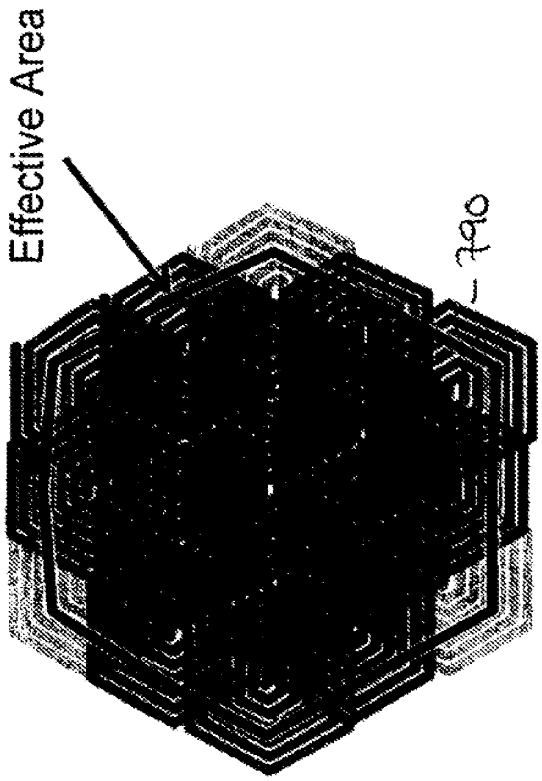


Figure 39

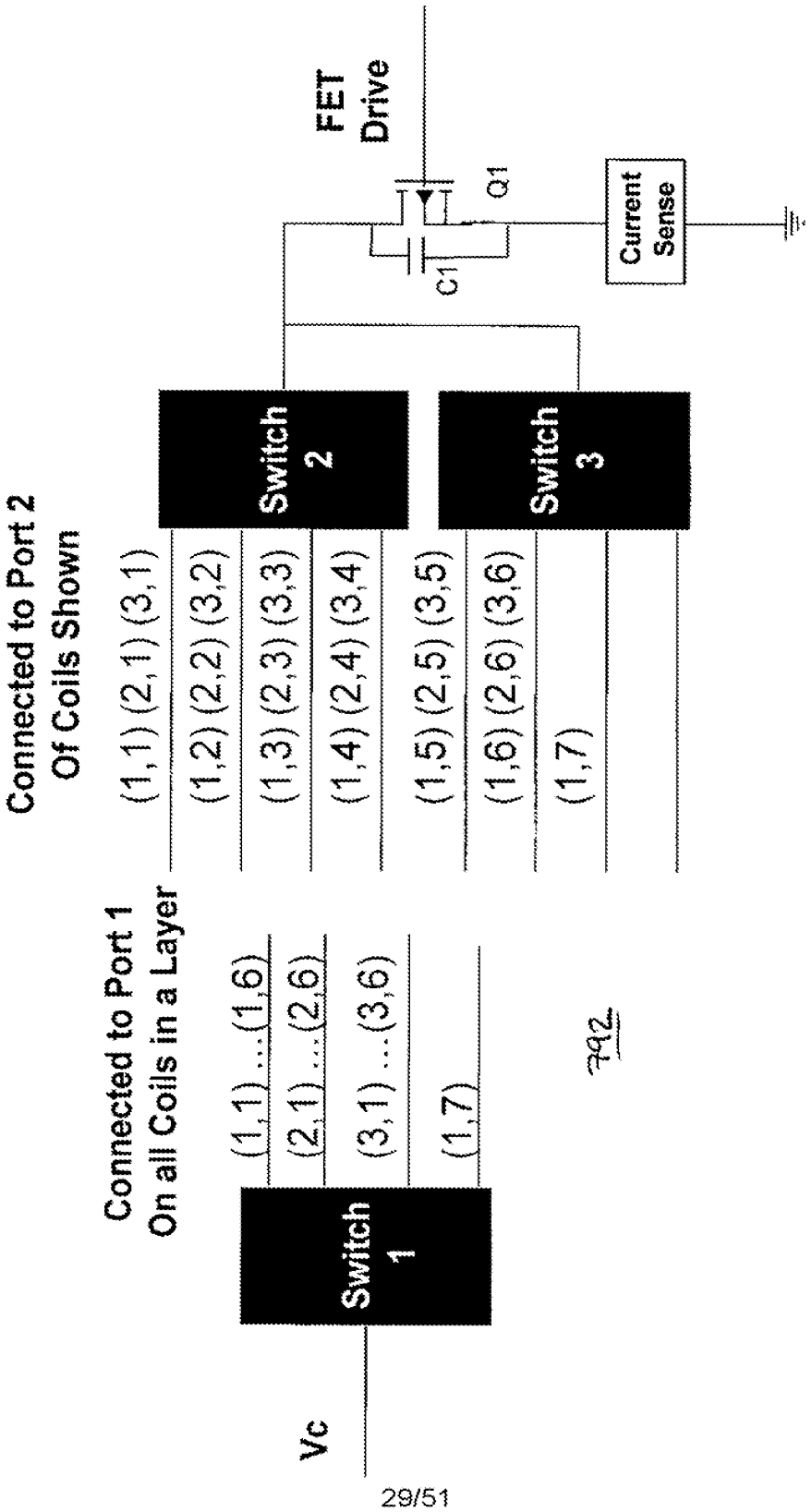

FET Drive
Q1
C1
Current Sense
Switch 2
Switch 3
Switch 1
Vc
Connected to Port 2
Of Coils Shown
(1,1) (2,1) (3,1)
(1,2) (2,2) (3,2)
(1,3) (2,3) (3,3)
(1,4) (2,4) (3,4)
(1,5) (2,5) (3,5)
(1,6) (2,6) (3,6)
(1,7)
Connected to Port 1
On all Coils in a Layer
(1,1) ...(1,6)
(2,1) ...(2,6)
(3,1) ...(3,6)
(1,7)
792

