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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	05/27/2014	8738103	0690.0023C	9346

027896 7596 05/07/2014
EDELL, SHAPIRO & FINNAN, LLC
9801 Washingtonian Blvd.
Suite 750
Gaithersburg, MD 20878

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 777 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):

Carles Puente Baliarda, Sant Cugat del Valles, SPAIN;
Josep Mumbro, Barcelona, SPAIN;
Jordi Ilario, Barcelona, SPAIN;

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

IR103 (Rev. 10/09)



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NOTICE OF ALLOWANCE AND FEE(S) DUE

27896 7590 01/08/2014
EDELL, SHAPIRO & FINNAN, LLC¹
9801 Washingtonian Blvd.
Suite 750
Gaithersburg, MD 20878

EXAMINER

FIGUEROA, MARISOL

ART UNIT

PAPER NUMBER

2643

DATE MAILED: 01/08/2014

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	12/21/2006	Carlos Puente Baliarda	0690.0023C	9346

TITLE OF INVENTION: MULTIPLE-BODY-CONFIGURATION MULTIMEDIA AND SMARTPHONE MULTIFUNCTION WIRELESS DEVICES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$960	\$0	\$0	\$960	04/08/2014

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

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

HOW TO REPLY TO THIS NOTICE:

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

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

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

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

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

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

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

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
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)

27896 7590 01/08/2014
EDELL, SHAPIRO & FINNAN, LLC
9801 Washingtonian Blvd.
Suite 750
Gaithersburg, MD 20878

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.
11/614,429	12/21/2006	Carles Puente Baliarda	0690.0023C	9346

TITLE OF INVENTION: MULTIPLE-BODY-CONFIGURATION MULTIMEDIA AND SMARTPHONE MULTIFUNCTION WIRELESS DEVICES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$960	\$0	\$0	\$960	04/08/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
FIGUEROA, MARISOL	2643	455-575700

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

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

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
☐ Applicant asserting small entity status. See 37 CFR 1.27
☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

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.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

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

Authorized Signature _____

Date: _____

Typed or printed name _____

Registration No. _____



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	12/21/2006	Carlos Puente Baliarda	0690.0023C	9346

27896 7590 01/08/2014
EDEL, SHAPIRO & FINNAN, LLC
9801 Washingtonian Blvd.
Suite 750
Gaithersburg, MD 20878

EXAMINER

FIGUEROA, MARISOL

ART UNIT	PAPER NUMBER
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2643

DATE MAILED: 01/08/2014

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 946 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 946 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.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

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

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.

**Notices of Allowance and Fee(s) Due mailed between October 1, 2013 and
December 31, 2013**

(Addendum to PTOL-85)

If the "Notice of Allowance and Fee(s) Due" has a mailing date on or after October 1, 2013 and before January 1, 2014, the following information is applicable to this application.

If the issue fee is being timely paid on or after January 1, 2014, the amount due is the issue fee and publication fee in effect January 1, 2014. On January 1, 2014, the issue fees set forth in 37 CFR 1.18 decrease significantly and the publication fee set forth in 37 CFR 1.18(d)(1) decreases to \$0.

If an issue fee or publication fee has been previously paid in this application, applicant is not entitled to a refund of the difference between the amount paid and the amount in effect on January 1, 2014.

Notice of Allowability	Application No. 11/614,429	Applicant(s) BALIARDA ET AL.	
	Examiner MARISOL FIGUEROA	Art Unit 2643	AI/A (First Inventor to File) Status No

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

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

1. ☒ This communication is responsive to 11/13/2013.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____

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

3. ☒ The allowed claim(s) is/are 1-5 and 16-30. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

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

Certified copies:

a) ☐ All b) ☐ Some *c) ☐ None of the:

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

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

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

* Certified copies not received: _____.

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

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

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

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

/MARISOL FIGUEROA/ Primary Examiner, Art Unit 2643	
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ALLOWANCE

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

Claims 1-5 and 16-30 are allowed because the prior art of record does not anticipate or render obvious the features of:

"wherein a perimeter of the second antenna element defines an antenna contour having a complexity level defined by the factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value less than 1.75" in independent claims 1, 16, and 20;

and the features of:

"wherein a perimeter of the first antenna element defines a first antenna contour comprising at least thirty-five segments, the first antenna element defining an antenna box, an orthogonal projection of the antenna box along a normal to a face with a largest area of the antenna box defining an antenna rectangle, wherein a length of the first antenna contour is greater than four times a diagonal of the antenna rectangle; and a second antenna element configured to operate in at least one frequency band used by a 4G communication standard, wherein a perimeter of the second antenna element defines a second antenna contour comprising at least twenty segments" in independent claim 18.

2. 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."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARISOL FIGUEROA whose telephone number is (571)272-7840. The examiner can normally be reached on M-F 8:30 a.m.-5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jinsong Hu can be reached on (571)272-3965. 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.

/MARISOL FIGUEROA/
Primary Examiner, Art Unit 2643

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.	:	11/614,429
First Named Inventor	:	Carles Puente Baliarda
Confirmation No.	:	9346
Filed	:	December 21, 2006
TC/A.U.	:	2643
Examiner	:	Figueroa, Marisol
Customer No.	:	27896
Docket No.	:	0690.0023C
Title	:	Multiple-Body-Configuration Multimedia and Smartphone Multifunction Wireless Devices

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

AMENDMENT AND RESPONSE TO NOTICE OF NON-COMPLIANT AMENDMENT

Madam:

In response to the notice of non-compliant amendment mailed September 13, 2013, please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims, which begins on page 2 of this paper.

Remarks begin on page 11 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Currently Amended) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

~~an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner;~~

a touch screen;

a geolocalization system; and

an antenna system comprising a ground plane layer and three antenna elements within the handheld multifunction wireless device, the handheld multifunction wireless device being configured to transmit and receive signals from at least four frequency bands, each of the at least four disposed within at least one of the upper body and the lower body and that provides operability at a first frequency band fully contained within 810MHz-960MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz-1990MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900MHz-2170MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard, ;~~wherein the antenna system comprising; comprises~~

~~a first antenna element having a conductive plate; wherein said conductive plate supports~~ configured to simultaneously support radiation modes for the at least first, second and third of the at least four frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands; and

a second antenna element configured to receive signals from a 4G communication standard, wherein a perimeter of said conductive plate the second antenna element defines an antenna contour having a level of complexity defined by complexity factors

factor F_{21} having a value of at least 1.05 1.20 and not greater than 1.80 and complexity factor F_{32} having a value of at least 1.10 and not greater less than 1.90 1.75.

2. (Currently Amended) The handheld multifunction wireless device of claim 1, wherein the multifunction wireless device has multimedia functionality first frequency band is contained within 810-960 MHz frequency range, the second frequency band is contained within 1710-1990 MHz frequency range, and the third frequency band is contained within 1900-2170 MHz frequency range.

3. (Currently Amended) The handheld multifunction wireless device of claim 1, wherein the multifunction wireless device has smartphone functionality first antenna element is proximate to a short side of a ground plane rectangle defined by the ground plane layer, and the second antenna element is proximate to a short side of the ground plane rectangle.

4. (Currently Amended) The handheld multifunction wireless device of claim 1, wherein the first antenna element is proximate to a short side of a ground plane rectangle defined by the ground plane layer, and the second antenna element is proximate to a long side of the ground plane rectangle

further comprising:

a microprocessor;

at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen; and

wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{22} has a value greater than 1.50.

5. (Currently Amended) The handheld multifunction wireless device of claim 1, wherein the third antenna element is configured to operate in a fifth frequency band within 2400-2480 MHz frequency range

~~further comprising:~~

~~a receiver of at least one of analog and digital sound signals;~~

~~an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;~~

~~data storage of at least 1 GB in capacity; and~~

~~wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{22} has a value greater than 1.50.~~

6-15. (Canceled)

16. (Currently Amended) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

a touch screen;

a microprocessor and an operating system adapted to permit running of word-processing, spreadsheet, and slide software applications;

an image recording system comprising an at least two-Megapixel image sensor;

at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

an antenna system within the handheld multifunction wireless device and configured to operate in at least five eapable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of at least three frequency bands, said at least three frequency bands being used by at least two communication standards, the antenna system comprising:

a ground plane layer;

a first antenna element having a conductive plate, the first antenna element supporting radiation modes for said at least three frequency bands configured to support

first, second, and third radiation modes respectively providing first, second, and third paths for current respectively associated with first, second, and third frequencies bands, the first, the second, and the third radiation modes overlapping at least partially with each other, the first frequency band being contained within a first frequency region of an electromagnetic spectrum, the second and the third frequency bands being contained within a second frequency region of the electromagnetic spectrum that is higher in frequency than the first frequency region; and

a second antenna element configured to operate in at least one frequency band, the at least one frequency band being used by a 4G communication standard, having a second conductive plate, the second antenna element being electromagnetically coupled to the first antenna element in at least one of said at least three frequency bands; wherein:

a perimeter of the first antenna element defines a first conductive plate and a perimeter of the second conductive plate define an antenna contour having a level of complexity defined by first complexity factor F_{21} having a value of at least ~~1.40~~ 1.20 and not greater than 1.80 and by first complexity factor F_{32} having a value of at least 1.20 and not greater ~~less~~ than ~~1.70~~ 1.75; and

a perimeter of the second antenna element defines a second antenna contour having a level of complexity defined by second complexity factor F_{21} having a value of at least 1.20 and second complexity factor F_{32} having a value less than 1.75.

17. (Currently Amended) The handheld multifunction wireless device of claim 16, wherein the first antenna element is configured to transmit and receive signals from a 4G communication standard further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner.

18. (Currently Amended) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

a receiver of at least one of analog and digital sound signals;

~~an image recording system comprising at least one of an at least two Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;~~

~~data storage means having a capacity of at least 1 GB;~~

~~a touch screen;~~

~~a processing module;~~

~~a memory module;~~

~~a communication module;~~

~~a power management module;~~

~~an antenna system within the handheld multifunction wireless device and comprising:~~

~~a ground plane layer;~~

~~a first antenna element having a conducting plate, the first antenna element configured to simultaneously supporting radiation modes for first, second, and third at least three frequency bands, the first frequency band being contained within a first frequency region of an electromagnetic spectrum, the second frequency band being contained within a second frequency region of the electromagnetic spectrum that is higher in frequency than the first frequency region, the third frequency band of operation being used by a 4G communication standard, so that the antenna system is capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of said at least three frequency bands; wherein said at least three frequency bands are used by at least a GSM communication standard and a WCDMA communication standard; wherein the antenna system a perimeter of the first antenna element defines a first an antenna contour comprising at least two disjointed subsets of segments, each of said at least two subsets of segments comprising at least six thirty-five segments, the first antenna element defining an antenna box, an orthogonal projection of the antenna box along a normal to a face with a largest area of the antenna box defining an antenna rectangle, wherein a length of the first antenna contour is greater than four times a diagonal of the antenna rectangle; and~~

a second antenna element configured to operate in at least one frequency band used by a 4G communication standard, wherein a perimeter of the second antenna element defines a second antenna contour comprising at least twenty segments wherein one of said at least two disjointed subsets of segments is defined by the perimeter of said conductive plate; and
wherein the antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.05 and not greater than 1.40 and by complexity factor F_{22} having a value of at least 1.20 and not greater than 1.70.

19. (Currently Amended) The handheld multifunction wireless device of ~~claim 18~~ claim 16, wherein the first antenna contour comprises at least thirty-five segments further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner.