Figure 40

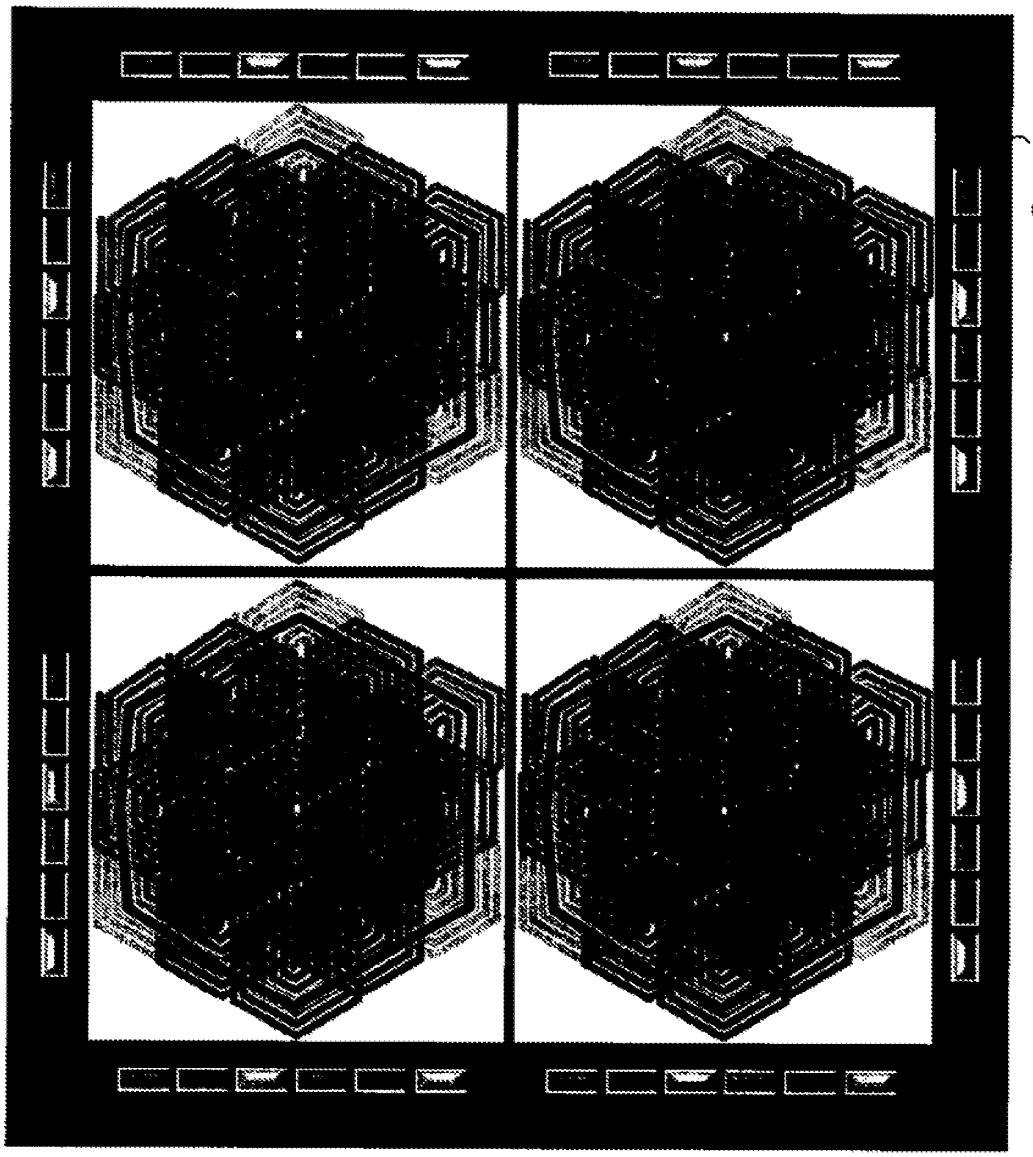


Figure 41

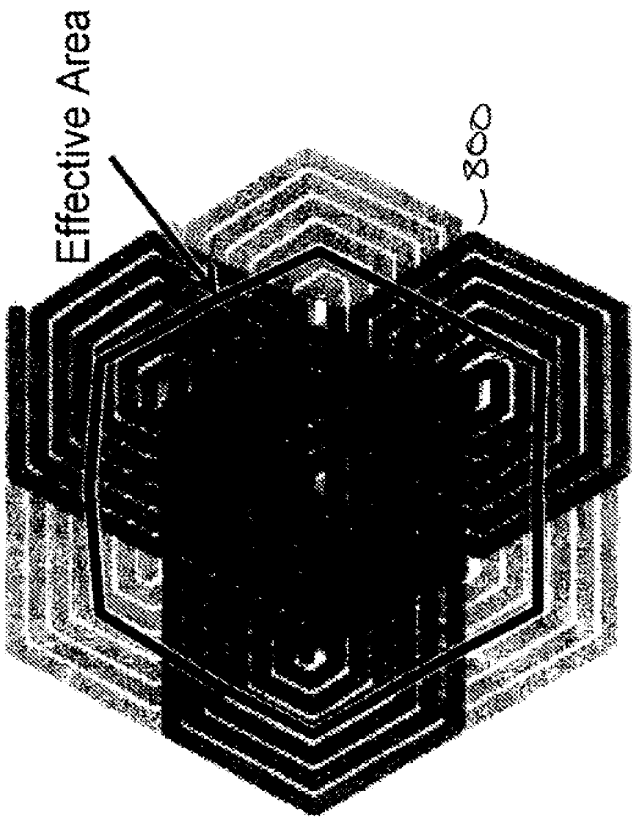


Figure 42

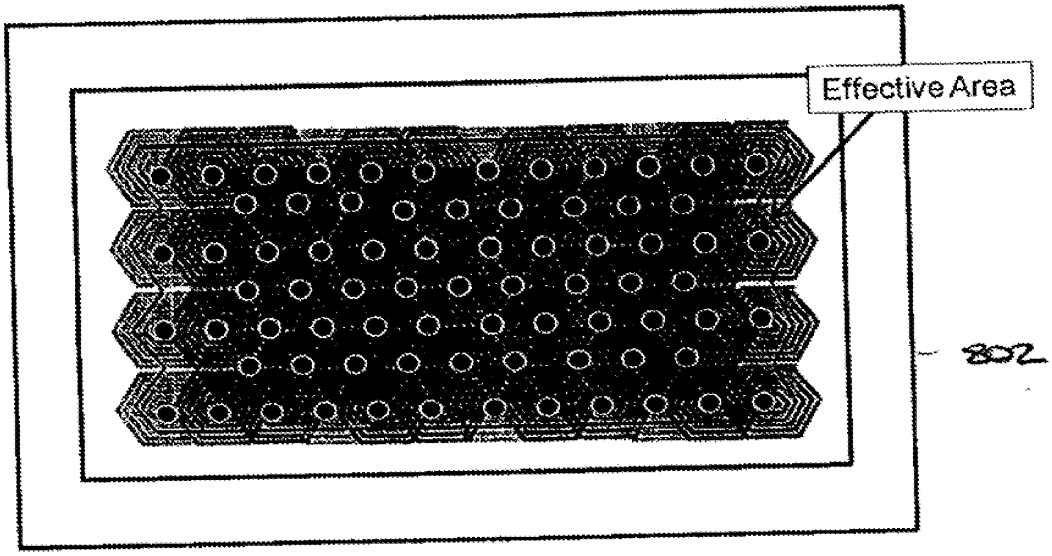

Effective Area
802

FIG. 43

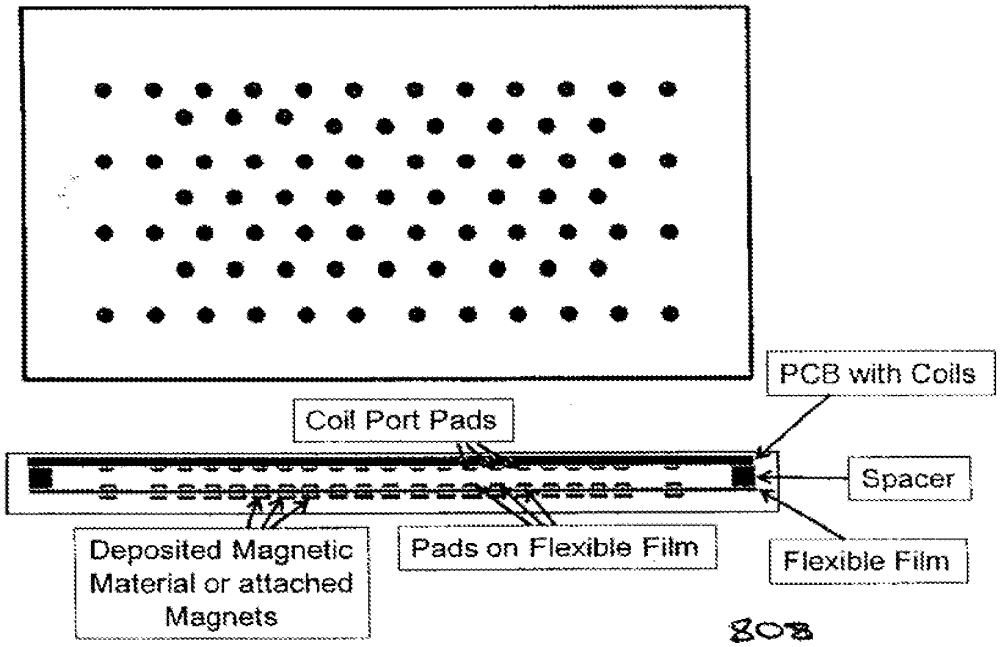

PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film
808

FIG. 44

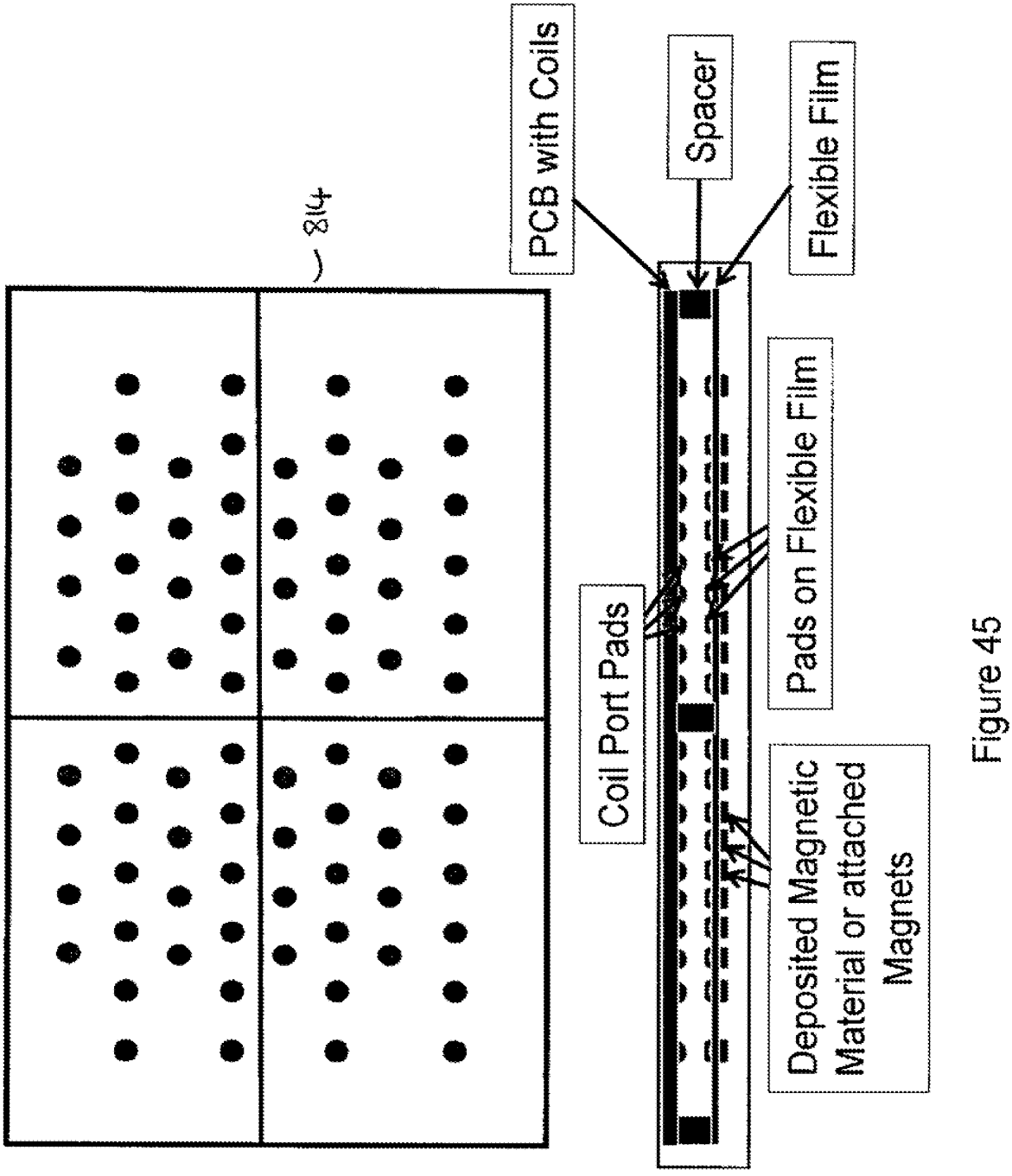
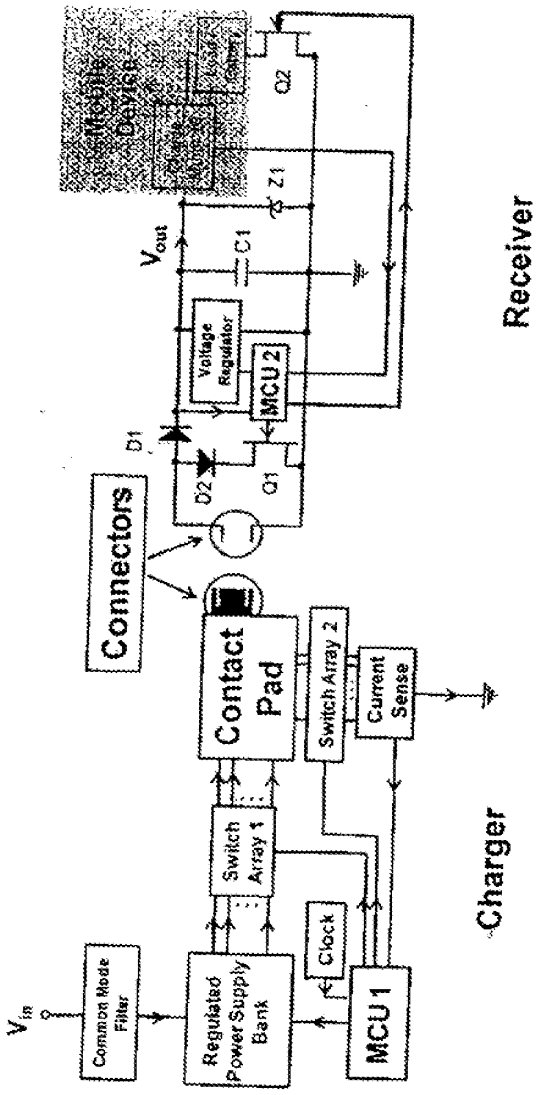
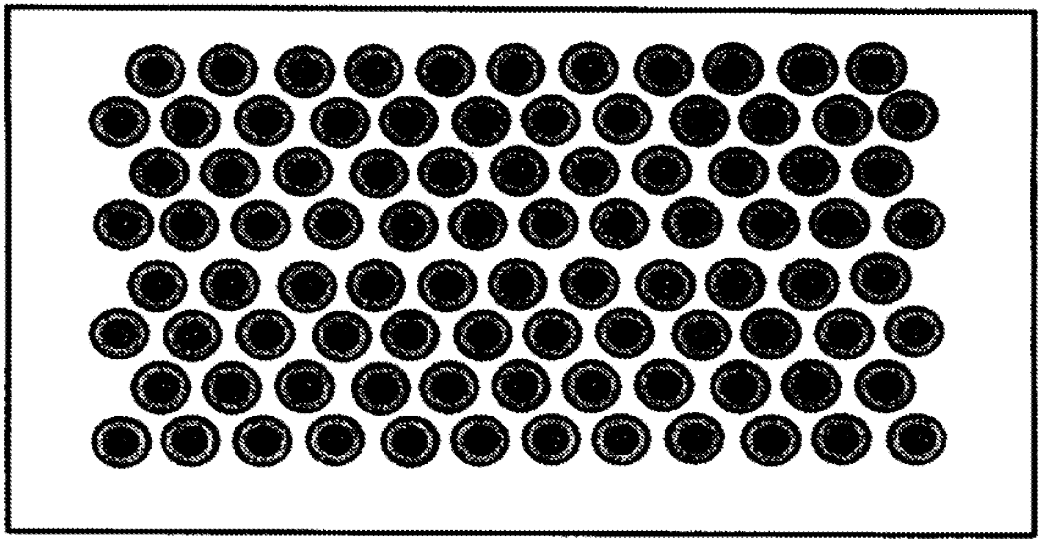

814
PCB with Coils
Spacer
Flexible Film
Coil Port Pads
Pads on Flexible Film
Deposited Magnetic Material or attached Magnets