20. (Currently Amended) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

~~an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner;~~

~~a display;~~

~~a processing module;~~

~~a touch screen;~~

~~a microprocessor;~~

~~at least one [[a]] memory module; and~~

a communication module configured to operate in a first frequency band used by at least one communication standard and contained within a first frequency region of an electromagnetic spectrum, in a second frequency band used by at least one communication standard and contained within a second frequency region of the electromagnetic spectrum that is higher in

frequency than the first frequency region, and in a third frequency band used by a 4G communication standard; and

a power management module;

wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body;

wherein the communication module operates at a first frequency band fully contained within 810MHz-960MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz-1990MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900MHz-2170MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard;

wherein the communication module comprising comprises an antenna system within the handheld multifunction wireless device having at least a first and a second antenna elements and a ground plane layer, the [[a]] first antenna element being configured to transmit and receive signals from a 4G communication standard, and the second antenna element being configured to receive signals from a 4G communication standard, wherein: comprising a conductive plate;

wherein said conductive plate supports radiation modes for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands

the ground plane layer defines a ground plane rectangle;

the first antenna element is proximate to a first short side of the ground plane rectangle;

the second antenna element is proximate to a second short side of the ground plane rectangle; and

wherein a perimeter of the second antenna element said conductive plate defines an antenna contour having a level of complexity defined by complexity factors factor F_{21} having a value of at least 1.05 1.20 and not greater than 1.80 and complexity factor F_{32} having a value of at least 1.10 and not greater less than 1.90 1.75.

21. (New) The handheld multifunction wireless device according to claim 19, wherein the second antenna contour comprises at least twenty segments.

22. (New) The handheld multifunction wireless device according to claim 16, wherein the first antenna contour comprises at least two disjointed subsets of segments, each of the at least two subsets of segments comprising at least ten segments.

23. (New) The handheld multifunction wireless device according to claim 16, wherein the handheld multifunction wireless device comprises a third antenna configured to operate in a frequency band within 2400-2480 MHz frequency range.

24. (New) The handheld multifunction wireless device according to claim 18, wherein the communication module is configured to simultaneously transmit signals from a CDMA communication standard, a WiFi communication standard, and a 4G communication standard.

25. (New) The handheld multifunction wireless device according to claim 18, wherein each of the first frequency band and the second frequency band is used by at least one communication standard selected from: GSM, UMTS, CDMA, and W-CDMA.

26. (New) The handheld multifunction wireless device according to claim 18, wherein the ground plane layer defines a ground plane rectangle, the projection of the antenna rectangle on the ground plane rectangle partially overlapping the ground plane rectangle.

27. (New) The handheld multifunction wireless device according to claim 20, wherein an antenna box is defined by the first antenna element, an antenna rectangle is defined by an orthogonal projection of the antenna box along a normal to a face with a largest area of the antenna box, and wherein a longer side of said antenna rectangle is substantially parallel to the first short side of the ground plane rectangle.

28. (New) The handheld multifunction wireless device according to claim 20, wherein the first frequency region is delimited by 810-960 MHz frequency range, and the second frequency region is delimited by 1710-1990 MHz frequency range.

29. (New) The handheld multifunction wireless device according to claim 20, wherein the complexity factor F_{21} has a value less than 1.45.

30. (New) The handheld multifunction wireless device according to claim 20, wherein the handheld multifunction wireless device is configured to use the first antenna element and the second antenna element as a diversity system.

REMARKS

Claims 1-20 have been examined and stand rejected. By the above amendments, claims 1-5 and 16-20 have been amended, claims 6-15 have been canceled, and new claims 21-30 have been added. Support for the amendments to the claims and for the new claims can be found in the published application at least in paragraphs [0002], [0032-35], [0038-39], [0042-43], [0082], [0089-96], [0098-99], [0101], [0103], [0114], [0117], [0119-121], [0130-131], [0171], [0212], [0232], and [0314-315]. Accordingly, claims 1-5 and 16-30 now are pending in the subject application. Favorable reconsideration of the application and allowance of all of the pending claims are respectfully requested in view of the above amendments and the following remarks.

Non-Responsive Amendment

This Amendment is responsive to the Notice of Non-Compliant Amendment dated September 13, 2013 and replaces the Amendment filed July 17, 2013, which was deemed to be non-compliant because newly submitted claims 21-40 were allegedly directed to an invention that is independent or distinct from the invention originally claimed. Accordingly, in the present Amendment, Applicant has amended the claims relative to the prior version (filed on November 12, 2011 in response to the Office Action mailed in May 27, 2011) rather than relative to the non-entered Amendment filed July 17, 2013. Applicant submits that the amended claims are generally directed to the invention originally presented in claims 1-20, and respectfully disagrees that claim language introduced in the Amendment filed July 17, 2013 or any of the claim amendments presented in the present Amendment are directed to an independent or distinct invention, as explained below.

In the Notice of Non-Compliance, the Examiner asserts that newly submitted claims 21-40 in the amendment filed on July 17, 2013 are directed to an invention that is independent or distinct from the invention originally claimed. The inventions are said to be distinct because the originally presented claims did not require the antenna system structure of the newly submitted claims comprising:

"a first subset of the plurality of conducting geometric elements defines a first conducting portion to provide a first path for currents associated with a radiation

mode in a first frequency band; a second conducting portion formed by at least a second subset of the plurality of conducting geometric elements provides a second path for currents associated with a radiation mode in a second frequency band; a third conducting portion formed by at least a third subset of the plurality of conducting geometric elements provides a third path for currents associated with a radiation mode in a third frequency band; the first, second, and third conducting portions overlap at least partially with each other."

Applicant respectfully disagrees with the Examiner, because the response to the Office Action mailed in May, 2011 included independent claims referring to the radiation modes of the antenna elements. For example, claim 1 included the following distinguishing feature:

"wherein the antenna system comprises a first antenna element having a conductive plate; wherein said conductive plate supports radiation modes for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands."

In claim 16, the following distinguishing feature was included:

"a first antenna element having a first conductive plate, the first antenna element supporting radiation modes for said at least three frequency bands."

In claim 18, the following distinguishing feature was included:

"an antenna system comprising a first antenna element having a conducting plate, the first antenna element supporting radiation modes for at least three frequency bands, so that the antenna system is capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of said at least three frequency bands."

In claim 20, the following distinguishing feature was included:

"wherein said conductive plate supports radiation modes for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands."

Such feature referred to the radiation modes for the frequency bands was included in previous submitted claims. Additionally, the patent specification clearly associates the radiation modes to the path of the currents.

As described in paragraph [0117] of the published application, a structure able to support different radiation modes is achieved by appropriately shaping the structure of the antenna system in a way that different paths are provided to the electric currents that flow on the conductive parts of the structure of the antenna system. The same paragraph also reads that, in some cases, the structure of an antenna system will comprise portions providing paths for the currents associated with the radiation mode in the frequency bands as in the submitted claims. In paragraph [0119], it is described that in some embodiments of the invention, the first, second and third portions are overlapping partially or completely with each other.

Applicant respectfully submits that the amended claims include the feature referring to the radiation modes and that such feature was submitted in previous claims and, in some cases, Applicant has limited the scope of the claim referring to the overlapping features of the radiation modes.

For the reasons set forth above, Applicant respectfully submits that amended claims 1-5 and 16-20 as well as new claims 21-30 are directed to the same invention submitted for responding to the Office Action mailed in May, 2011, and reconsideration of the application in view of the foregoing amendments and the following remarks is respectfully requested.

Response to Prior Art Rejections

Claim 1

Claims 1-3, 6-9, and 11-14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,989,794 to Tran in view of U.S. Patent No. 7,548,915 to Ramer et al. Further, claims 4 and 5 stand rejected over Tran, Ramer, and U.S. Patent App. Pub. No. 2002/0175211 to Dominquez et al., and claims 10 and 15 stand rejected over Tran, Ramer, and U.S. Patent App. Pub. No. 2007/0229383 to Koyanagi et al. Claims 6-15 have been canceled, thereby rendering moot the rejections thereof.

Amended independent claim 1 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Applicant respectfully submits that the combination of references fails to disclose at least one of the distinguishing features of amended independent claim 1.

Tran discloses a recursive pattern antenna and a method for forming a recursive pattern antenna for a transceiver system. The recursive pattern antenna has a plurality of radiators that each resonate at a different frequency. At most, Tran discloses a wireless device with an antenna and a telephone transceiver.¹ Tran fails to disclose multimedia or smartphone functionality, a touch screen, or a geolocalization system.

Tran discloses that:

"Antennas designed with fractal generators and a number of iterations, which is referred to herein as fractal geometry, appear to offer performance advantages over the conventional Euclidian antenna designs. Alternately, even if performance is not improved, the fractal designs permit antennas to be designed in a new form factor. However, the form factor of a fractal antenna need not necessarily be smaller than a comparable Euclidian antenna, and it need not fit within the constraints of a portable wireless communication device package."²

Applicant respectfully submits that the antenna taught by Tran *cannot* be integrated within a *handheld* wireless device due to its physical dimensions. Tran discloses an antenna that, in order to resonate and be conducive to electromagnetic communications of a particular frequency range, must have effective electrical lengths approximately equal to one half of a wavelength in the frequency range. As such, the longest length is determined by the lowest frequency of operation, in this case 824 MHz, resulting in a length of 7.1 inches (18.2 centimeters) that imposes very large minimum physical dimensions as seen in Figure 6 (606).

Furthermore, Tran fails to disclose a handheld multifunction wireless device configured to transmit and receive signals from at least four frequency bands. In Tran, the wireless device is configured to transmit and receive, at most, three frequency bands (824-894 MHz, 1850-1990 MHz, and 2400-2480 MHz). In contrast, amended independent claim 1 requires, among other things, that the handheld multifunction wireless device is configured to transmit and receive signals from at least *four frequency bands*. Such a feature is not disclosed by Tran. In addition, Tran fails to disclose an antenna system comprising *three antenna elements* within the handheld

¹ Tran, Fig. 2.

² Tran, Col. 1, line 60-Col. 2, line 3

multifunction wireless device. Tran discloses only one antenna element. Moreover, Tran fails to disclose a second antenna element configured to receive signals from a 4G communication standard and that a perimeter of the second antenna element defines an antenna contour having a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value less than 1.75, as required by amended independent claim 1.

Furthermore, the Office Action asserts that it would have been obvious to one of ordinary skill in the art at the time of the invention to include particular values for the complexity factors for which discovering the optimum or workable ranges involves only routine skill in the art. Applicant respectfully submits that, at the time of the invention, only the level of complexity defined by complexity factor F_{32} was known as a factor that numerically quantifies the degree of miniaturization achieved by the geometry of an antenna system.

The non-anticipated and non-obvious level of complexity defined by complexity factor F_{21} is geared towards an assessment of the number of paths that the antenna system provides to electric currents and/or the equivalent magnetic currents to excite radiation modes. The formula and method for computing complexity factor F_{21} are relevant in the design of antenna systems according to a set of specifications such as, for instance, space available within the multifunction wireless device for the integration of an antenna system and of the ground-plane of the device, information of the functionality envisioned for a given multifunction device (smartphone and multimedia functionalities for instance), and, among others, the requirements on RF performance of the antenna system and the communication standards that are to be operated by the multifunction wireless device.³ The latter defines which frequency bands are to be operated and, thus, the wide-band or multi-band behavior of the antenna system. Therefore, complexity factor F_{21} becomes advantageous in the design of the antenna system for shaping the antenna elements through slots, gaps or apertures being created within the plates, peripheral parts being removed from the plate, parts of the plate being folded or bent and/or additional conducting parts being added that defines the geometrical characteristics, namely, the internal and external perimeters,

³ *Published application*, paragraphs [0170, 0171, 0287-0291].

of the resulting antenna system.⁴ For the reasons set forth, Applicant respectfully submits that the values set for the complexity factor F_{21} are non-obvious, and that the combination of the values set for the complexity factors F_{21} and F_{32} are also non-obvious.

Ramer, which is cited merely for allegedly teaching features no longer recited in claim 1, does not compensate for the deficiencies of Tran, since Ramer also fails to disclose or suggest the aforementioned requirements of claim 1. Accordingly, the subject matter of claim 1 and its dependent claims would not have been obvious from any combination of Tran and Ramer.

Dominquez and Koyanagi, which are cited merely for allegedly teaching features recited in certain dependent claims, also do not compensate for the deficiencies of Tran, since Dominquez and Koyanagi also fail to disclose or suggest the aforementioned requirements of claim 1. Thus, the subject matter of claim 1 and its dependent claims would not have been obvious from any combination of Tran, Ramer, Dominquez and Koyanagi.

While claim 1 was not rejected over Lehtola in the previous Office Action, for completeness, an explanation of the distinctions between amended claim 1 and Lehtola is provided. According to Lehtola, the sub-antenna structure is a portion of the antenna element that has a conductive plate which does not simultaneously support radiation modes for at least three frequency bands. The second radiating arm always provides the second resonant frequency, and the first radiating arm provides the first resonant frequency and the fifth resonant frequency but not at the same time because it is necessary to change the open/closed position of the two switching devices. Therefore, only two radiation modes will be supported simultaneously at most, and not three as required by amended independent claim 1. Furthermore, Lehtola discloses one antenna element and not three antenna elements as required by amended independent claim 1. Lehtola does not disclose either a second antenna element being configured to receive signals from a 4G communication standard and that a perimeter of the second antenna element defines an antenna contour having a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value less than 1.75, as required by amended independent claim 1.

⁴ *Published application*, paragraphs [0121-0123].

For at least the reasons set forth above, amended independent claim 1 and its dependent claims are in condition for allowance, and withdrawal of the rejections of these claims is respectfully requested.

Claim 16

Claim 16 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Tran in view of Domínguez, and dependent claim 17 stands rejected over Tran, Domínguez, and Ramer.

Amended independent claim 16 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Applicant respectfully submits that the combination of references fails to disclose at least one of the distinguishing features of amended independent claim 16, namely, a touch screen, a microprocessor and an operating system adapted to permit running of word-processing, spreadsheet, and slide software applications, an image recording system comprising an at least two-Megapixel image sensor, and that the handheld multifunction wireless device operates in at least five frequency bands. In addition, the combination of references fails to disclose that the first, the second, and the third radiation modes overlap at least partially with each other.

Tran discloses an antenna element in the form of a monopole, dipole or patch.⁵ Applicant respectfully submits that Tran fails to disclose a second antenna element. The antenna disclosed in Tran is a *recursive pattern antenna* and not a *plurality of antennas*. Applicant respectfully disagrees that Tran's dipole is a first antenna element and a second antenna element because, in addition, a dipole antenna requires two arms which cannot be treated independently as otherwise the antenna would not work. For these reasons, Applicant respectfully submits that the dipole antenna of Tran counts as one antenna element. As such, Tran fails to disclose a second antenna element as required by amended independent claim 16.

In addition, Applicant respectfully submits that Tran fails to disclose operation in a fifth frequency band as it can operate in up to four frequency bands: 824-894 MHz, 1565-1585 MHz,

⁵ *Tran*, Col. 3, lines 60-65.

1850-1990 MHz, and 2400-2480 MHz.⁶ Additionally, Tran discloses an antenna and a wireless device, but not a handheld multifunction wireless device configured to operate in at least five frequency bands as required by amended independent claim 16. Furthermore, Tran fails to disclose that the second antenna element is configured to operate in at least one frequency band, the at least one frequency band being used by a 4G communication standard and that a perimeter of the second antenna element defines a second antenna contour having a level of complexity defined by second complexity factor F21 having a value of at least 1.20 and second complexity factor F32 having a value less than 1.75 as required by amended independent claim 16.

Dominquez, which is cited merely for allegedly teaching features no longer recited in claim 16, does not compensate for the deficiencies of Tran, since Dominquez also fails to disclose or suggest the aforementioned requirements of claim 16. Accordingly, the subject matter of claim 16 and its dependent claims would not have been obvious from any combination of Tran and Dominquez.

Ramer, which is cited merely for allegedly teaching features recited in dependent claim 17, also does not compensate for the deficiencies of Tran, since Ramer also fails to disclose or suggest the aforementioned requirements of claim 16. Thus, the subject matter of claim 16 and its dependent claims would not have been obvious from any combination of Tran, Dominquez, and Ramer.

While claim 16 was not rejected over Lehtola in the previous Office Action, for completeness, an explanation of the distinctions between amended claim 16 and Lehtola is provided. Lehtola discloses an internal multi-band antenna for use in a hand-held telecommunication device. The antenna of Lehtola has three radiating elements that each produces one resonance. Using two switching devices, the antenna generates a fourth resonant frequency.⁷ Lehtola fails to disclose multimedia or smartphone functionality and does not teach a touch screen, a microprocessor, an operating system adapted to permit running applications, or an image recording system comprising an at least two-Megapixel image sensor, as required by amended independent claim 16.

⁶ *Tran*, Abstract.

⁷ *Lehtola*, Col. 2, lines 33-40.

According to Lehtola, an internal multi-band antenna is operable to resonate at up to four resonant frequencies but not at the same time. Lehtola fails to disclose a handheld multifunction wireless device configured to operate in at least five frequency bands as required by amended independent claim 16. According to Lehtola, the three radiation modes are excited within three different portions.⁸ As such, the radiation modes *do not* overlap with each other, not even partially. In contrast, amended independent claim 16 requires, among other things, that the first, the second, and the third radiation modes *overlap* at least partially with each other. Such a feature is not disclosed by Lehtola. None of the other references cure the deficiencies of Tran and Lehtola noted above. In addition, Applicant respectfully submits that amended independent claim 16 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to amended independent claim 1 and is therefore also in condition for allowance, and withdrawal of the rejections of these claims is respectfully requested.

Claim 18

Claims 18 and 19 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,476,769 to Lehtola in view of Ramer and Dominquez. Amended independent claim 18 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Applicant respectfully submits that amended independent claim 18 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to amended independent claims 1 and 16 and is therefore also in condition for allowance.

Claim 20

Claim 20 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Tran in view of Ramer.

Amended independent claim 20 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Tran discloses a

⁸ Lehtola, Fig. 1.

telephone transceiver that operates in a frequency band at the GSM850 frequency range (824-894 MHz) and a frequency band at the PCS1900 frequency range (1850-1990 MHz). Tran fails to disclose a communication module configured to operate in *a third frequency band*, as required by amended independent claim 20. In addition, Tran fails to disclose a communication module comprising an antenna system within the handheld multifunction wireless device having at least a first and second antenna elements. Applicant respectfully submits that Tran's telephone transceiver together with the antenna system cannot be integrated *within* a handheld wireless device due to the physical dimensions of the antenna system. Furthermore, Tran does not disclose a second antenna element that is configured to receive signals from a 4G communication standard, as required by amended independent claim 20.

Ramer, which is cited merely for allegedly teaching features no longer recited in claim 20, does not compensate for the deficiencies of Tran, since Ramer also fails to disclose or suggest the aforementioned requirements of claim 20. Accordingly, the subject matter of claim 20 would not have been obvious from any combination of Tran and Ramer.

While claim 20 was not rejected over Lehtola in the previous Office Action, for completeness, an explanation of the distinctions between amended claim 20 and Lehtola is provided. In Lehtola, the first radiating arm has a first end connected to the ground plane, the second radiating element has a second end electrically connected to the first end of the first electrically conducting area, and the third radiating element has a third end connected to the ground plane. Lehtola does not provide any information about the location of the antenna in relation to the shortest side of the ground plane. As such, Lehtola fails to disclose that the first antenna element is proximate to a first short side of the ground plane rectangle and that the second antenna element is proximate to a second short side of the ground plane rectangle, as required by amended independent claim 20. In addition, Applicant respectfully submits that amended independent claim 20 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to amended independent claims 1, 16, and 18 and is therefore also in condition for allowance.

Conclusion

In view of the foregoing, Applicant respectfully requests the Examiner to find the application to be in condition for allowance with claims 1-5 and 16-30. However, if for any reason the Examiner feels that the application is not now in condition for allowance, the Examiner is respectfully requested to call the undersigned attorney to discuss any unresolved issues and to expedite the disposition of the application.

Filed concurrently herewith is a Petition (with payment) for an Extension of Time of One Month. Applicant hereby petitions for any extension of time that may be necessary to maintain the pendency of this application. The Commissioner is hereby authorized to charge payment of any additional fees required for the above-identified application or credit any overpayment to Deposit Account No. 05-0460.

Dated: November 13, 2013

Respectfully submitted by:

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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.

DETAILED ACTION

Non-Responsive Amendment

1. The amendment filed on 07/17/2013 cancelled the originally presented Claims 1-20.

Newly submitted claims 21-40 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons:

The inventions are distinct because the originally presented claims did not require the antenna system structure of the newly submitted claims comprising:

"a first subset of the plurality of conducting geometric elements defines a first conducting portion to provide a first path for currents associated with a radiation mode in a first frequency band; a second conducting portion formed by at least a second subset of the plurality of conducting geometric elements provides a second path for currents associated with a radiation mode in a second frequency band; a third conducting portion formed by at least a third subset of the plurality of conducting geometric elements provides a third path for currents associated with a radiation mode in a third frequency band; the first, second, and third conducting portions overlap at least partially with each other".

Applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, **claims 21-40 are withdrawn from consideration** as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

Furthermore, given that the Applicant failed to respond to the rejections of the originally presented claims, the amendment filed on 07/17/2013 is non-responsive (MPEP § 821.03).

Since the above-mentioned amendment appears to be a *bona fide* attempt to reply, applicant is given a TIME PERIOD of ONE (1) MONTH or THIRTY (30) DAYS, whichever is longer, from the mailing date of this notice within which to supply the omission or correction in order to avoid abandonment. EXTENSIONS OF THIS TIME PERIOD UNDER 37 CFR 1.136(a) ARE AVAILABLE.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARISOL FIGUEROA whose telephone number is (571)272-7840. The examiner can normally be reached on M-F 8:30 a.m.-5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jinsong Hu can be reached on (571)272-3965. 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.

/MARISOL FIGUEROA/
Primary Examiner, Art Unit 2643

**Notice of Non-Compliant
Amendment (37 CFR 1.121)**

Application No.

11/614,429

Examiner

MARISOL FIGUEROA

Applicant(s)

BALIARDA ET AL.

Art Unit

2643

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

The amendment document filed on 17 July 2013 is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121 or 1.4. In order for the amendment document to be compliant, correction of the following item(s) is required.