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



824

FIG. 47

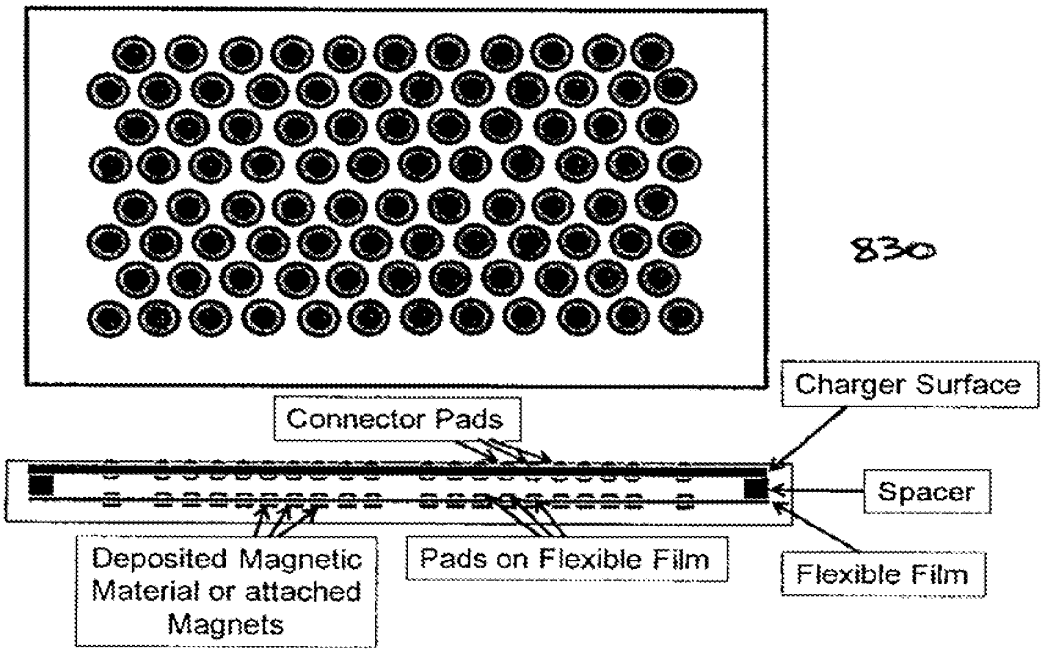


FIG. 48

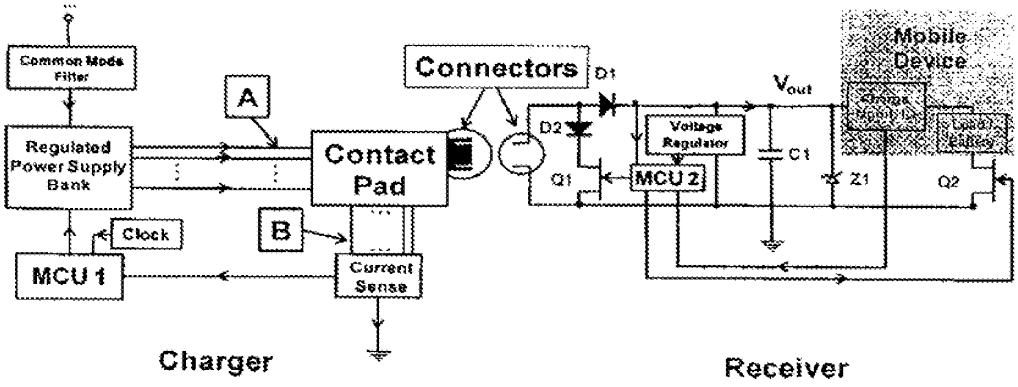


FIG. 49

836

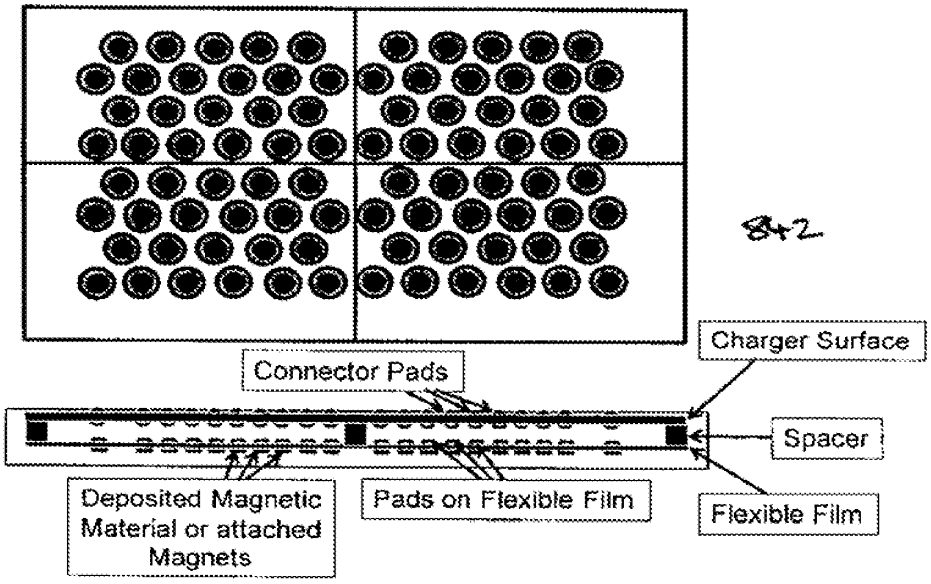
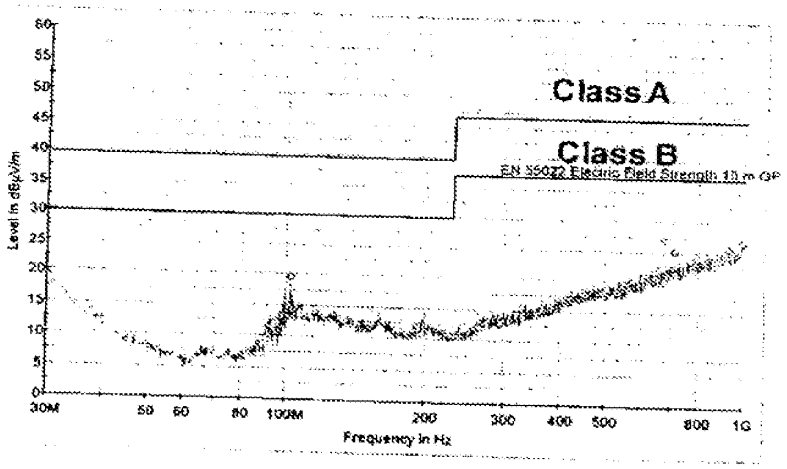
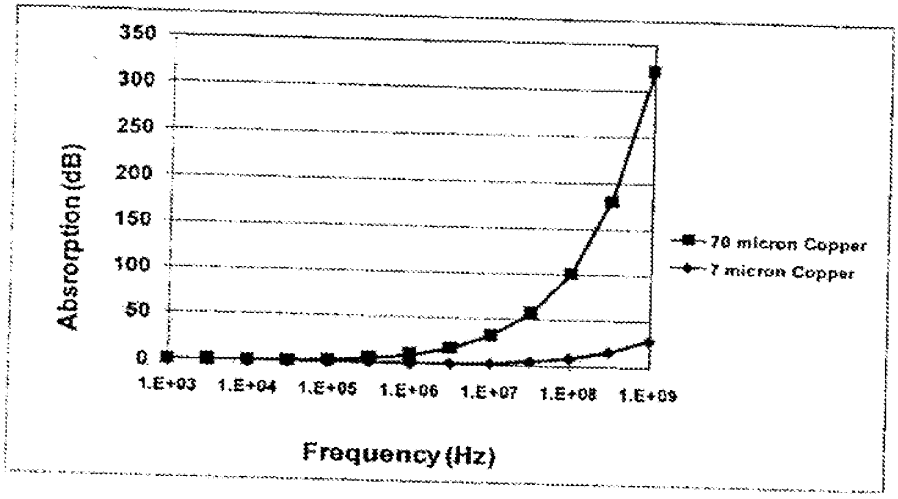


FIG. 50



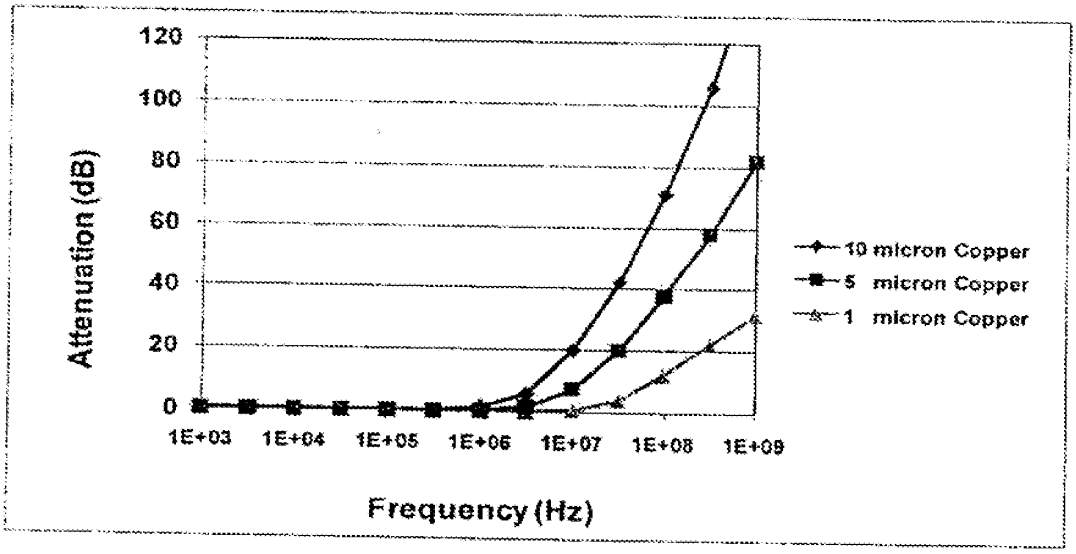
846

FIG. 51

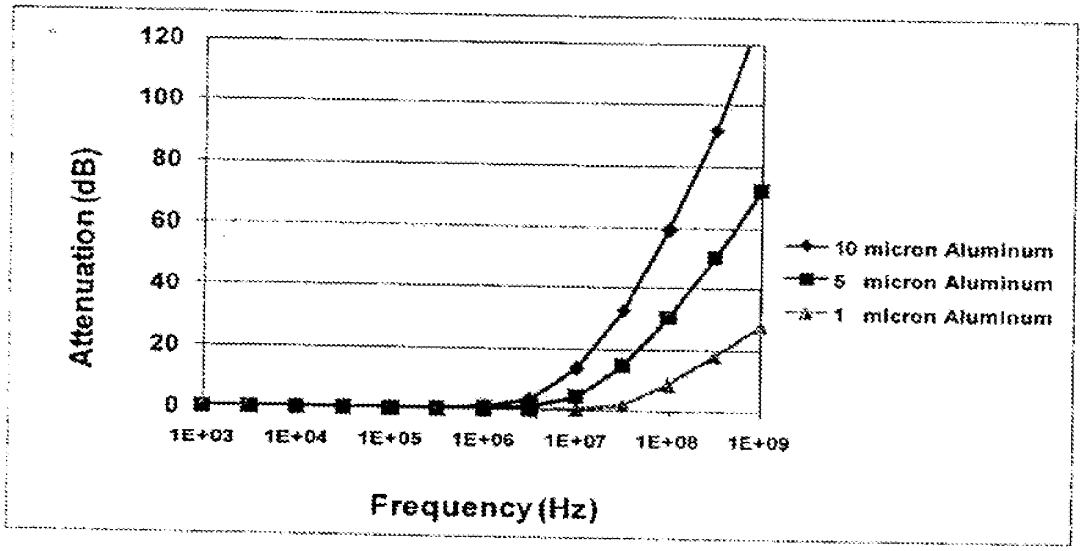


850

FIG. 52



854



856

FIG. 53

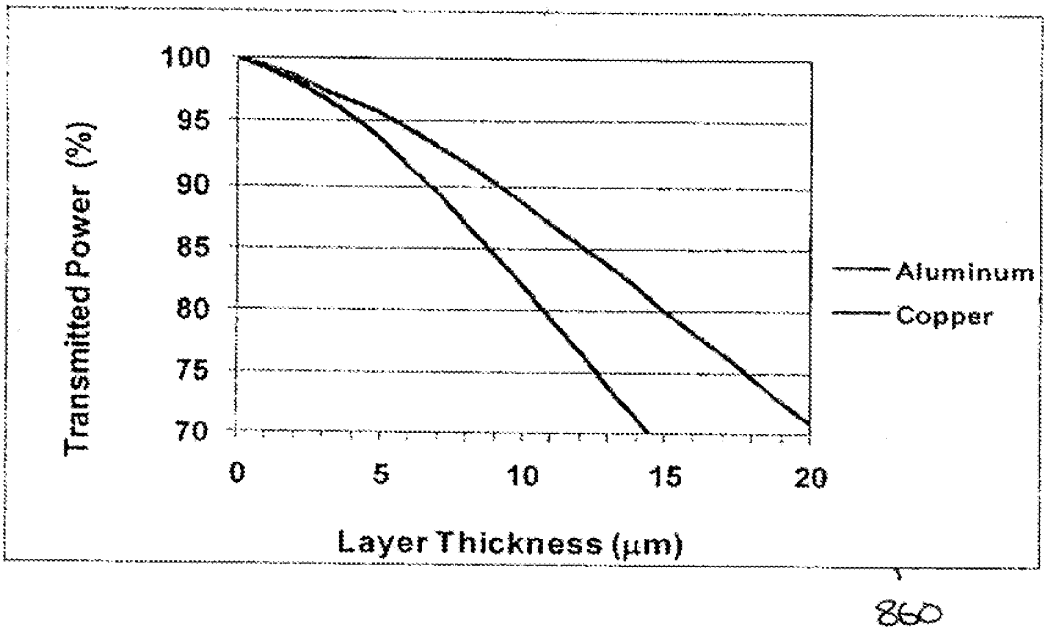

100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper
860

FIG. 54

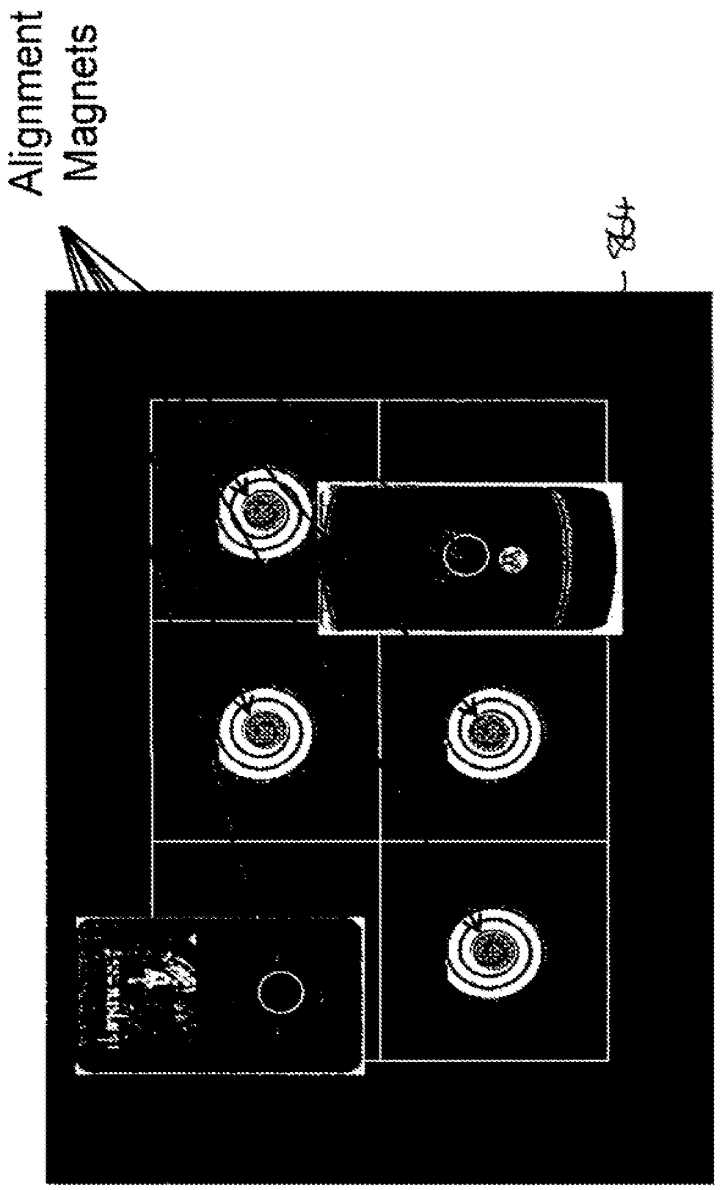


Figure 55

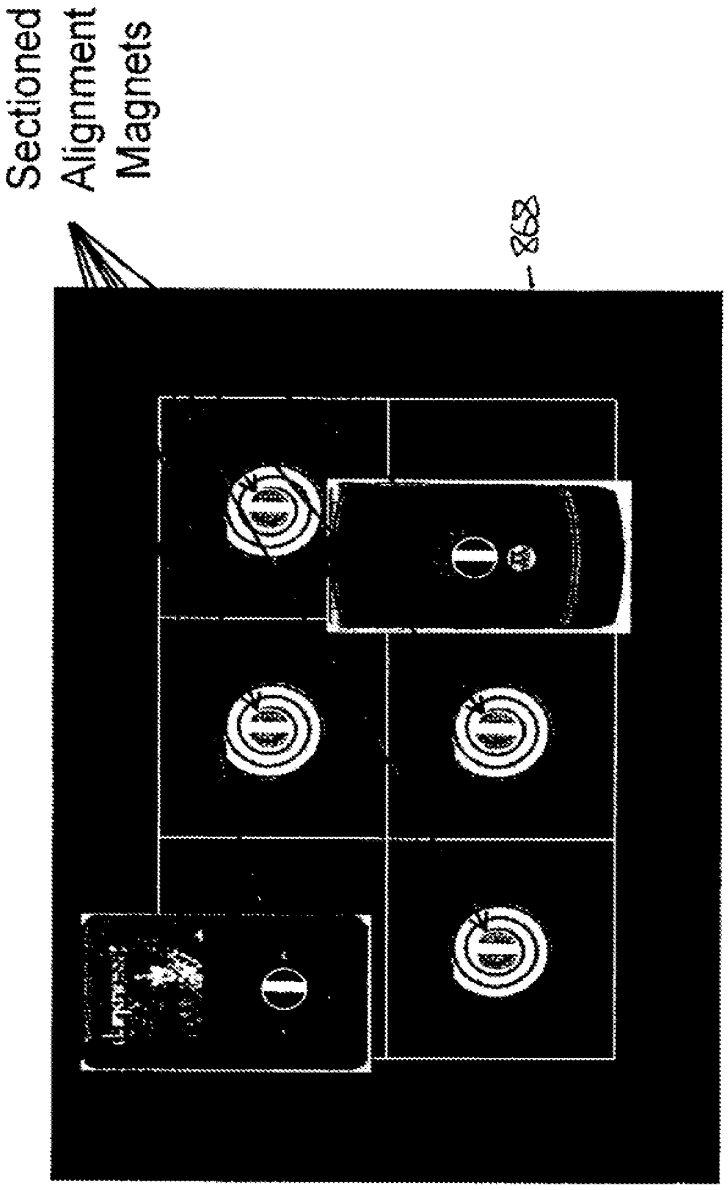


Figure 56

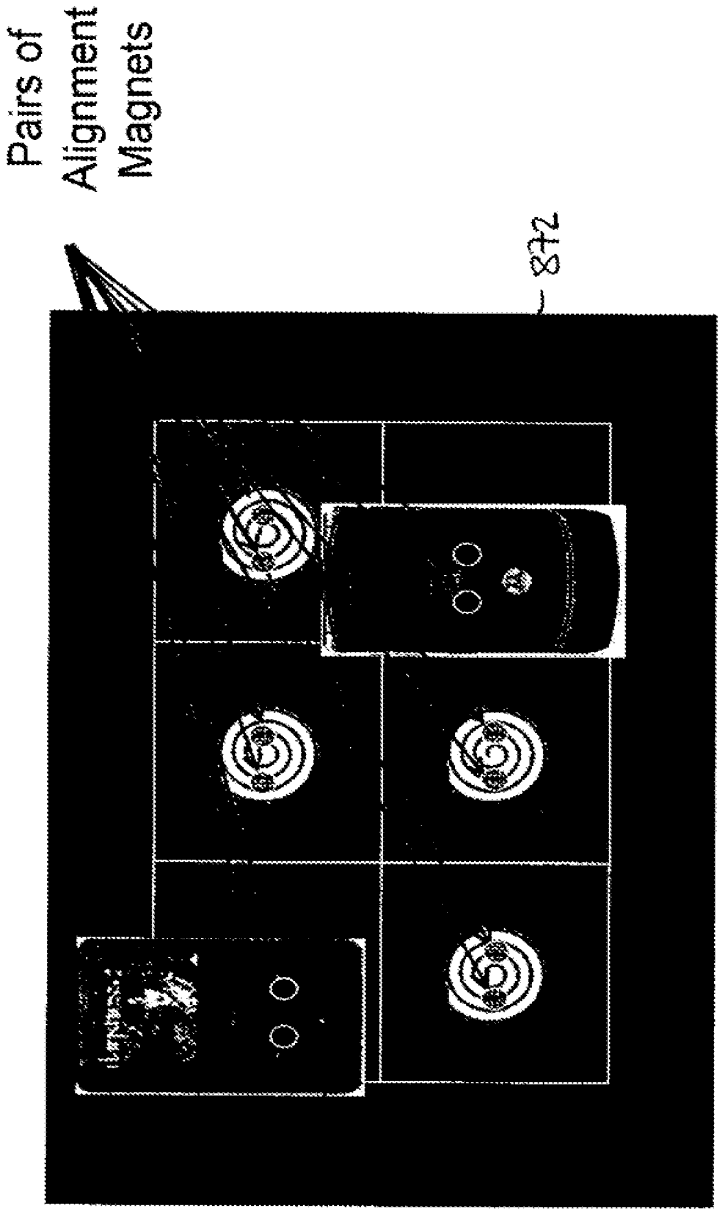


Figure 57

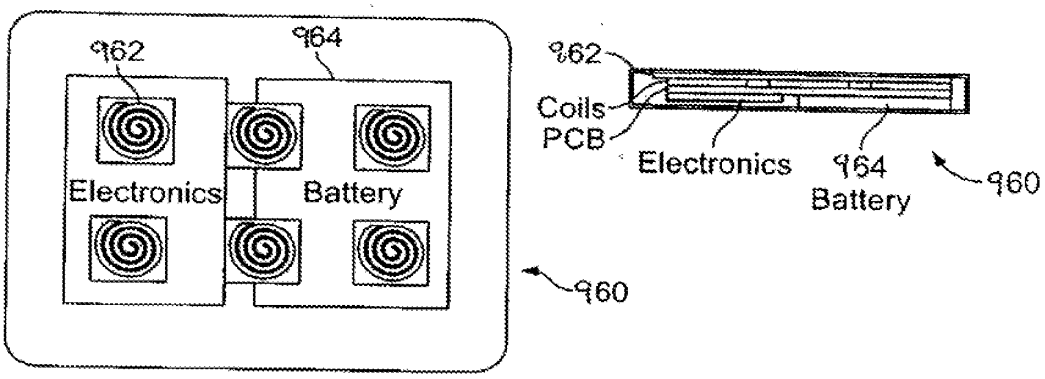

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

FIG. 58

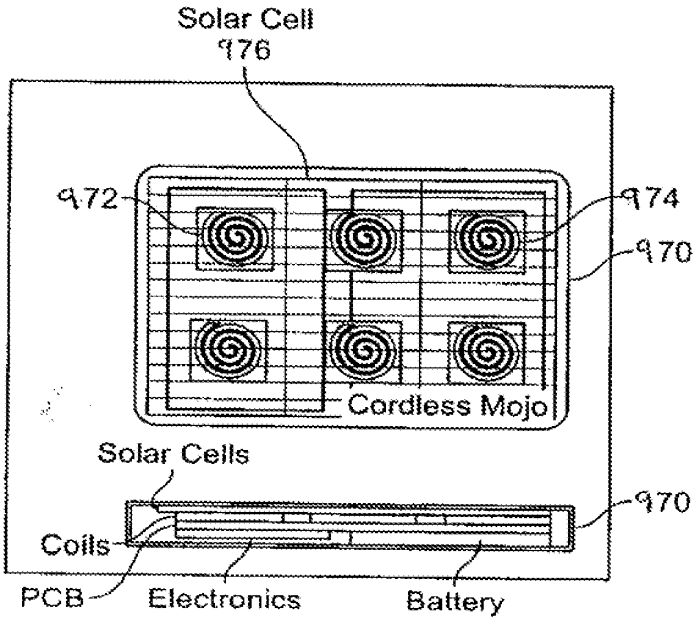

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

FIG. 59

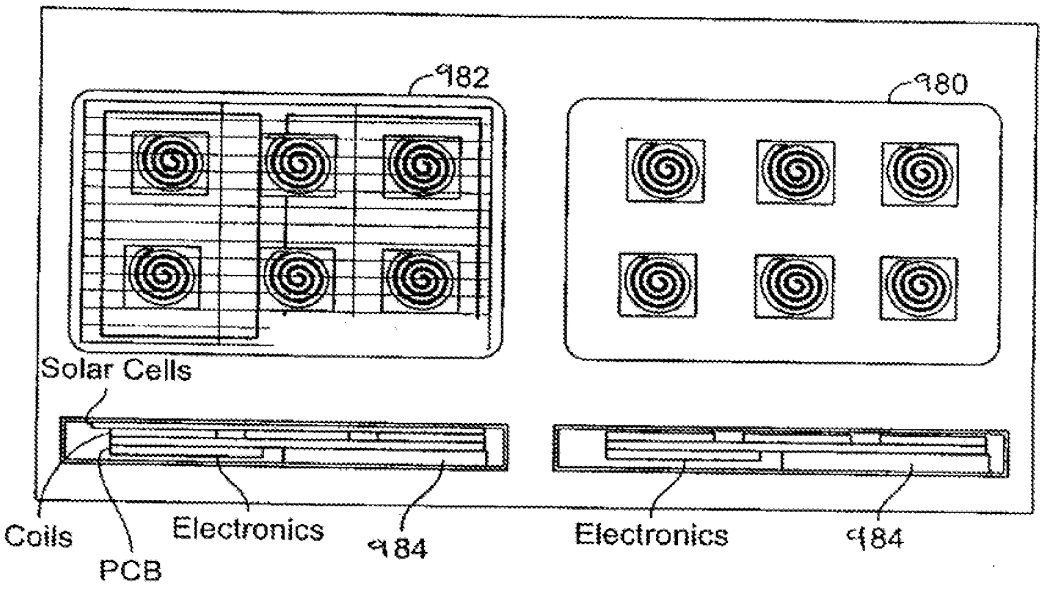

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