THE FOLLOWING MARKED (X) ITEM(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

- ☐ 1. Amendments to the specification:
- ☐ A. Amended paragraph(s) do not include markings.
 - ☐ B. New paragraph(s) should not be underlined.
 - ☐ C. Other _____.
- ☐ 2. Abstract:
- ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
 - ☐ B. Other _____.
- ☐ 3. Amendments to the drawings:
- ☐ A. The drawings are not properly identified in the top margin as "Replacement Sheet," "New Sheet," or "Annotated Sheet" as required by 37 CFR 1.121(d).
 - ☐ B. The practice of submitting proposed drawing correction has been eliminated. Replacement drawings showing amended figures, without markings, in compliance with 37 CFR 1.84 are required.
 - ☐ C. Other _____.
- ☒ 4. Amendments to the claims:
- ☐ A. A complete listing of all of the claims is not present.
 - ☐ B. The listing of claims does not include the text of all pending claims (including withdrawn claims)
 - ☐ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified. Note: the status of every claim must be indicated after its claim number by using one of the following status identifiers: (Original), (Currently amended), (Canceled), (Previously presented), (New), (Not entered), (Withdrawn) and (Withdrawn-currently amended).
 - ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
 - ☒ E. Other: _____.
- ☐ 5. Other (e.g., the amendment is unsigned or not signed in accordance with 37 CFR 1.4):

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP § 714.

TIME PERIODS FOR FILING A REPLY TO THIS NOTICE:

1. Applicant is given **no new time period** if the non-compliant amendment is an after-final amendment or an amendment filed after allowance. If applicant wishes to resubmit the non-compliant after-final amendment with corrections, the **entire corrected amendment** must be resubmitted.
2. Applicant is given **one month**, or thirty (30) days, whichever is longer, from the mail date of this notice to supply the correction, if the non-compliant amendment is one of the following: a preliminary amendment, a non-final amendment (including a submission for a request for continued examination (RCE) under 37 CFR 1.114), a supplemental amendment filed within a suspension period under 37 CFR 1.103(a) or (c), and an amendment filed in response to a *Quayle* action. If any of above boxes 1. to 4. are checked, the correction required is only the **corrected section** of the non-compliant amendment in compliance with 37 CFR 1.121.

Extensions of time are available under 37 CFR 1.136(a) only if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action.

Failure to timely respond to this notice will result in:

Abandonment of the application if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action; or

Non-entry of the amendment if the non-compliant amendment is a preliminary amendment or supplemental amendment.

/MARISOL FIGUEROA/
Primary Examiner, Art Unit 2643

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with 37 CFR § 1.8(a)(4).

Dated: July 17, 2013
Electronic Signature for Shoaib A. Mithani: /Shoaib A. Mithani/

Docket No. 47005-P022US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Carles Puente Baliarda et al.

Application No.: 11/614,429

Confirmation No.: 9346

Filed: December 21, 2006

Art Unit: 2643

For: MULTIPLE-BODY CONFIGURATION
MULTIMEDIA AND SMARTPHONE
MULTIFUNCTION WIRELESS DEVICES

Examiner: M. Figueroa

AMENDMENT IN RESPONSE TO NON-FINAL OFFICE ACTION

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

Dear Madam:

INTRODUCTORY COMMENTS

In response to the Office Action dated March 19, 2013, please amend the above-identified U.S. patent application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 8 of this paper.

6097538v.1 47005-P022US
DALLAS_1 6097538v1

AMENDMENTS TO THE CLAIMS

1-20. (Canceled)

21. (New) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

a touch screen;

a microprocessor and an operating system adapted to permit running of word-processing, spreadsheet, and slide software applications;

an image recording system comprising an at least two-Megapixel image sensor;

an antenna system within the handheld multifunction wireless device;

the antenna system comprises a first antenna element formed by a plurality of conducting geometric elements, a second antenna element, and a ground plane layer;

the handheld multifunction wireless device operates in at least five frequency bands;

a first subset of the plurality of conducting geometric elements defines a first conducting portion to provide a first path for currents associated with a radiation mode in a first frequency band;

a second conducting portion formed by at least a second subset of the plurality of conducting geometric elements provides a second path for currents associated with a radiation mode in a second frequency band;

a third conducting portion formed by at least a third subset of the plurality of conducting geometric elements provides a third path for currents associated with a radiation mode in a third frequency band;

the first, second, and third conducting portions overlap at least partially with each other;

the first frequency band is contained within a low frequency region of an electromagnetic spectrum;

the second and the third frequency bands are contained within a high frequency region of the electromagnetic spectrum;

the second antenna element is configured to operate in at least one frequency band, the at

least one frequency band being used by a 4G communication standard;

a perimeter of the first antenna element defines a first antenna contour having a level of complexity defined by first complexity factor F21 having a value of at least 1.20 and first complexity factor F32 having a value smaller than 1.75; and

a perimeter of the second antenna element defines a second antenna contour having a level of complexity defined by second complexity factor F21 having a value of at least 1.20 and second complexity factor F32 having a value smaller than 1.75.

22. (New) The handheld multifunction wireless device according to claim 21, wherein the first antenna element is configured to transmit and receive signals from a 4G communication standard.

23. (New) The handheld multifunction wireless device according to claim 21, wherein the first antenna contour comprises at least thirty-five segments.

24. (New) The handheld multifunction wireless device according to claim 23, wherein the second antenna contour comprises at least twenty segments.

25. (New) The handheld multifunction wireless device according to claim 21, wherein the first antenna contour comprises at least two disjointed subsets of segments, each of said at least two subsets of segments comprises at least ten segments.

26. (New) The handheld multifunction wireless device according to claim 21, wherein the handheld multifunction wireless device comprises a third antenna configured to operate in a frequency band within 2400-2480 MHz frequency range.

27. (New) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

a touch screen;

a geolocalization system;

data storage module having a capacity of at least 1 GB;

the handheld multifunction wireless device is configured to transmit and receive signals from at least four frequency bands, each of the at least four frequency bands is used by at least one communication standard;

an antenna system comprising a ground plane layer and three antenna elements within the handheld multifunction wireless device;

a first antenna element having a conductive plate configured to simultaneously support radiation modes for the at least first, second and third frequency bands;

the second antenna element is configured to receive signals from a 4G communication standard; and

a perimeter of the second antenna element defines an antenna contour having a level of complexity defined by complexity factor F21 having a value of at least 1.20 and complexity factor F32 having a value smaller than 1.75.

28. (New) The handheld multifunction wireless device according to claim 27, wherein the first frequency band is contained within 810-960 MHz frequency range, the second frequency band is contained within 1710-1990 MHz frequency range, and the third frequency band is contained within 1900-2170 MHz frequency range.

29. (New) The handheld multifunction wireless device according to claim 27, wherein the first antenna element is substantially close to a short side of a ground plane rectangle defined by the ground plane layer, and the second antenna element is close to a short side of the ground plane rectangle.

30. (New) The handheld multifunction wireless device according to claim 27, wherein the first antenna element is substantially close to a short side of a ground plane rectangle defined by the ground plane layer, and the second antenna element is close to a long side of the ground plane rectangle.

31. (New) The handheld multifunction wireless device according to claim 27, wherein the third antenna element is configured to operate in a fifth frequency band within 2400-2480 MHz frequency range.

32. (New) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

- a touch screen;
- a processing module;
- a memory module;
- a communication module;
- a power management module;

an antenna system within the handheld multifunction wireless device comprising a first antenna element, a second antenna element, and a ground plane layer;

the first antenna element is configured to simultaneously support radiation modes for a first, a second and a third frequency bands of operation, the first frequency band of operation being contained within a low frequency region of the electromagnetic spectrum, the second frequency band of operation being contained within a high frequency region of the electromagnetic spectrum, the third frequency band of operation being used by a 4G communication standard;

the second antenna element is configured to operate in at least one frequency band used by a 4G communication standard;

a perimeter of the first antenna element defines a first antenna contour comprising at least thirty-five segments;

a perimeter of the second antenna element defines a second antenna contour comprising at least twenty segments;

the first antenna element defines an antenna box;

an orthogonal projection of the antenna box along a normal to a face with a largest area of the antenna box defines an antenna rectangle; and

a length of the first antenna contour is larger than four times a diagonal of the antenna rectangle.

33. (New) The handheld multifunction wireless device according to claim 32, wherein the communication module is configured to simultaneously transmit signals from a CDMA communication standard, a WiFi communication standard, and a 4G communication standard.

34. (New) The handheld multifunction wireless device according to claim 32, wherein each of the first frequency band and the second frequency band is used by at least one communication standard selected from: GSM, UMTS, CDMA, W-CDMA.

35. (New) The handheld multifunction wireless device according to claim 32, wherein the ground plane layer defines a ground plane rectangle, the projection of the antenna rectangle on the ground plane rectangle partially overlaps the ground plane rectangle.

36. (New) A handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the handheld multifunction wireless device comprising:

- a touch screen;

- a microprocessor;

- at least one memory having a total capacity of at least 1 GB;

- a communication module configured to operate in a first frequency band contained within a low frequency region of the electromagnetic spectrum, in a second frequency band contained within a high frequency region of the electromagnetic spectrum, and in a third frequency band used by a 4G communication standard;

- the communication module comprises an antenna system within the handheld multifunction wireless device having at least two antenna elements and a ground plane layer, the at least first antenna element is configured to transmit and receive signals from a 4G communication standard, and the at least second antenna element is configured to receive signals from a 4G communication standard;

- each of the first frequency band and the second frequency band is used by at least one communication standard;

the ground plane layer defines a ground plane rectangle;
the first antenna element is substantially close to a first short side of the ground plane rectangle;

the second antenna element is substantially close to a second short side of the ground plane rectangle; and

a perimeter of the second antenna element defines an antenna contour having a level of complexity defined by complexity factor F21 having a value of at least 1.20 and complexity factor F32 having a value smaller than 1.75.

37. (New) The handheld multifunction wireless device according to claim 36, wherein an antenna box is defined by the first antenna element, an antenna rectangle is defined by an orthogonal projection of the antenna box along a normal to a face with a largest area of the antenna box, and wherein a longer side of said antenna rectangle is substantially parallel to the first short side of the ground plane rectangle.

38. (New) The handheld multifunction wireless device according to claim 36, wherein the low frequency region is delimited by 810-960 MHz frequency range, and the high frequency region is delimited by 1710-1990 MHz frequency range.

39. (New) The handheld multifunction wireless device according to claim 36, wherein the complexity factor F21 has a value smaller than 1.45.

40. (New) The handheld multifunction wireless device according to claim 36, wherein the handheld multifunction wireless device is configured to use the first antenna element and the second antenna element as a diversity system.

REMARKS

Reconsideration of the application is respectfully requested. Claims 21-40 are pending. Claims 21-40 have been added. Claims 1-20 have been canceled. Applicant respectfully submits that no new matter has been added by the amendments presented herein.

Claims 1-3, 6-9, 11-14, and 20 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,989,794 to Tran ("Tran") in view of U.S. Patent No. 7,548,915 to Ramer et al. ("Ramer"). Claims 4-5 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Tran in view of Ramer and in further view of U.S. Patent Application Publication No. 2002/0175211 to Dominquez et al. ("Dominquez"). Claims 10 and 15 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Tran in view of Ramer and in further view of U.S. Patent Application Publication No. 2007/0229383 to Koyanagi et al. ("Koyanagi"). Claim 16 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Tran in view of Dominquez. Claim 17 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Tran in view of Dominquez and in further view of Ramer. Claims 18-19 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,476,769 to Lehtola ("Lehtola") in view of Ramer and in further view of Dominquez. Claims 1-20 have been canceled, thus rendering the rejections thereof moot.