FIG. 60

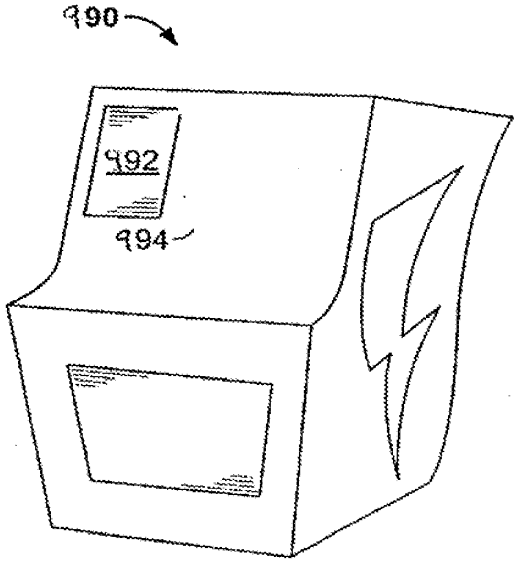

990
992
994

FIG. 61



FIG. 62

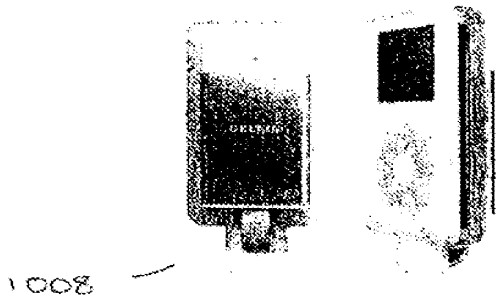


FIG. 63

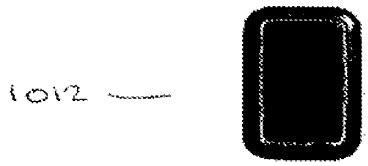


FIG. 64

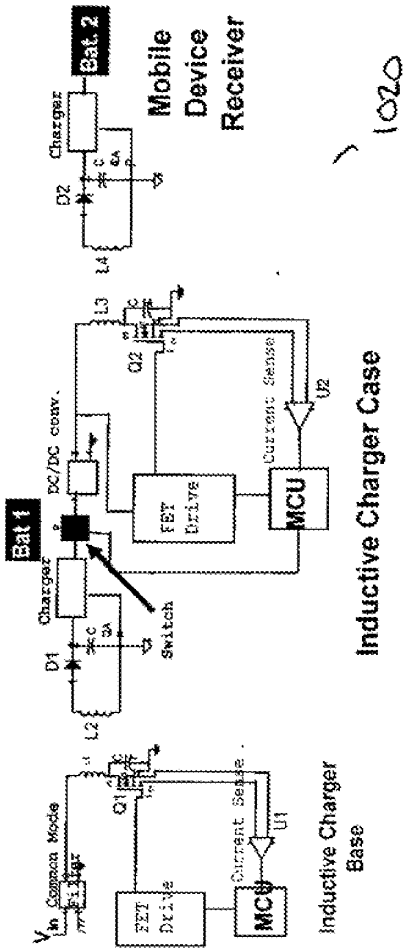

Mobile Device Receiver
1020
Bat. 2
Charger
D2
L4
L3
Q2
DC/DC conv.
Current Sense
U2
FET Drive
MCU
Bat 1
Charger
Switch
D1
L2
Inductive Charger Case
Q1
Current Sense
U1
Common Mode Filter
FET Drive
MCU
Inductive Charger Base

Figure 65

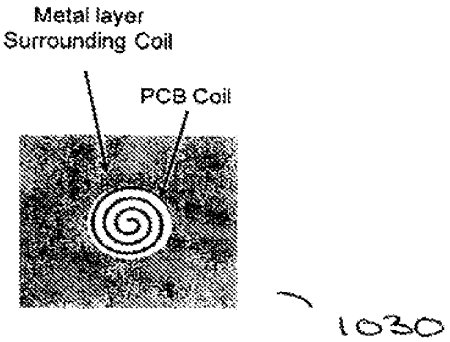


Figure 66

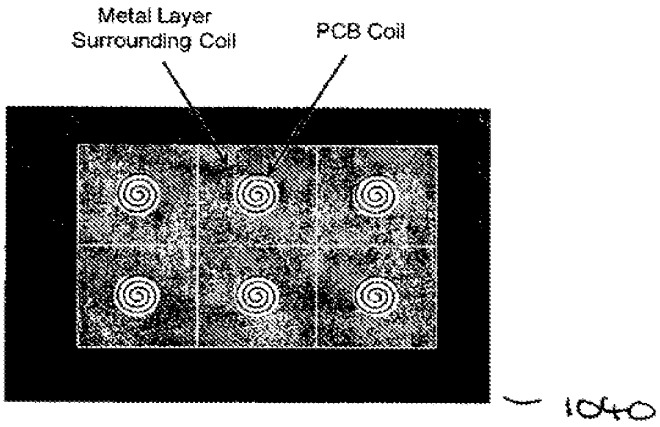


Figure 67

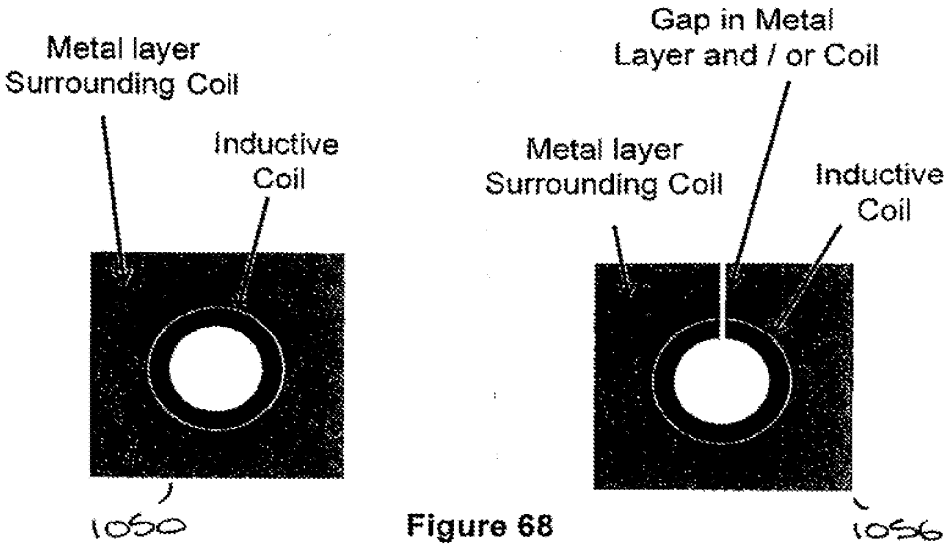


Figure 68

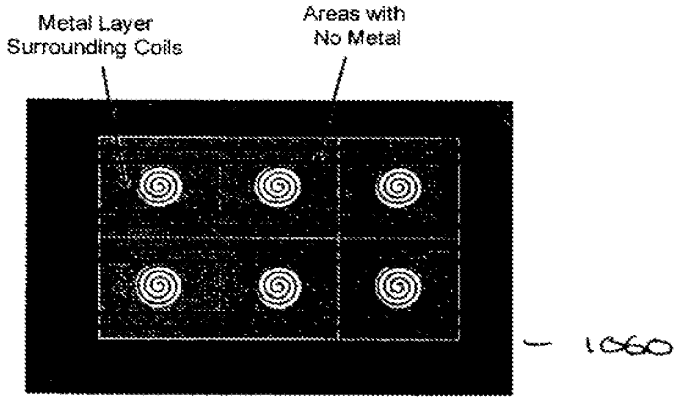
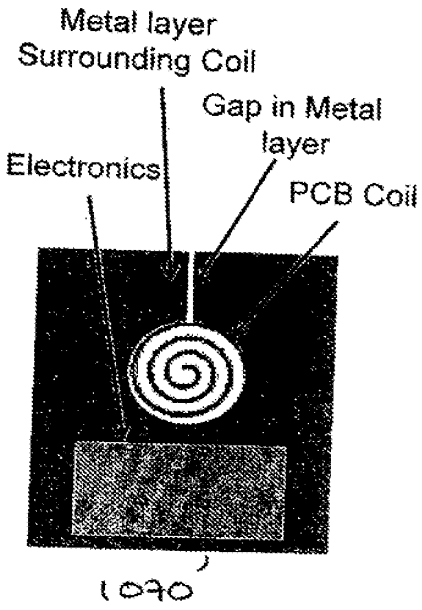


Figure 69



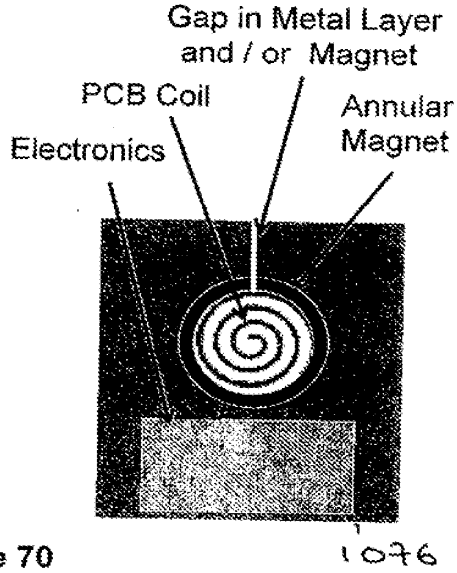


Figure 70

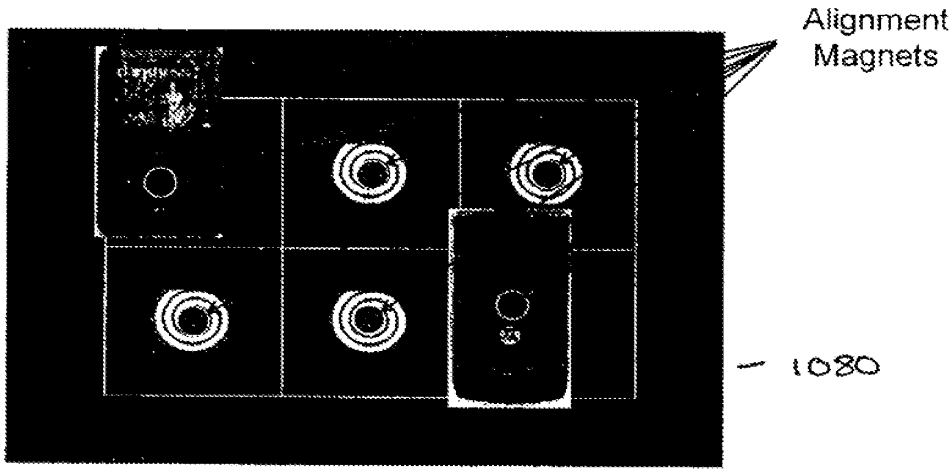


Figure 71

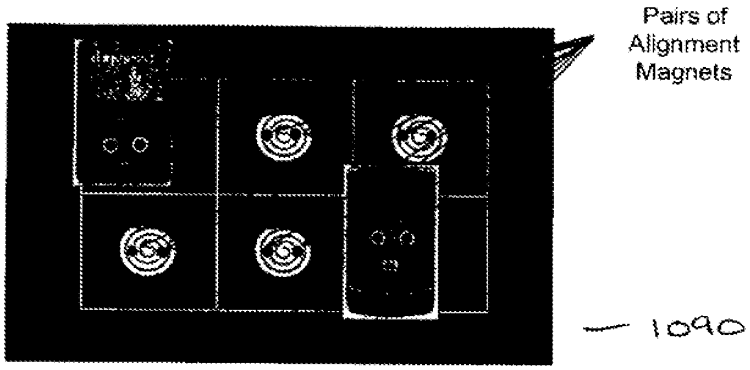


Figure 72

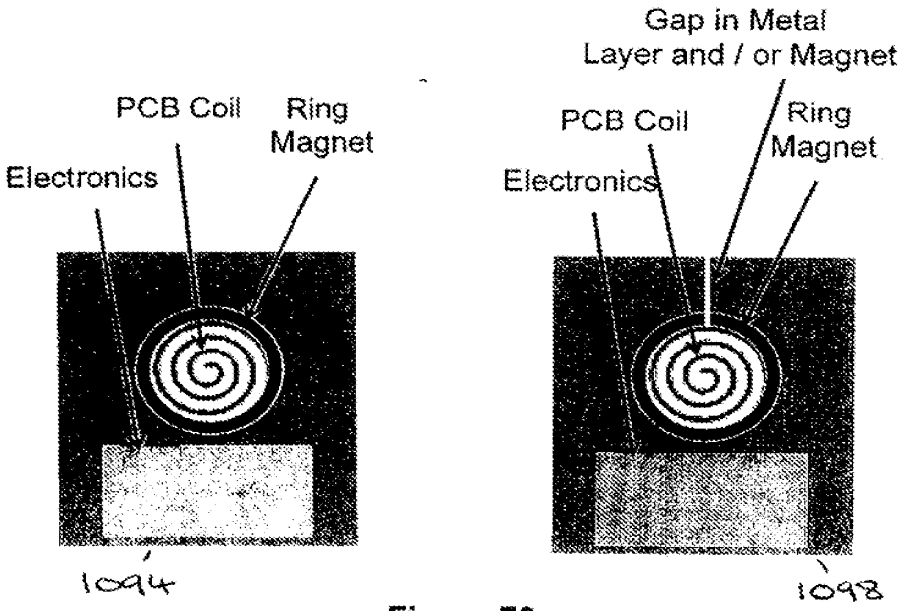


Figure 73

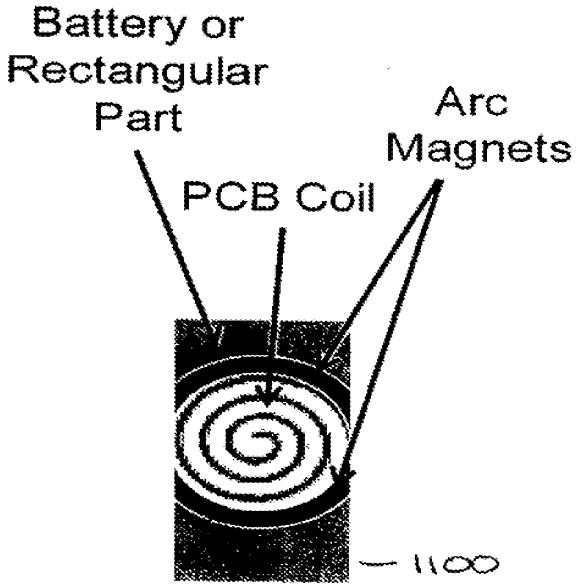


Figure 74

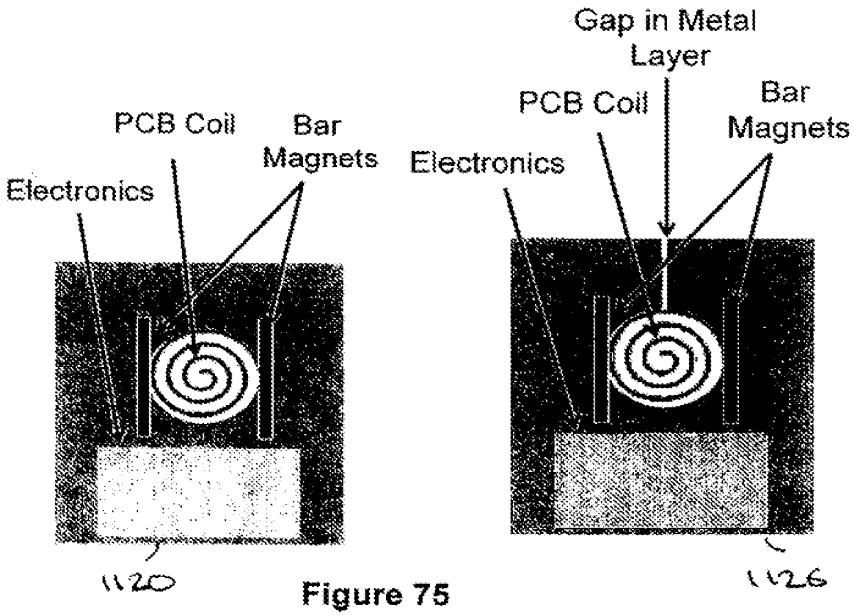


Figure 75

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

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* **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 pποπfy 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)

Electronic Patent Application Fee Transmittal

Application Number:	11757067
Filing Date:	01-Jun-2007
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Filer:	Karl Kenna/Maria Torres
Attorney Docket Number:	AFPA-01001US1

Filed as Small 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:				
Utility Appl issue fee	2501	1	755	755
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**1235**

Electronic Acknowledgement Receipt	
EFS ID:	9480572
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/Maria Torres
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	18-FEB-2011
Filing Date:	01-JUN-2007
Time Stamp:	17:32:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1235
RAM confirmation Number	4295
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	Issue Fee Payment (PTO-85B)	AFPA1001US1_Issue_Fee_Transmittal.pdf	248625 1b8006eb1e5e141e58ea6082de544495f4dd7191	no	1
Warnings:					
Information:					
2	Transmittal Letter	afpa_1001us1_IDS_Transmittal_Letter.pdf	131503 ab119a551a80631fc0f17f2ad29cb0bcd348db52	no	3
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Filed (SB/08)	afpa_1001us1_IDS_List.pdf	775404 f8daf9d36f596e58ccbb41d1e819fea13f0903d2	no	4
Warnings:					
Information:					
4	NPL Documents	IntlSearchReport_PCTUS2010032845.pdf	275440 55984226b510e5175f745fc6401b46fce0663790	no	10
Warnings:					
Information:					
5	Foreign Reference	KR_100836634.pdf	9642076 02fc9ba7eb815e5d2228bf5a4d54cb275f49900e	no	22
Warnings:					
Information:					
6	Foreign Reference	PCTUS2010032845_20101211658221.pdf	2825055 6015dc82995d66769db2473da14f85b2cea00f24	no	148
Warnings:					
Information:					
7	Fee Worksheet (PTO-875)	fee-info.pdf	33522 7cf5b4f54a9195bc4f794e8d0ca3b00d3d1b7b47	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	13931625		

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.

Form PTO-1449 (Substitute)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	Attorney Docket Number AFPA-01001US1	Application/Patent Number 11/757,067
		Applicant/Patent Owner Afshin Partovi	
	Information Disclosure Statement **BY APPLICANT** *(Use several sheets if necessary)*	Filing/Issue Date 06/01/2007	Group Art Unit Unknown

U.S. PATENTS							
Examiner Initial		Patent Number	Issue Date	First Named Inventor	Class	Subclass	Filing Date
/R.R./		6906495	6-14-05	Cheng			
		5959433	09-28-99	Rohde			
		6208115	03-27-01	Binder			
		5952814	9-14-99	Van Lerbergne			
		6489745	12-03-02	Koreis			
		6331744	12-18-01	Chen			
		6040680	03-21-00	~~Shoichi~~ Tonya			
		5734254	03-31-98	Stephens			
		6906495	06-14-05	Cheng			
		6586909	07-01-03	Trepka			
		6462509	10-08-02	Abe			
		7042196	05-09-06	~~Cheng~~ Ka-Lai			
		6184651	02-06-01	Fernandez			
		6016046	01-18-00	Kaite			
		7164255	01-16-07	Hui			
		6844702	01-18-05	Giannopoulos			
		6756765	06-29-04	Bruning			
		5367242	11-22-94	Hulman			
		6917182	07-12-05	Burton			
		6741064	05-25-04	Liu			
		6650088	11-18-03	Webb			
/R.R./		6697272	02-24-04	Nanbu			

CH 2-18-11

Receipt date: 07/27/2009

Form PTO-1449 (Substitute)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	Attorney Docket Number AFPA-01001US1	Application/Patent Number 11/757,067
	Information Disclosure Statement **BY APPLICANT** *(Use several sheets if necessary)*	Applicant/Patent Owner Afshin Partovi	
		Filing/Issue Date June 1, 2007	Group Art Unit 2838

U.S. PATENT PUBLICATIONS				
Examiner Initial		Patent Application Publication Number	Publication Date	Applicant
	7	20050007067	01-2005	Baarman
	8	20050093475	05-2005	Kuennen
	9	20050116650	06-2005	Baarman
	10	20050122058	06-2005	Baarman
	11	20050122059	06-2005	Baarman
	12	20050127849	06-2005	Baarman
	13	20050127850	06-2005	Baarman
	14	20060132045	06-2006	Baarman
2-18-11	15	~~2004011359~~ 20040135589	06-2004	Crisp
	16	20030094921	05-2003	Lau et al.
	17	20030103039	06-2003	Burr et al.
	18	20050127867	06-2005	Calhoon et al.
	19	20050189910	09-2005	Hui
	20	20040145342	07-2004	Lyon
	21	20050189910	09-2005	Hui

PENDING U.S. PATENT APPLICATIONS						
Examiner Initial		Application Number	Filing Date	First Named Inventor	Petition to Expunge? Yes | No	

FOREIGN PATENT DOCUMENTS									
Examiner Initial		Document Number	Publication Date	Country	Name	Class	Subclass	Trans-lation Yes | No	
	1	JP408000838	01-1996	JP	Sudo				

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R./

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
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BIB DATA SHEET

CONFIRMATION NO. 2001

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/757,067	06/01/2007	320	2858	AFPA-01001US1

APPLICANTS

AFSHIN PARTOVI, SUNNYVALE, CA;
Michael Sears, Ben Lomond, CA;

**** CONTINUING DATA ***************************

This appln claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/868,674 12/05/2006

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
06/22/2007

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /RAMY O RAMADAN/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	11	20	3

ADDRESS

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108
UNITED STATES

TITLE

POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

FILING FEE RECEIVED		
639	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).

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

23910 7590 02/14/2011

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER	
RAMADAN, RAMY O	
ART UNIT	**PAPER NUMBER**
2858	

NOTIFICATION DATE	DELIVERY MODE
02/14/2011	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

Supplemental Notice of Allowability	**Application No.** 11/757,067	**Applicant(s)** PARTOVI, AFSHIN	
	Examiner RAMY RAMADAN	**Art Unit** 2858	

-- 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 *the communication filed on 08/31/2010*.

2. ☒ The allowed claim(s) is/are *1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36*.

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

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Edward Tso/
Primary Examiner, Art Unit 2858

DETAILED ACTION

Inventorship

1. In view of the papers filed July 27, 2009, it has been found that this non-provisional application, as filed, through error and without deceptive intent, improperly set forth the inventorship, and accordingly, this application has been corrected in compliance with 37 CFR 1.48(a). The inventorship of this application has been changed by Michael Sears.

The application will be forwarded to the Office of Initial Patent Examination (OIPE) for issuance of a corrected filing receipt, and correction of Office records to reflect the inventorship as corrected.

Allowable Subject Matter

2. Claims 1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36 are allowed.

3. The following is an examiner's statement of reasons for allowance:

With respect to claim 1 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that decreases harmonics in that activated primary coil; and selectively switch, using their associated switching circuits to activate, only those one or more primary coils which are determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

With respect to claim 20 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, one or more capacitive or other components that decreases harmonics in the activated primary coil, and selectively switch, using their associated switching circuits to activate, only those primary coils which are determined to be in general alignment with a receiver coil at the device and/or battery.

With respect to claims 31 and 34 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that increases energy transfer efficiency by that activated primary coil; and selectively switch, using their associated switching circuits to activate, only that one or more primary coils which is determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

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.”

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAMY RAMADAN whose telephone number is (571) 272-9761. The examiner can normally be reached on Mon-Fri 7:30 am-5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, PATRICK ASSOUAD can be reached on (571) 272-2210. 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.

/Edward Tso/
Primary Examiner, Art Unit 2858

/Ramy Ramadan/
Examiner
Art Unit 2858

/RR/

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

23910 7590 11/18/2010

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER	
RAMADAN, RAMY O	
ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 11/18/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	02/18/2011

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 SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

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.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

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 11/18/2010

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

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.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

TITLE OF INVENTION: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	02/18/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAMADAN, RAMY O	2858	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 _____

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 (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:

❑ 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 credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information 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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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/757,067	06/01/2007	AFSHIN PARTOVI	AFPA-01001US1	2001

23910 7590 11/18/2010

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14TH FLOOR
SAN FRANCISCO, CA 94108

EXAMINER	
RAMADAN, RAMY O	
ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 11/18/2010

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

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

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 Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	Application No.	Applicant(s)	
	11/757,067	PARTOVI, AFSHIN	
	Examiner	Art Unit	
	RAMY RAMADAN	2858	

-- 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 *the communication filed on 08/31/2010*.