New independent claim 21 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Applicant respectfully submits that the combination references fails to disclose at least one of the distinguishing features of new independent claim 21, namely, a touch screen, a microprocessor and an operating system adapted to permit running of word-processing, spreadsheet, and slide software applications, an image recording system comprising an at least two-Megapixel image sensor, and that the handheld multifunction wireless device operates in at least five frequency bands. In addition, the combination of references fails to disclose that the first, second, and third conducting portions overlap at least partially with each other, the second antenna element being configured to operate in at least one frequency band, the at least one frequency band being used by a 4G communication standard and that a perimeter of the second antenna element defines a

second antenna contour having a level of complexity defined by second complexity factor F21 having a value of at least 1.20 and second complexity factor F32 having a value smaller than 1.75.

Tran discloses a recursive pattern antenna and a method for forming a recursive pattern antenna for a transceiver system. The recursive pattern antenna has a plurality of radiators that each resonate at a different frequency. At most, Tran discloses a wireless device with an antenna and a telephone transceiver.¹ Tran fails to disclose multimedia or smartphone functionality nor does it teach a touch screen, a microprocessor, and an operating system adapted to permit running applications, nor an image recording system comprising an at least two-Megapixel image sensor as required by new independent claim 21.

Tran discloses that “Antennas designed with fractal generators and a number of iterations, which is referred to herein as fractal geometry, appear to offer performance advantages over the conventional Euclidian antenna designs. Alternately, even if performance is not improved, the fractal designs permit antennas to be designed in a new form factor. However, the form factor of a fractal antenna need not necessarily be smaller than a comparable Euclidian antenna, and it need not fit within the constraints of a portable wireless communication device package.”² Applicant respectfully submits that the antenna taught by Tran *cannot* be integrated *within a handheld* wireless device due to its physical dimensions. Tran discloses an antenna that, in order to resonate and be conducive to electromagnetic communications of a particular frequency range, must have effective electrical lengths approximately equal to one half of a wavelength in the frequency range. As such, the longest length is determined by the lowest frequency of operation, in this case 824MHz, resulting in a length of 7.1 inches (18.2 centimeters) that imposes very large minimum physical dimensions as seen in Figure 6 (606).

¹ Tran, Fig. 2.

² Tran, Col. 1, line 60-Col. 2, line 3.

Tran discloses an antenna element in the form of a monopole, dipole or patch.³ Applicant respectfully submits that Tran fails to disclose a second antenna element. The antenna disclosed in Tran is a *recursive pattern antenna* and not a *plurality of antennas*. Applicant respectfully disagrees that Tran's dipole is a first antenna element and a second antenna element because, in addition, a dipole antenna requires two arms which cannot be treated independently as otherwise the antenna would not work. For these reasons, Applicant respectfully submits that the dipole antenna of Tran counts as one antenna element. As such, Tran fails to disclose a second antenna element as required by new independent claim 21.

In addition, Applicant respectfully submits that Tran fails to disclose operation in a fifth frequency band as it can operate in up to four frequency bands: 824-894 MHz, 1565-1585 MHz, 1850-1990 MHz, and 2400-2480 MHz.⁴ In addition, Tran discloses an antenna and a wireless device, but not a handheld multifunction wireless device that operates in at least five frequency bands as required by new independent claim 21. Furthermore, Tran fails to disclose that the second antenna element is configured to operate in at least one frequency band, the at least one frequency band being used by a 4G communication standard and that a perimeter of the second antenna element defines a second antenna contour having a level of complexity defined by second complexity factor F21 having a value of at least 1.20 and second complexity factor F32 having a value smaller than 1.75 as required by new independent claim 21.

Lehtola discloses an internal multi-band antenna for use in a hand-held telecommunication device. The antenna of Lehtola has three radiating elements that each produce one resonance. Using two switching devices, the antenna generates a fourth resonant frequency.⁵ Lehtola fails to disclose multimedia or smartphone functionality nor does it teach a touch screen, a microprocessor, and an operating system adapted to permit running applications, nor an image recording system comprising an at least two-Megapixel image sensor as required by new independent claim 21.

³ Tran, Col. 3, lines 60-65.

⁴ Tran, Abstract.

⁵ Lehtola, Col. 2, lines 33-40.

According to Lehtola, an internal multi-band antenna is operable to resonate at up to four resonant frequencies but not at the same time. Lehtola fails to disclose a handheld multifunction wireless device operating in at least five frequency bands as required by new independent claim 21. According to Lehtola, the three radiation modes are excited within three different portions.⁶ As such, the conducting portions *do not* overlap with each other, not even partially. In contrast, new independent claim 21 requires, among other things, that the first, second, and third conducting portions *overlap* at least partially with each other. Such a feature is not disclosed by Lehtola. In addition, Lehtola fails to disclose that the second antenna element is configured to operate in at least one frequency band, the at least one frequency band being used by a 4G communication standard and that a perimeter of the second antenna element defines a second antenna contour having a level of complexity defined by second complexity factor F21 having a value of at least 1.20 and second complexity factor F32 having a value smaller than 1.75 as required by new independent claim 21. None of the other references cure the deficiencies of Tran and Lehtola noted above. For at least the reasons set forth above, new independent claim 21 is in condition for allowance.

New independent claim 27 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Tran fails to disclose a handheld multifunction wireless device configured to transmit and receive signals from at least four frequency bands. In Tran, the wireless device is configured to transmit and receive, at most, three frequency bands. In contrast, new independent claim 27 requires, among other things, that the handheld multifunction wireless device is configured to transmit and receive signals from at least *four frequency bands*. Such a feature is not disclosed by Tran. In addition, Tran fails to disclose an antenna system comprising *three antenna elements* within the handheld multifunction wireless device. Tran discloses only one antenna element.

According to Lehtola, the sub-antenna structure is a portion of the antenna element has a conductive plate which does not simultaneously support radiation modes for at least three frequency bands. The second radiating arm always provides the second resonant frequency, and

⁶ Lehtola, Fig. 1.

the first radiating arm provides the first resonant frequency and the fifth resonant frequency but not at the same time because it is necessary to change the open/closed position of the two switching devices. Therefore only two radiation modes will be supported simultaneously at most, and not three as required by new independent claim 27. Furthermore, Lehtola discloses one antenna element and not three antenna elements as required by new independent claim 27. In addition, Applicant respectfully submits that new independent claim 27 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to new independent claim 21 and is therefore also in condition for allowance.

New independent claim 32 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Applicant respectfully submits that new independent claim 32 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to new independent claims 21 and 27 and is therefore also in condition for allowance.

New independent claim 36 relates to a handheld multifunction wireless device having at least one of multimedia functionality and smartphone functionality. Tran discloses a telephone transceiver that operates in a frequency band at the GSM850 frequency range (824-894 MHz) and a frequency band at the PCS1900 frequency range (1850-1990 MHz). Tran fails to disclose a communication module that operates in *a third frequency band* as required by new independent claim 36. In addition, Tran fails to disclose a communication module comprising an antenna system within the handheld multifunction wireless device having at least two antenna elements. Applicant respectfully submits that Tran's telephone transceiver together with the antenna system cannot be integrated *within* a handheld wireless device due to the physical dimensions of the antenna system. Furthermore, Tran does not disclose a second antenna element that is configured to receive signals from a 4G communication standard as required by new independent claim 36.

In Lehtola, the first radiating arm has a first end connected to the ground plane, the second radiating element has a second end electrically connected to the first end of the first

electrically conducting area, and the third radiating element has a third end connected to the ground plane. Lehtola does not provide any information about the location of the antenna in relation to the shortest side of the ground plane. As such, Lehtola fails to disclose that the first antenna element is substantially close to a first short side of the ground plane rectangle and that the second antenna element is substantially close to a second short side of the ground plane rectangle as required by new independent claim 36. In addition, Applicant respectfully submits that new independent claim 36 patentably distinguishes over the combination of references for similar reasons to those discussed above with respect to new independent claims 21, 27, and 32 and is therefore also in condition for allowance.

Dependent claims 22-26 depend from and further limit new independent claim 21 in a patentable sense. Dependent claims 28-31 depend from and further limit new independent claim 27 in a patentable sense. Dependent claims 33-35 depend from and further limit new independent claim 32 in a patentable sense. Dependent claims 37-40 depend from and further limit new independent claim 36 in a patentable sense. These dependent claims are therefore deemed to distinguish over the combination of references for at least the same reasons as those set forth above relative to the rejection of amended independent claims 21, 27, 32, and 36, respectively, and are in condition for allowance.

Furthermore, the Office Action asserts that it would have been obvious to one having ordinary skill in the art, at the time of the invention, to include particular values for the complexity factors for which discovering the optimum or workable ranges involves only routine skill in the art, since it had been held that where the general conditions of a claim are disclosed in the prior art. Applicant respectfully submits that, at the time of the invention, only the level of complexity defined by complexity factor F32 was known as a factor that numerically quantify the degree of miniaturization achieved by the geometry of an antenna system.

The non-anticipated and non-obvious level of complexity defined by complexity factor F21 is geared towards an assessment of the number of paths that the antenna system provides to electric currents and/or the equivalent magnetic currents to excite radiation modes. The formula

and method for computing complexity factor F21 are relevant in the design of antenna systems according to a set of specifications such as, for instance, space available within the multifunction wireless device for the integration of an antenna system and of the ground-plane of the device, information of the functionality envisioned for a given multifunction device (smartphone and multimedia functionalities for instance), and, among others, the requirements on RF performance of the antenna system and the communication standards that are to be operated by the multifunction wireless device. The latter defines which frequency bands are to be operated and, thus, the wide-band or multi-band behavior of the antenna system. Therefore complexity factor F21 becomes advantageous in the design of the antenna system for shaping the antenna elements through slots, gaps or apertures being created within the plates, peripheral parts being removed from the plate, parts of said plate being folded or bended and/or additional conducting parts being added that defines the geometrical characteristics, namely the internal and external perimeters, of the resulting antenna system. For the reasons set forth, Applicant respectfully submits that the values set for complexity factors F21 and F32 are non- obvious.

In view of the above, Applicant respectfully submits that the present application is in condition for allowance. A Notice to that effect is respectfully requested.

Dated: July 17, 2013

Respectfully submitted,

Electronic signature: /Shoaib A. Mithani/
Shoaib A. Mithani

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	12/21/2006	INV001Carles Puente Baliarda	47005-P022US	9346
61060	7590	03/19/2013		
WINSTEAD PC P.O. BOX 131851 DALLAS, TX 75313			EXAMINER FIGUEROA, MARISOL	
			ART UNIT 2643	PAPER NUMBER
			MAIL DATE 03/19/2013	DELIVERY MODE PAPER

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

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

Office Action Summary	Application No. 11/614,429	Applicant(s) BALIARDA ET AL.	
	Examiner MARISOL FIGUEROA	Art Unit 2643	
	-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --		

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED. (35 U.S.C. § 133).

Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1) ☒ Responsive to communication(s) filed on 23 November 2011.

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

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

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

Disposition of Claims

5) ☒ Claim(s) 1-20 is/are pending in the application.

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

6) ☐ Claim(s) ____ is/are allowed.

7) ☒ Claim(s) 1-20 is/are rejected.

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

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

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

Application Papers

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

11) ☐ The drawing(s) filed on ____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

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

a) ☒ All b) ☐ Some * c) ☐ None of:

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

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

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

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

Attachment(s)

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

2) ☒ Information Disclosure Statement(s) (PTO/SB/08)
 Paper No(s)/Mail Date ____.

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

4) ☐ Other: ____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 11/23/2011 has been entered.

Information Disclosure Statement

2. The information disclosure statements (IDS) submitted on 6/20/11, 1/13/2012, 4/12/2012, 6/7/2012, and 12/14/2012 was filed after the mailing date of the Final Office Action on 05/27/2011. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner. However, documents have not been checked to the extent necessary due to the length and amount of documents submitted. Applicant's cooperation is requested in indicating the relevance of the documents.