2. ☒ The allowed claim(s) is/are *1,2,5-9,11,12,20-26,28,29 and 31-36*.

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

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 08/31/2010
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date *10/27/2010* .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Edward Tso/
Primary Examiner, Art Unit 2858

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	11/757,067	PARTOVI, AFSHIN	
	Examiner	Art Unit	
	RAMY RAMADAN	2858	

All Participants:

(1) *RAMY RAMADAN*.

(2) *KARL KENNA*.

Status of Application: *Pending*

(3) _____.

(4) _____.

Date of Interview: *27 October 2010*

Time: *2 p.m.*

Type of Interview:
☒ Telephonic
☐ Video Conference
☐ Personal (Copy given to: ☐ Applicant ☐ Applicant's representative)

Exhibit Shown or Demonstrated: ☐ Yes ☒ No
If Yes, provide a brief description: .

Part I.

Rejection(s) discussed:
N/A

Claims discussed:
1, 20, 31 and 34

Prior art documents discussed:
Hui and Lyon

Part II.

SUBSTANCE OF INTERVIEW DESCRIBING THE GENERAL NATURE OF WHAT WAS DISCUSSED:
See Continuation Sheet

Part III.

☒ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview directly resulted in the allowance of the application. The examiner will provide a written summary of the substance of the interview in the Notice of Allowability.
☐ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview did not result in resolution of all issues. A brief summary by the examiner appears in Part II above.

(Applicant/Applicant's Representative Signature – if appropriate)

Continuation of Substance of Interview including description of the general nature of what was discussed: The examiner initiated a telephone interview with Applicant's Representative to obtain authorization for proposed amendments to the claims --as indicated in the Examiner's Amendments section of the attached office action-- to expedite prosecution and place the application in condition for allowance. Applicant's Representative authorized the proposed amendments.
.

DETAILED ACTION

Amendments

1. Acknowledgement is made of the amendment filed October 25, 2010. Claims 1, 20, 23 and 24 have been amended. Claims 31-36 have been added. Accordingly, Claims 1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36 are now pending in the application.

Terminal Disclaimer

2. The terminal disclaimer filed on November 05, 2010 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of patent application 11/669113 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Information Disclosure Statement

3. The Information Disclosure Statement dated August 31, 2010 has been acknowledged by the examiner and the cited references have been considered in the examination of the pending claims. As required by M.P.E.P 609 C (2), a copy of the Information Disclosure Statement initiated and dated by the examiner is attached.

EXAMINER'S AMENDMENT

4. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Mr. Karl Kenna on October 27, 2010.

The application has been amended as follows:

Claim 1. (Currently Amended) A charger system for use with a mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, for charging and/or powering the device and/or battery inductively, comprising:

a base unit having a surface, and comprising a plurality of primary coils arranged behind and parallel to the surface,

wherein each of the primary coils is positioned within the base unit, and

wherein each of the primary coils is associated with a switching circuit in the base unit, which switching circuit is capable of being selectively switched to activate its associated primary coil so that, when an electrical current is passed through that activated primary coil, a magnetic field is generated by that activated primary coil in a direction substantially perpendicular to the surface of the base unit, and

wherein the base unit and/or switching circuit includes a capacitive or other component that decreases harmonics in that activated primary coil;

a power supply for passing a current through the primary coils when activated, to generate the magnetic field in a direction substantially perpendicular to the plane of the primary coils;

a communications interface that the base unit, and the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, use to communicate with one another during powering or charging, to

poll each of the primary coils, or receive a signal from a sensor associated therewith, to verify the presence of the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device placed upon or close to the surface of the base unit,

select, based on the polling or sensing, from within the plurality of primary coils, and selectively switch, using their associated switching circuits to activate, only those one or more primary coils which are determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, and

periodically thereafter exchange information to provide power transfer to the device and/or battery, including device and/or battery charging or power status or presence; and

wherein the substantially perpendicular magnetic field is used to inductively generate a current in the receiver coil within or on the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device placed upon the activated primary coil of the base unit, to charge or power the device and/or battery, and

wherein the base unit, and receiver coil or circuitry associated therewith, use current modulation performed by the receiver coil or its circuitry, to provide an indication that is then used by the base unit to

determine and regulate one or more of output voltage, current, or power provided by the base unit to the device and/or battery to be within the range of one or more of a value of a required voltage, current, or other power parameter for the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, and/or

verify the continued presence of the receiver coil near the base unit.

Claim 20. (Currently Amended) A system for simultaneously charging or powering a plurality of mobile, electronic, or other device and/or battery and/or skin or battery door for use with the device, comprising:

a base unit having a surface and comprising

a plurality of primary coils arranged behind and parallel to the surface, wherein each of the primary coils are positioned within the base unit and include a switching circuit that is capable of being selectively switched or activated by a switch in the base unit associated with that primary coil so that, when an electrical current is passed through an activated primary coil, a magnetic field is generated in a direction substantially perpendicular to the surface of the base unit,

one or more capacitive or other components that decreases harmonics in the activated primary coil,

a power supply for passing a current through the primary coils to generate magnetic fields for each primary coil in a direction substantially perpendicular to the plane of the primary coils,

one or more aligning magnets within the base unit, which are oriented so that their magnetic field is perpendicular to the surface of the base unit, that encourage the general alignment of the primary coil with ~~the~~ a receiver coil using corresponding magnets at the receiver coil, mobile, or electronic device and/or battery, and/or skin or battery door for use with the device, and

a plurality of mobile, or electronic devices and/or battery, and/or skin or battery door for use with the device, capable of inductive powering or charging, each mobile, or electronic device or battery, each of which comprising

a battery for powering a mobile, or electronic device, and

a receiver that is one of attached to, incorporated within, or coupled to the mobile, or electronic device or the battery, wherein the receiver comprises a receiver coil;

wherein the substantially perpendicular magnetic fields are used to inductively generate a current in the plurality of the receiver coils within one or more of the mobile, or electronic device and/or battery and/or skin or battery door for use with the device, proximate the base unit, to charge or power the mobile, or electronic device and/or battery and/or skin, including

polling each of the primary coils, or receiving a signal from a sensor associated therewith, to verify the presence of the mobile, or electronic device and/or battery placed upon the surface of the base unit,

selecting, based on the polling or sensing, from the plurality of primary coils, and selectively switch, using their associated switching circuits to activate, only those primary coils which are determined to be in general alignment with a receiver coil at the device and/or battery, and

periodically thereafter use current modulation performed by the receiver coil or its circuitry, to provide an indication, or otherwise exchanging information, including device and/or battery charging status or presence, to provide power transfer to the device and/or battery; and

a regulator that regulates one or more of output voltage, current, or power provided by the receiver to a mobile, or electronic device and/or battery and/or skin or battery door for use with the device, proximate the base unit, to be within the range of one or more of a value of voltage, current, or other power parameter for the mobile device and/or battery, and/or to modify the duty cycle, frequency or input voltage of the base unit or charger switching circuit therein to modify the output voltage and/or current to the device and/or battery or a charger circuit for the battery.

Claim 31. (Currently Amended) A charger system for use with a mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, for charging and/or powering the device and/or battery inductively, comprising:

a base unit having a surface, and comprising one or more primary coils,

wherein each of the primary coils is positioned within the base unit, ~~and~~

wherein each of the primary coils is associated with a switching circuit in the base unit, which switching circuit is capable of being selectively switched to activate its associated primary coil so that, when an electrical current is passed through that activated primary coil, a magnetic field is generated by that activated primary coil in a direction substantially perpendicular to the surface of the base unit, and

wherein the base unit and/or switching circuit includes a capacitive or other component that increases energy transfer efficiency by that activated primary coil;

a power supply for passing a current through the primary coil when activated, to generate the magnetic field in a direction substantially perpendicular to the plane of the primary coil;

wherein the base unit, and the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, communicate with one another during powering or charging, to

poll the one or more primary coils, or receive a signal from a sensor associated therewith, to verify the presence of the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device placed upon the surface of the base unit,

select, based on the polling or sensing, from within the one or more primary coils, and selectively switch, using their associated switching circuits to activate, only that one or more primary coils which is determined to be most closely aligned with a receiver coil

at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, and

periodically thereafter exchange information to provide power transfer to the device and/or battery, including device and/or battery charging or power status or presence; and

wherein the base unit, and receiver coil or circuitry associated therewith, provide an indication that is then used by the base unit to determine the presence of a receiver or one or more of output voltage, current, or power provided by the base unit to the device and/or battery to be within the range of one or more of a value of a required voltage, current, or other power parameter for the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

Claim 34. (Currently Amended) A method of using a charger system for use with a mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, for charging and/or powering the device and/or battery inductively, comprising the steps of:

providing a base unit having a surface, and comprising one or more primary coils,

wherein each of the primary coils is positioned within the base unit, ~~and~~

wherein each of the primary coils is associated with a switching circuit in the base unit, which switching circuit is capable of being selectively switched to activate its associated primary coil so that, when an electrical current is passed through that activated primary coil, a magnetic field is generated by that activated primary coil in a direction substantially perpendicular to the surface of the base unit, and

wherein the base unit and/or switching circuit includes a capacitive or other component that increases energy transfer efficiency by that activated primary coil;

passing a current through the one or more primary coils when activated, to generate the magnetic field in a direction substantially perpendicular to the plane of the primary coils;

wherein the base unit, and the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, communicate with one another during powering or charging, to

poll the one or more primary coils, or receive a signal from a sensor associated therewith, to verify the presence of the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device placed upon the surface of the base unit,

select, based on the polling or sensing, from within the one or more primary coils, and selectively switch, using their associated switching circuits to activate, only that one or more primary coil which is determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device, and

periodically thereafter exchange information to provide power transfer to the device and/or battery, including device and/or battery charging status or presence; and

wherein the base unit, and receiver coil or circuitry associated therewith, provide an indication that is then used by the base unit to determine the presence of a receiver or one or more of output voltage, current, or power provided by the base unit to the device and/or battery to be within the range of one or more of a value of a required voltage, current, or other power parameter for the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

Allowable Subject Matter

5. Claims 1, 2, 5-9, 11, 12, 20-26, 28, 29 and 31-36 are allowed.

6. The following is an examiner's statement of reasons for allowance:

With respect to claim 1 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that decreases harmonics in that activated primary coil; and selectively switch, using their associated switching circuits to activate, only those one or more primary coils which are determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

With respect to claim 20 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, one or more capacitive or other components that decreases harmonics in the activated primary coil, and selectively switch, using their associated switching circuits to activate, only those primary coils which are determined to be in general alignment with a receiver coil at the device and/or battery.

With respect to claims 31 and 34 primarily, the prior art of record, taken alone or in combination thereof, does not disclose or suggest, inter alia, wherein the base unit and/or switching circuit includes a capacitive or other component that increases energy transfer efficiency by that activated primary coil; and selectively switch, using their associated switching circuits to activate, only that one or more primary coils which is determined to be most closely aligned with a receiver coil at the mobile, electronic, or other device and/or battery, battery door, or skin for use with the device.

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.”

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAMY RAMADAN whose telephone number is (571) 272-9761. The examiner can normally be reached on Mon-Fri 7:30 am-5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, PATRICK ASSOUAD can be reached on (571) 272-2210. 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.

/Edward Tso/
Primary Examiner, Art Unit 2858

/Ramy Ramadan/
Examiner
Art Unit 2858

/RR/

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	556	320/108.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 12:32
L2	581	320/104.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 12:32
L4	0	(primary adj coil receiver capacitive regulat$3 aligned perpendicular).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 13:10
L5	0	(primary adj coil receiver capacitive regulat$3 aligned). clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 13:10
L6	0	(primary adj coil receiver capacitive regulat$3).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 13:11
L7	24	(primary adj coil receiver regulat$3). clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2010/10/27 13:11

EAST Search History (Interference)

<This search history is empty>

10/27/2010 1:11:26 PM
C:\Documents and Settings\rramadan.USPTO\My Documents\EAST\Workspaces\11757067 power source and inductive receiver.wsp

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11757067	PARTOVI, AFSHIN
	Examiner	Art Unit
	RAMY RAMADAN	2838

SEARCHED			
Class	Subclass	Date	Examiner
307	104	5/5/2010	/RR/

SEARCH NOTES		
Search Notes	Date	Examiner
Updated East search (attached)	5/5/2010	/RR/

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

Form PTO-1449 *(Substitute)*	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	Attorney Docket Number AFPA-01001US1	Application/Patent Number 11/757,067
Information Disclosure Statement **BY APPLICANT** *(Use several sheets if necessary)*		Applicant/Patent Owner Afshin Partovi	
		Filing/Issue Date June 1, 2007	Group Art Unit 2115

U.S. PATENTS

Examiner Initial		Patent Number	Issue Date	First Named Inventor	Class	Subclass	Filing Date
/R.R./		5237257	08/17/1993	Johnson et al.			
		5656917	08/12/1997	Theobald			
		5696433	12/09/1997	Patino			
		6016046	01/18/2000	Kaite et al.			
		6040680	03/21/2000	Toya et al.			
		6208115	03/27/2001	Binder			
		6636017	10/21/2003	Zink et al.			
/R.R./		6625477	09/23/2003	Wakefield			

U.S. PATENT PUBLICATIONS

Examiner Initial		Patent Application Publication Number	Publication Date	Applicant

PENDING U.S. PATENT APPLICATIONS

Examiner Initial		Application Number	Filing Date	First Named Inventor	Petition to Expunge? Yes | No	

FOREIGN PATENT DOCUMENTS

Examiner Initial		Document Number	Publication Date	Country	Class	Subclass	Trans-lation Yes | No	

NON-PATENT LITERATURE DOCUMENTS

(Include name of the author (in CAPITAL LETTERS), title of the article, title of the item (book, magazine, journal, serial, symposium, catalog, etc.) date, pages, volume-issue number(s), publisher, city and/ or country where published.