Response to Arguments

3. Applicant's arguments with respect to claims 1-20 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection. See rejection below.

Claim Rejections - 35 USC § 103

Art Unit: 2643

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. **Claims 1-3, 6-9, 11-14, and 20** are rejected under 35 U.S.C. 103(a) as being unpatentable over TRAN (US 6,989,794) in view of RAMER et al. (US 7,548,915).

Regarding claim 1, Tran discloses a multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the multimedia wireless device comprising:

an antenna system disposed within the wireless device (Fig. 2) that provides operability at a first frequency band fully contained within 810MHz-960Mhz region(1) of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz-1990MHz region(2) of the electromagnetic spectrum, and a third band fully contained within 1900MHz-2170MHz region(3) of the electromagnetic spectrum (abstract; col. 2, lines 24-54; col. 3, lines 15-41 and 50-58; the wireless device comprises a recursive pattern antenna which can perform electromagnetic communications in the range between 824 and 894 MHz(1), 1850 and 1990 MHz(2), and 2400 and 2480 MHz(3)), said first, second and third frequency bands being used by at least one communication standard (col. 7, lines 49-56);

wherein the antenna comprises a first antenna element having a conductive plate (Figs. 1a-1c; col. 3, lines 15-24 and line 59-col. 4, lines 1-5; the recursive pattern antenna comprises a

plurality of radiators formed within the antenna shape, one of ordinary skill in the art would recognize that the antenna is inherently a conductive plate element);

wherein said conductive plate supports radiation mode for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands (abstract; col. 3, lines 15-41 and 50-58; the antenna has a plurality of shape radiators that are conductive to the electromagnetic communications in different frequency ranges, thus the antenna (i.e., conductive plate) support the first, second, and third frequency bands of operation).

But, Tran does not particularly disclose wherein a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F21 having a value of at least 1.05 and not greater than 1.80 and F32 having a value of at least 1.10 and not greater than 1.90.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *so that a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F21 having a value of at least 1.05 and not greater than 1.80 and F32 having a value of at least 1.10 and not greater than 1.90*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Further, Tran does not particularly disclose wherein the wireless device comprises an upper body and a lower body, the upper body and lower body being adapted to move relative to

each other in at least one of a clamshell, a slide, and a twist manner and the antenna being disposed within at least one of the upper body and the lower body.

However, Ramer discloses wireless device comprises an upper body and a lower body, the upper body and lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (Figs. 7A-7C) and the antenna being disposed within at least one of the upper body and the lower body (col. 8, lines 44-49). Therefore, it would have been obvious to a person having ordinary skill in the art, to modify Tran with the teachings of Ramer, since these are well known wireless communication device types.

Regarding claim 2, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses wherein the multifunction wireless device has multimedia functionality (col. 8, lines 19-43 and 50-61).

Regarding claim 3, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses wherein the multifunction wireless device has smartphone functionality (col. 8, lines 19-43 and 50-61).

Regarding claim 6, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses wherein the first body and the second body comprise a clamshell configuration (Fig. 7B).

Regarding claim 7, the combination of Tran and Ramer disclose the multifunction wireless device of claim 6, Ramer discloses comprising: an image-recording system (col. 8, lines 50-61); a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels (col. 8, lines 6-12 and 50-61); a keyboard (Figs. 8A-8C); and wherein the antenna system is mounted on the lower body below the keyboard (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising complexity factor F21 having a value greater than 1.45 and complexity factor F32 having a value greater than 1.75.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 having a value greater than 1.45 and complexity factor F32 having a value greater than 1.75*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 8, the combination of Tran and Ramer disclose the multifunction wireless device of claim 6, Ramer discloses comprising: a keyboard comprising at least 40 keys (Fig. 8A); and wherein the antenna system is mounted on the lower body below the keyboard (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising complexity factor F.sub.21 having a value less than 1.45 and complexity factor F.sub.32 having a value less than 1.50.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 having a value less than 1.45 and complexity factor F32 having a value less than 1.50*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 9, the combination of Tran and Ramer disclose the multifunction wireless device of claim 6, Ramer discloses further comprising: a hinge connecting the upper body to the lower body (Fig. 7B); and wherein the antenna system is mounted on the lower body adjacent to the hinge (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising a complexity factor F21 having a value greater than 1.20 and the complexity F32 having a value of at least 1.55.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 having a value greater than 1.20 and the complexity F32 having a value of at least 1.55*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 11, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses wherein the upper body and the lower body are adapted to move relative to each other in a manner selected from the group consisting of a twist manner and a slide manner (col. 11, lines 13-38).

Regarding claim 12, the combination of Tran and Ramer disclose the multifunction wireless device of claim 11, Ramer discloses further comprising: a receiver of at least one of analog and digital sound signals (col. 17, lines 34-41 and col. 38, lines 12-29); a microprocessor interoperably coupled to the receiver (col. 6, lines 65-col. 7, line 25; processor is inherent in a

wireless device); a keyboard (Figs. 8A-8C); wherein the antenna system is mounted on the lower body below the keyboard (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising complexity factor F21 that has a value greater than 1.45 and the complexity factor F32 that has a value greater than 1.75.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 that has a value greater than 1.45 and the complexity factor F32 that has a value greater than 1.75*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 13, the combination of Tran and Ramer disclose the multifunction wireless device of claim 11, Ramer discloses comprising: a microphone system adapted to record sound and convert the recorded sound to a digital format (col. 17, lines 34-41 and col. 38, lines 12-29); a keyboard (Figs. 8A-8C); wherein the antenna system is mounted on the lower body below the keyboard (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising complexity factor F21 that has a value less than 1.45 and the complexity factor F32 that has a value less than 1.50.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 that has a value less than 1.45 and the complexity factor F32 that has a value less*

than 1.50, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 14, the combination of Tran and Ramer disclose the multifunction wireless device of claim 11, Ramer discloses further comprising: a hinge connecting the upper body to the lower body (Fig. 7B); and wherein the antenna system is mounted on the lower body adjacent to the hinge (col. 8, lines 44-49; *internal antenna*).

But, Tran and Ramer does not particularly disclose the antenna comprising a complexity factor F21 having a value greater than 1.20 and the complexity F32 having a value of at least 1.55.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *for the antenna to comprise complexity factor F21 having a value greater than 1.20 and the complexity F32 having a value of at least 1.55*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 20, Tran discloses a multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

a processing module; a memory module; a communication module (Fig. 2; wireless device has communication module 202/204 and has inherent processing and memory module since these are necessary components of a wireless device);

wherein the communication module operates at a first frequency band fully contained within 810 MHz-960 MHz(1) region of the electromagnetic spectrum, at a second frequency band fully contained within 1710 MHz-1990 MHz(2) region of the electromagnetic spectrum, and at a third band fully contained within 1900 MHz-2170 MHz(3) region of the electromagnetic spectrum (abstract; col. 2, lines 24-54; col. 3, lines 15-41 and 50-58; the wireless device comprises a recursive pattern antenna which can perform electromagnetic communications in the range between 824 and 894 MHz(1), 1850 and 1990 MHz(2), and 2400 and 2480 MHz(3)), said first, second and third frequency bands being used by at least one communication standard (col. 7, lines 49-56);

wherein the communication module comprises an antenna system having a first antenna element comprising a conductive plate (Figs. 1a-1c; col. 3, lines 15-24 and line 59-col. 4, lines 1-5; the recursive pattern antenna comprises a plurality of radiators formed within the antenna shape, one of ordinary skill in the art would recognize that the antenna is inherently a conductive plate element);

wherein said conductive plate supports radiation mode for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands (abstract; col. 3, lines 15-41 and 50-58; the antenna has a plurality of shape radiators that are conductive to the electromagnetic communications in different frequency ranges, thus the antenna (i.e., conductive plate) support the first, second, and third frequency bands of operation).

But, Tran does not particularly disclose wherein the wireless device comprises an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner; a display; and a power management module; wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body; and wherein a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F21 having a value of at least 1.05 and not greater than 1.80 and F32 having a value of at least 1.10 and not greater than 1.90.

However, Ramer discloses wireless device comprises an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner; a display; and a power management module; wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body (Figs. 7A-7C). Therefore, it would have been obvious to a person having ordinary skill in the art, to modify Tran with the teachings of Ramer, since these are well known wireless communication device types.

Further, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tran's invention *so that a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F21 having a value of at least 1.05 and not greater than 1.80 and F32 having a value of at least 1.10 and not greater than 1.90*, since it has been held that where the general conditions of a claim are

disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

6. **Claims 4-5** are rejected under 35 U.S.C. 103(a) as being unpatentable over TRAN in views of RAMER et al., and DOMINQUEZ et al. (US 2002/0175211).

Regarding claim 4, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses further comprising: a microprocessor (col. 6, lines 65-col. 7, line; processor is inherent in a wireless device); at least one memory interoperably coupled to the microprocessor (Fig. 1; data storage 18); an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen (Figs. 8A-8C; col. 8, lines 6-11).

But, Tran and Ramer does not particularly disclose wherein the complexity factor F21 has a value greater than 1.39 and the complexity factor F32 has a value greater than 1.50; and wherein the at least one memory having a total capacity of at least 1GB.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention *for the antenna to comprise complexity factor F21 has a value greater than 1.39 and the complexity factor F32 has a value greater than 1.50*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Further, Dominquez teaches a wireless device with memory having a total capacity of at least 1GB (Fig. 2 and p. [0040]). Therefore, it would have been obvious to modify the combination with the teachings of Dominquez, since it would provide a memory that will allow the storage of great amount of programs and user data.

Regarding claim 5, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Ramer discloses further comprising: a receiver of at least one of analog and digital sound signals (col. 17, lines 34-41 and col. 38, lines 12-29); an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom (col. 8, lines 50-61); data storage (Fig. 1; data storage 18).

But, Tran and Ramer does not particularly disclose wherein the complexity factor F21 has a value greater than 1.39 and the complexity factor F32 has a value greater than 1.50; and wherein the data storage is at least 1GB in capacity.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention *for the antenna to comprise complexity factor F21 has a value greater than 1.39 and the complexity factor F32 has a value greater than 1.50*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Further, Dominiquez teaches a wireless device with memory having a total capacity of at least 1GB (Fig. 2 and p. [0040]). Therefore, it would have been obvious to modify the combination with the teachings of Dominiquez, since it would provide a memory that will allow the storage of great amount of programs and user data.

7. **Claims 10 and 15** are rejected under 35 U.S.C. 103(a) as being unpatentable over TRAN in views of RAMER et al., and KOYANAGI et al. (US 2007/0229383).

Regarding claim 10, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, but does not particularly disclose wherein the upper body and the

lower body each have a thickness value of at least 5 mm and not greater than 9 mm and the complexity factor F21 has a value greater than 1.43 and the complexity factor F32 has a value greater than 1.63.

However, Koyanagi discloses wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm (p. [0002]; since the mobile telephone is placed in a pocket the thickness of the housing is limited to 30mm or less). Therefore, it would have been obvious to a person having ordinary skill in the art at the time of the invention, to modify the combination with the teachings of Koyanagi, in order to conveniently place a mobile telephone in one's pocket.

Further, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention *for the antenna to comprise complexity factor F21 has a value greater than 1.43 and the complexity factor F32 has a value greater than 1.63*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Regarding claim 15, the combination of Tran and Ramer disclose the multifunction wireless device of claim 1, Tran discloses further comprising: a geolocalization system (Fig. 2; GPS receiver 208).