/R.R./		Office Action in connection with U.S. Patent Application No. 11/669,113 dated May 13, 2010, 22 pages.

Examiner /Ramy Ramadan/	Date Considered 10/27/2010

Form PTO-1449 *(Substitute)*	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	Attorney Docket Number AFPA-01001US1	Application/Patent Number 11/757,067
		Applicant/Patent Owner Afshin Partovi	
Information Disclosure Statement **BY APPLICANT** *(Use several sheets if necessary)*		Filing/Issue Date June 1, 2007	Group Art Unit 2115

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

*1 = Copy not submitted because it was submitted in prior application SN __/_____, filed _____, 20___, relied on under 35 USC §120.
**2 = Copy not submitted because it was submitted in prior application SN __/_____, filed _____, 20___, relied on under 35 USC §120.

Examiner Signature:_____ Date Considered:_____

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BIB DATA SHEET

CONFIRMATION NO. 2001

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/757,067	06/01/2007	713	2858	AFPA-01001US1

APPLICANTS
AFSHIN PARTOVI, SUNNYVALE, CA;

**** CONTINUING DATA ***************************
This appln claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/868,674 12/05/2006

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
06/22/2007

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
❑ Yes ☑ No	❑ Yes ☑ No	/RAMY O RAMADAN/ Examiner's Signature	❑ Initials	CA	11	20	3

ADDRESS

FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108
UNITED STATES

TITLE

POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

FILING FEE RECEIVED		
639	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
	11757067	PARTOVI, AFSHIN
	Examiner	Art Unit
	RAMY RAMADAN	2858

✓	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	11/09/2010								
1	1	=								
2	2	=								
	3	-								
	4	-								
3	5	=								
4	6	=								
5	7	=								
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21	33	=								
22	34	=								
23	35	=								
24	36	=								

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11757067	PARTOVI, AFSHIN
	Examiner	**Art Unit**
	RAMY RAMADAN	2858

ORIGINAL		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)															

☐ 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	17	28												
2	2	18	29												
3	5	19	31												
4	6	20	32												
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14	24														
15	25														
16	26														

/RAMY RAMADAN/ Examiner.Art Unit 2858 (Assistant Examiner)	11/07/2010 (Date)	**Total Claims Allowed:** 24	
/Edward Tso/ Primary Examiner.Art Unit 2858 (Primary Examiner)	11/14/2010 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/757,067	PARTOVI, AFSHIN	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☒ APPROVED	☐ DISAPPROVED
Date Filed : 11/03/2010	This patent is subject to a Terminal Disclaimer	

Approved/Disapproved by:
Dorethea Lawrence

U.S. Patent and Trademark Office

PTO/SB/25 (07-09)
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TERMINAL DISCLAIMER TO OBVIATE A PROVISIONAL DOUBLE PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION	Docket Number (Optional) AFPA-1001US1

In re Application of: Afshin Partovi

Application No.: 11/757,067

Filed: 6/1/2007

For: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

The owner*, MOJO MOBILITY, INC., of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending reference Application Number 11/669,113, filed on 1/30/2007, as such term is defined in 35 U.S.C. 154 and 173, and as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the reference application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of any patent granted on said reference application, "as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application," in the event that: any such patent: granted on the pending reference application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

Check either box 1 or 2 below, if appropriate.

1. ☑ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

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 Section 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 issued thereon.

2. ☐ The undersigned is an attorney or agent of record. Reg. No. _____

Afshin Partovi — Oct. 22, 2010
Signature — Date

Afshin Partovi
Typed or printed name

650-892-5001
Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

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.

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner). Form PTO/SB/96 may be used for making this statement. See MPEP § 324.

This collection of information is required by 37 CFR 1.321. 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. 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: AFSHIN PARTOVI

Application No./Patent No.: 11/757,067 Filed/Issue Date: 6/1/2007

Titled: POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES

MOJO MOBILITY, INC., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1 [X] 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 [X] 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 _____, Frame _____, or for which a copy therefore is attached.

OR

B [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[ ] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

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

Afshin Partovi — Oct. 22, 2010
Signature — Date

Afshin Partovi — CEO
Printed or Typed Name — Title

This collection of information is required by 37 CFR 3.73(b). 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. 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.

COPY

JOINT TO CORPORATE ASSIGNMENT

WHEREAS, the undersigned Inventors:

(1) Afshin Partovi,
a resident of Sunnyvale, California; and

(2) Michael Sears,
a resident of Ben Lomond, California.

have invented certain new and useful improvements set forth in **SCHEDULE A**:

WHEREAS MOJO MOBILITY, INC. (hereinafter termed "Assignee"), a corporation of the State of California, having a place of business at 440 N. Wolfe Rd., Sunnyvale, State of California 94085, wishes to acquire the entire right, title and interest in and to said application(s) and the invention disclosed therein, and in and to all embodiments of the invention, heretofore conceived, made or discovered jointly or severally by said Inventors (all collectively hereinafter termed "said invention"), and in and to any and all patent applications, patents, certificates of invention and other forms of protection thereon (hereinafter termed "patents") applied for or granted in the United States and/or other countries.

NOW THEREFORE, for good and valuable consideration acknowledged by each of said Inventors to have been received in full from said Assignee:

1. Said Inventors do hereby sell, assign, transfer and convey unto said Assignee, the entire right, title and interest (a) in and to said application(s) and said invention; (b) in and to all rights to apply in any and all countries of the world for patent applications, patents, certificates of inventions or other governmental grants on said invention, including the right to apply for patents pursuant to the International Convention for the Protection of Industrial Property or pursuant to any other convention, treaty, agreement or understanding; (c) in and to any and all applications filed and any and all patents, certificates of inventions or other governmental grants granted on said invention in the United States or any other country, including each and every application filed and each and every patent granted on any application which is a division, substitution, or continuation of any of said applications; (d) in and to each and every reissue or extension of any of said patents; and (e) in and to each and every patent claim resulting from a reexamination certificate for any and all of said patents.

2. Said Inventors hereby jointly and severally covenant and agree to cooperate with said Assignee to enable said Assignee to enjoy to the fullest extent the right, title and interest herein conveyed in the United States and other countries. Such cooperation by said Inventors shall include prompt production of pertinent facts and documents, giving of testimony, executing of petitions, oaths, specifications, declarations or other papers, and other assistance all to the extent deemed necessary or desirable by said Assignee (a) for perfecting in said Assignee the right, title and interest herein conveyed; (b) for complying with any duty of disclosure; (c) for prosecuting any of said applications; (d) for filing and prosecuting provisional, utility, substitute, divisional, continuing or additional applications covering said invention; (e) for filing and prosecuting applications for reissue of any of said patents; (f) for interference or other priority proceedings involving said invention; and (g) for legal proceedings involving said invention and any applications therefor and any patents granted thereon, including without limitation opposition proceedings, cancellation proceedings, priority contests, public use proceedings, reexamination proceedings, compulsory licensing proceedings, infringement actions, invalidity actions, and court actions; provided, however, that the expense incurred by said Inventors in providing such cooperation shall be paid for by said Assignee.

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3. The terms and covenants of this Assignment shall inure to the benefit of said Assignee, its successors, assigns and other legal representatives, and shall be binding upon said Inventors, their respective heirs, legal representatives and assigns.

4. Said Inventors hereby jointly and severally warrant and represent that they have not entered and will not enter into any assignment, contract, or understanding in conflict herewith.

IN WITNESS WHEREOF, the said Inventors have executed this instrument on the date as given below and delivered this instrument to said Assignee:

Date

(1) Afshin Partovi

****

Date

(2) Michael Sears

****

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SCHEDULE A

Application No.	Filing Date	Title	Our File No.
60/763,816	01/31/2006	PORTABLE INDUCTIVE POWER SOURCE	AFPA-01000US0
60/810,262	06/01/2006	MOBILE DEVICE, CHARGER, AND POWER SUPPLY	AFPA-01001US0
11/757,067	06/01/2007	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES	AFPA-01001US1
60/810,298	06/01/2006	MOBILE DEVICE, BATTERY, CHARGING SYSTEM, AND POWER SUPPLY SYSTEM	AFPA-01002US0
60/868,674	12/05/2006	SYSTEM AND METHOD FOR PROVIDING AND USING A PORTABLE INDUCTIVE POWER SOURCE	AFPA-01004US0
11/669,113	01/30/2007	INDUCTIVE POWER SOURCE AND CHARGING SYSTEM	AFPA-01007US0
PCT/US2007/061406	01/31/2007	INDUCTIVE POWER SOURCE AND CHARGING SYSTEM	AFPA-01007WO0
60/916,748	05/08/2007	SYSTEM AND METHOD FOR CHARGING AND POWERING MOBILE DEVICES BATTERIES, AND OTHER DEVICES	AFPA-01008US0
60/952,835	07/30/2007	SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES	AFPA-01009US0
61/012,922	12/12/2007	WIRELESS CHARGER WITH POSITION INSENSITIVITY TO PLACEMENT OF MOBILE DEVICES	AFPA-01010US0
61/012,924	12/12/2007	SYSTEM AND METHOD FOR PROVIDING CONTROL, REGULATION, AND COMMUNICATION IN CHARGERS AND POWER SUPPLIES	AFPA-01011US0
61/015,606	12/20/2007	WIRELESS CHARGER WITH POSITION INSENSITIVITY TO PLACEMENT OF MOBILE AND ELECTRONIC DEVICES	AFPA-01012US0
12/116,876	05/07/2008	SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES	AFPA-01013US0
PCT/US2008/063084	05/08/2008	SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES	AFPA-01013WO0
61/043,027	04/07/2008	INDUCTIVE POWER SOURCE AND CHARGING SYSTEM	AFPA-01019US0

Electronic Patent Application Fee Transmittal	
Application Number:	11757067
Filing Date:	01-Jun-2007
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Filer:	Karl Kenna/narissa besada
Attorney Docket Number:	AFPA-01001US1
Filed as Small 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($)
Miscellaneous:				
Statutory or terminal disclaimer	2814	1	70	70
		Total in USD ($)		**70**

Electronic Acknowledgement Receipt	
EFS ID:	8764385
Application Number:	11757067
International Application Number:	
Confirmation Number:	2001
Title of Invention:	POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES
First Named Inventor/Applicant Name:	AFSHIN PARTOVI
Customer Number:	23910
Filer:	Karl Kenna/narissa besada
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01001US1
Receipt Date:	03-NOV-2010
Filing Date:	01-JUN-2007
Time Stamp:	19:39:33
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$70
RAM confirmation Number	5435
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		afpa_1001us1_SIGNED_TerminalDisclaimer.pdf	392043 ff768726bb2450b1d06b83e756bea9a2b7f6b303	yes	5

Multipart Description/PDF files in .zip description

Document Description	Start	End
Terminal Disclaimer Filed	1	1
Assignee showing of ownership per 37 CFR 3.73(b).	2	2
Miscellaneous Incoming Letter	3	5

Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	30148 df3126b8db32b3a7eb38956f3ff46ef893e8ab98	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	422191		

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.

<u>New Applications Under 35 U.S.C. 111</u>
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.

<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.

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/757,067	PARTOVI, AFSHIN	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☐ APPROVED	☒ DISAPPROVED
Date Filed : 10/25/2010	This patent is subject to a Terminal Disclaimer	

Approved/Disapproved by:

Dorethea Lawrence

not readable

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