But, does not particularly disclose wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and wherein the complexity factor F21 has a value greater than 1.43 and the complexity factor F32 has a value greater than 1.63.

However, Koyanagi discloses wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm (p. [0002]; since the mobile telephone is placed in a pocket the thickness of the housing is limited to 30mm or less). Therefore, it would have been obvious to a person having ordinary skill in the art at the time of the invention, to modify the combination with the teachings of Koyanagi, in order to conveniently place a mobile telephone in one's pocket.

Further, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention *for the antenna to comprise complexity factor F21 has a value greater than 1.43 and the complexity factor F32 has a value greater than 1.63*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

8. **Claim 16** is rejected under 35 U.S.C. 103(a) as being unpatentable over TRAN in view of DOMINQUEZ et al.

Regarding claim 16, Tran discloses a multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

a microprocessor and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications (Fig. 2; microprocessor is an inherent component of a wireless device);

at least one memory interoperably coupled to the microprocessor (Fig. 2; memory is an inherent component of a wireless device to store program executed by the microprocessor),

an antenna system capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of at least three frequency bands (abstract; col. 2, lines 24-54; col. 3, lines 15-41 and 50-58; the wireless device comprises a recursive pattern antenna which can perform electromagnetic communications in the range between 824 and 894 MHz(1), 1850 and 1990 MHz(2), and 2400 and 2480 MHz(3)), said at least three frequency bands used by at least two communication standards (col. 7, lines 49-56), the antenna system comprising:

a first antenna element having a first conductive plate, the first antenna element supporting radiation modes for said at least three frequency bands; and a second antenna element having a second conductive plate, the second antenna element being electromagnetically coupled to the first antenna element in at least one of said at least three frequency bands (Figs. 3a-3c; col. 2, lines 24-54; col. 3, lines 15-58; the recursive pattern antenna can be a bow tie dipole antenna as shown in figures 3a-3c having first conductive plate 100 and second conductive plate 310, having plurality of radiators formed within to support the plurality of frequency bands of operation).

Bui, Tran does not particularly disclose the memory having a total capacity of at least 1GB; and wherein a perimeter of the first conductive plate and a perimeter of the second conductive plate define an antenna contour having a level of complexity defined by complexity factor F21 having a value of at least 1.40 and not greater than 1.80 and by complexity factor F32 having a value of at least 1.20 and not greater than 1.70.

However, Dominquez teaches a wireless device with memory having a total capacity of at least 1GB (Fig. 2 and p. [0040]). Therefore, it would have been obvious to modify the

combination with the teachings of Dominguez, since it would provide a memory that will allow the storage of great amount of programs and user data.

Further, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention to include *wherein a perimeter of the first conductive plate and a perimeter of the second conductive plate define an antenna contour having a level of complexity defined by complexity factor F21 having a value of at least 1.40 and not greater than 1.80 and by complexity factor F32 having a value of at least 1.20 and not greater than 1.70*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

8. **Claim 17** is rejected under 35 U.S.C. 103(a) as being unpatentable over TRAN in views of DOMINQUEZ et al. and RAMER.

Regarding claim 17, the combination of Tran and Dominguez disclose the multifunction wireless device of claim 16, but does not particularly disclose further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner.

However, Ramer discloses wireless device comprises an upper body and a lower body, the upper body and lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (Figs. 7A-7C) and the antenna being disposed within at least one of the upper body and the lower body (col. 8, lines 44-49). Therefore, it would have been obvious to a person having ordinary skill in the art, to modify Tran with the teachings of Ramer, since these are well known wireless communication device types.

9. **Claims 18-19** are rejected under 35 U.S.C. 103(a) as being unpatentable over LEHTOLA (US 6,476,769) in view of RAMER, and DOMINQUEZ et al.

Regarding claim 18, Lehtola discloses a multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

a receiver of at least one of analog and digital sound signals; data storage means (col. 1, lines 5-8; a receiver and data storage means are inherent components of hand-held communications device);

an antenna system (col. 1, lines 5-8; multi-band antenna); comprising a first antenna element having a conducting plate, the first antenna element supporting radiation modes for at least three frequency bands, so that the antenna system is capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of said at least three frequency bands (Fig. 1; col. 1, lines 44-67; col. 2, lines 33-39);

wherein said at least three frequency bands are used by at least a GSM communication standard and a WCDMA communication standard (col. 5, lines 21-22);

wherein the antenna system defines an antenna contour comprising at least two disjointed subsets of segments, each of said at least two subsets of segments comprising at least six segments; wherein one of said at least two disjointed subsets of segments is defined by the perimeter of said conductive plate (Fig. 1; antenna structure has a subantenna structure 10 having a radiating element 30 (i.e., first disjointed subset) and disjointed radiating element 40 (i.e., second disjointed subset), at least one of the radiating elements have six segments; the perimeter of the radiating elements is defined by the perimeter of the conductive plate 40/30/20).

But, Lehtola does not particularly disclose wherein the antenna contour has a level of complexity defined by complexity factor F21 having a value of at least 1.05 and not greater than 1.40 and by complexity factor F32 having a value of at least 1.20 and not greater than 1.70;

and the multifunction wireless device comprising at least one of an two-megapixel image sensor, a flashlight, an optical zoom, and a digital zoom and wherein the storage means have a capacity of at least 1 GB.

However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the invention to include *wherein the antenna contour has a level of complexity defined by complexity factor F21 having a value of at least 1.05 and not greater than 1.40 and by complexity factor F32 having a value of at least 1.20 and not greater than 1.70*, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233.

Further, Ramer teaches wireless device comprising at least one of a two-megapixel image sensor, a flashlight, an optical zoom, and a digital zoom (col. 8, lines 50-61) and **Dominquez** teaches a wireless device with storage means having a capacity of at least 1 GB (Fig. 2 and p. [0040]). Therefore, it would have been obvious to a person having ordinary skill in the art at the time of the invention, to modify Lehtola with the teachings of Ramer and Dominquez, since it would provide more functionality to the wireless communication device and would provide a memory that will allow the storage of great amount of programs and user data.

Regarding claim 19, the combination of Lehtola, Ramer and Dominquez disclose the multifunction wireless device of claim 18, Ramer discloses further comprising an upper body

and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (Figs. 7A-7C).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARISOL FIGUEROA whose telephone number is (571)272-7840. The examiner can normally be reached on M-F 8:30 a.m.-5:00 p.m..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jinsong Hu can be reached on (571)272-3965. 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.

/MARISOL FIGUEROA/
Primary Examiner, Art Unit 2643

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.

Request for Continued Examination (RCE) Transmittal Address to: Mail Stop RCE Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450	Application Number	11/614,429-Conf. #9346
	Filing Date	December 21, 2006
	First Named Inventor	Carles Puente Baliarda
	Art Unit	2617
	Examiner Name	M. Figueroa
	Attorney Docket Number	47005-P022US

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. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. **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).
- a. ☐ 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.
- i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ii. ☐ Other _____
- b. ☒ Enclosed
- i. ☒ Amendment/Reply
- ii. ☐ Affidavit(s)/Declaration(s)
- iii. ☐ Information Disclosure Statement (IDS)
- iv. ☐ Other _____
2. **Miscellaneous**
- a. ☐ 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(l) required)
- b. ☐ Other _____
3. **Fees** The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
- a. ☒ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any Overpayments, to Deposit Account No. 23-2426.
- i. ☒ RCE fee required under 37 CFR 1.17(e)
- ii. ☒ Extension of time fee (37 CFR 1.136 and 1.17)
- iii. ☒ Other Any deficiency in the fees
- b. ☐ Check in the amount of \$ _____ enclosed
- c. ☐ Payment by credit card (Form PTO-2038 enclosed)

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.**SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED**

Signature	/Ross T. Robinson/	Date	November 23, 2011
Name (Print/Type)	Ross T. Robinson	Registration No.	47,031

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4).

Dated: November 23, 2011

Electronic Signature for Kimberly Benline: /Kimberly Benline/

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4).

Dated: November 23, 2011 Signature: /Kimberly Benline/
(Kimberly Benline)

Docket No. 47005-P022US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Carles Puente Baliarda et al.

Application No. 11/614,429

Confirmation No. 9346

Filed: December 21, 2006

Art Unit: 2617

For: MULTIPLE-BODY CONFIGURATION
MULTIMEDIA AND SMARTPHONE
MULTIFUNCTION WIRELESS DEVICES

Examiner: M. Figueroa

AMENDMENT AFTER FINAL ACTION

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

Dear Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action dated May 27, 2011, please amend the above-identified U.S. patent application as indicated herein.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 9 of this paper.

AMENDMENTS TO THE CLAIMS

1. (CURRENTLY AMENDED) A multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the multifunction wireless device comprising:

an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner; and

an antenna system disposed within at least one of the upper body and the lower body and that provides operability at a first frequency band fully contained within 810MHz–960MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz–1990MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900MHz–2170MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard;

wherein the antenna system comprises a first antenna element having a ~~shape with a level of complexity of an antenna contour~~ conductive plate;

wherein said conductive plate supports radiation modes for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands; and

wherein a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.

2. (ORIGINAL) The multifunction wireless device of claim 1, wherein the multifunction wireless device has multimedia functionality.

3. (ORIGINAL) The multifunction wireless device of claim 1, wherein the multifunction wireless device has smartphone functionality.

4. (ORIGINAL) The multifunction wireless device of claim 1, further comprising:
a microprocessor;
at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen; and
wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{32} has a value greater than 1.50.
5. (ORIGINAL) The multifunction wireless device of claim 1, further comprising:
a receiver of at least one of analog and digital sound signals;
an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;
data storage of at least 1 GB in capacity; and
wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{32} has a value greater than 1.50.
6. (ORIGINAL) The multifunction wireless device of claim 1, wherein the first body and the second body comprise a clamshell configuration.
7. (ORIGINAL) The multifunction wireless device of claim 6, comprising:
an image-recording system;
a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels;
a keyboard; and
wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor F_{21} having a value greater than 1.45 and the complexity factor F_{32} having a value greater than 1.75.
8. (ORIGINAL) The multifunction wireless device of claim 6, comprising:

a keyboard comprising at least 40 keys; and
wherein the antenna system is mounted on the lower body below the keyboard,
the complexity factor F_{21} having a value less than 1.45 and the complexity factor F_{32} having a
value less than 1.50.

9. (ORIGINAL) The multifunction wireless device of claim 6, further comprising:
a hinge connecting the upper body to the lower body; and
wherein the antenna system is mounted on the lower body adjacent to the hinge,
the complexity factor F_{21} having a value greater than 1.20 and the complexity F_{32} having a value
of at least 1.55.

10. (ORIGINAL) The multifunction wireless device of claim 1, wherein the upper
body and the lower body each have a thickness value of at least 5mm and not greater than 9mm
and the complexity factor F_{21} has a value greater than 1.43 and the complexity factor F_{32} has a
value greater than 1.63.

11. (ORIGINAL) The multifunction wireless device of claim 1, wherein the upper
body and the lower body are adapted to move relative to each other in a manner selected from
the group consisting of a twist manner and a slide manner.

12. (ORIGINAL) The multifunction wireless device of claim 11, further comprising:
a receiver of at least one of analog and digital sound signals;
a microprocessor interoperably coupled to the receiver;
a keyboard;
wherein the antenna system is mounted on the lower body below the keyboard;
and
wherein the complexity factor F_{21} has a value greater than 1.45 and the
complexity factor F_{32} has a value greater than 1.75.

13. (ORIGINAL) The multifunction wireless device of claim 11, comprising:

a microphone system adapted to record sound and convert the recorded sound to a digital format;

a keyboard;

wherein the antenna system is mounted on the lower body below the keyboard;

and

wherein the complexity factor F_{21} has a value less than 1.45 and the complexity factor F_{32} has a value less than 1.50.

14. (ORIGINAL) The multifunction wireless device of claim 11, comprising:

a hinge connecting the upper body to the lower body; and

wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor F_{21} having a value greater than 1.20 and the complexity factor F_{32} having a value of at least 1.55.

15. (ORIGINAL) The multifunction wireless device of claim 1, further comprising:

a geolocalization system;

wherein the upper body and the lower body each have a thickness value of at least 5mm and not greater than 9mm; and

wherein the complexity factor F_{21} has a value greater than 1.43 and the complexity factor F_{32} has a value greater than 1.63.

16. (CURRENTLY AMENDED) A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

a microprocessor and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications;

at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

an antenna system ~~and~~ capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of at least three frequency bands, said at least

three frequency bands being used by at least two communication standards, the antenna system comprising:

wherein the antenna system has a shape with a first antenna element having a first conductive plate, the first antenna element supporting radiation modes for said at least three frequency bands; and

a second antenna element having a second conductive plate, the second antenna element being electromagnetically coupled to the first antenna element in at least one of said at least three frequency bands;

wherein a perimeter of the first conductive plate and a perimeter of the second conductive plate define an antenna contour having a level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least ~~1.05~~1.40 and not greater than 1.80 and by complexity factor F_{32} having a value of at least ~~1.10~~1.20 and not greater than ~~1.90~~1.70.

17. (ORIGINAL) The multifunction wireless device of claim 16, further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner.

18. (CURRENTLY AMENDED) A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

a receiver of at least one of analog and digital sound signals;

an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;

data storage means having a capacity of at least 1 GB;

an antenna system; ~~and comprising~~ a first antenna element having a conducting plate, the first antenna element supporting radiation modes for at least three frequency bands, so that the antenna system is capable of simultaneously transmitting and receiving electromagnetic signals across the frequencies of said at least three frequency bands;

wherein said at least three frequency bands are used by at least a GSM communication standard and a WCDMA communication standard;

wherein the antenna system defines an antenna contour comprising at least two disjointed subsets of segments, each of said at least two subsets of segments comprising at least six segments;

wherein one of said at least two disjointed subsets of segments is defined by the perimeter of said conductive plate; and

wherein the antenna contour has a ~~shape with a~~ level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least 1.05 and not greater than ~~1.80~~1.40 and by complexity factor F_{32} having a value of at least ~~1.10~~1.20 and not greater than ~~1.90~~1.70.

19. (ORIGINAL) The multifunction wireless device of claim 18, further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner

20. (CURRENTLY AMENDED) A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner;

a display;

a processing module;

a memory module;

a communication module; and

a power management module;

wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body;

wherein the communication module operates at a first frequency band fully contained within 810MHz–960MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz–1990MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900MHz–2170MHz region of the

electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard;~~and~~

wherein the communication module comprises an antenna system having a ~~shape~~
~~with a level of complexity of~~ first antenna element comprising a conductive plate;

wherein said conductive plate supports radiation modes for the first, second and third frequency bands of operation, so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across the frequencies of said first, second and third frequency bands; and

wherein a perimeter of said conductive plate defines an antenna contour having a level of complexity defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.

REMARKS

Petition for Extension of Time

Applicant petitions for a three-month extension of time and authorizes the Office to debit the required fee from Deposit Account 23-2426.

Request for Continued Examination

Applicant requests continued examination of this patent application and authorizes the Office to debit the required fee from Deposit Account 23-2426.

Arguments

Claims 1-20 are pending. Claims 1, 16, 18, and 20 have been amended. No claims have been added. No claims have been canceled. Applicant respectfully submits that no new matter has been added by the amendments presented herein. Reconsideration of the application as amended is respectfully requested.

Claims 1-3, 6-9, 11, 14, and 20 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of U.S. Patent No. 7,548,915 to Ramer, et al. ("Ramer") and U.S. Patent Application Publication No. 2004/0119644 to Puente-Baliarda, et al. ("Puente-Baliarda").

Notwithstanding the amendments presented herein to rejected independent claims 1 and 20, Applicant respectfully disagrees that independent claims 1 and 20 prior to their amendment herein were unpatentable over the cited combination of Ramer and Puente-Baliarda. Applicant has amended each of independent claims 1 and 20 to facilitate prosecution of the application.

Independent claim 1 has been amended to recite, among other things, that the antenna system provides operability in three frequency bands, each being fully contained in a specific and different region of the electromagnetic spectrum. On page 10 of the Office Action, a similar feature of claim 20 prior to its amendment herein is asserted to be disclosed by Ramer and col. 6, Ins. 49-64 and col. 8, Ins. 19-43 of Ramer cited. The first cited portion of Ramer merely

indicates that a mobile communication facility 102 of a wireless search platform 100 may be a device that utilizes a mobile communication protocol, providing the passage some examples of such protocols. The second cited portion of Ramer simply indicates that "[t]he mobile communication facility 102 may also accommodate high-speed data communications by utilizing GPRS, EGPRS... or iDEN protocols." Applicant respectfully submits that, even if it is assumed, for the sake of argument, that a device utilizes a particular protocol, or even two or more protocols, it does not necessarily follow that the features of amended claim 1 of a first, second, and third frequency bands, in which the claimed frequency bands are fully contained in specific frequency ranges as set forth in amended independent claim 1, are disclosed by Ramer.

The mobile communication facility 102 of Ramer could, for example, utilize two communication protocols in a single frequency band, which need not be fully contained in any of the regions of the electromagnetic spectrum as set forth in amended independent claim 1. Moreover, even if it is assumed, for the sake of argument, that the mobile communication facility 102 utilizes communication protocols in two frequency bands, the two frequency bands could both be fully contained in the same region of the electromagnetic spectrum. Applicant respectfully submits that Ramer does not disclose the above-described features of amended independent claim 1.

In addition, amended independent claim 1 recites, among other things, that the antenna system comprises a first antenna element having a conductive plate that supports radiation modes for the three frequency bands of operation so that the first antenna element is able to simultaneously transmit and receive electromagnetic signals across frequencies of the three frequency bands. Amended independent claim 1 thus requires that the same antenna element be able to provide operation in the three frequency bands. Applicant respectfully submits that this feature of amended independent claim 1 is also not disclosed by Ramer. Ramer provides limited information about the antenna and, in particular, provides no disclosure as to whether operation in any frequency band is provided with a single antenna element.

Puente-Baliarda fails to cure the deficiencies of Ramer. For example, Puente-Baliarda discloses use of different independently fed antenna elements, each of which provides a different frequency band.¹

In light of the above, Applicant respectfully submits that amended independent claim 1 distinguishes over the cited combination of Ramer and Puente-Baliarda and is in condition for allowance. Withdrawal of the rejection thereof is respectfully requested.

Dependent claims 2-3, 6-9, 11, and 14 depend from and further limit independent claim 1 in a patentable sense. Each of these claims is deemed to distinguish over the cited combination of Ramer and Puente-Baliarda for at least the same reasons as those set forth above with regard to the rejection of independent claim 1. Withdrawal of the rejection of these dependent claims is respectfully requested.

Independent claim 20 has been amended to include similar features to those discussed above with regard to amended independent claim 1 and is deemed to distinguish over the cited combination of Ramer and Puente-Baliarda for similar reasons. Withdrawal of the rejection of independent claim 20 is respectfully requested.

Claims 4-5 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer and Puente-Baliarda as applied to claim 1 and further in view of U.S. Patent Application Publication No. 2002/0175211 to Dominquez, et al. ("Dominquez"). Applicant respectfully submits that Dominquez fails to cure the deficiencies of the cited combination of Ramer and Puente-Baliarda discussed above. Because claims 4-5 depend from and further limit independent claim 1 in a patentable sense, these dependent claims are deemed to distinguish over the cited combination of Ramer, Puente-Baliarda, and Dominquez for at least the same reasons as those set forth above with regard to the rejection of independent claim 1. Withdrawal of the rejection thereof is respectfully requested.

Claims 12-13 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer and Puente-Baliarda as applied to claim 1 and further in view of U.S.

¹ See, e.g., Fig. 4, ¶ [0070].

Patent No. 7,183,983 to Ozden ("Ozden"). Applicant respectfully submits that Ozden fails to cure the deficiencies noted above of the cited combination of Ramer and Puente-Baliarda.

Claims 12-13 depend from and further limit independent claim 1 in a patentable sense.

Applicant respectfully submits that claims 12-13 distinguish over the cited combination of Ramer, Puente-Baliarda, and Ozden for at least the same reasons as those set forth above with respect to the rejection of independent claim 1.

Claims 16-19 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer, Puente-Baliarda, and Dominguez. Dominguez has been cited as teaching the feature of "the at least one memory interoperably coupled to the microprocessor has a total capacity of at least 1 GB." Applicant respectfully submits that, notwithstanding the amendments presented herein to claims 16 and 18, the cited combination of Ramer, Puente-Baliarda, and Dominguez fails to render obvious claims 16 and 18 prior to their amendment herein. Claims 16 and 18 are amended herein in order to facilitate prosecution.

Applicant respectfully submits that Dominguez' discussion of preferable dimensions and weight of a recording apparatus are incompatible with an apparatus such as the mobile communication facility shown in Figs. 7-8 of Ramer. From the passage in which Dominguez discloses that "[t]he recording apparatus's depth preferably is less than four inches, the longest dimension of its face preferably is less than twelve inches and its weight preferably is less than five pounds,"² the skilled person would simply understand that the recording device of Ramer has dimensions and weight approximately close to those preferred values but without exceeding them. On the contrary, Ramer's mobile communication facility typically is approximately eight times thinner, has transversal dimensions about 3-4 times shorter, and is about 40 times lighter in weight than the preferred values set out in Dominguez for the recording apparatus. Thus, due to the substantial difference in form factor, it is at the very least arguable whether the skilled person could find the teachings of Dominguez relevant for the mobile communication facility of Ramer.

Moreover, amended independent claim 16 requires that the antenna provide operability in three frequency bands. This feature has been discussed above with regard to the rejection of

² See ¶ [0048].

independent claim 1. Applicant respectfully submits that claim 16 defines over the cited combination of Ramer, Puente-Baliarda, and Dominquez for similar reasons to those discussed above relative to independent claim 1. In addition, claim 16 requires that the three frequency bands be used by at least two different communication standards.

Additionally, amended independent claim 16 requires that the antenna system comprise first and second antenna elements, each comprising a conductive plate, with the first antenna element supporting radiation modes for the three frequency bands of operation, and the second antenna element being electromagnetically coupled to the first antenna element in at least one of the three frequency bands. As discussed above, Ramer provides limited information about the antenna. In particular, there is no disclosure in Ramer of an antenna having a first antenna element supporting radiation modes in a plurality of bands. Further, there is no disclosure in Ramer of a second antenna element coupled to a first antenna element. Puente-Baliarda fails to cure the deficiencies of Ramer at least because Puente-Baliarda teaches the use of different independent antenna elements for each frequency band. Puente-Baliarda does not suggest an antenna element supporting radiation modes for several frequency bands. Moreover, Puente-Baliarda does not disclose plate-like antenna elements being electromagnetically coupled. Finally, Puente-Baliarda does not disclose an antenna contour being defined by perimeters of two conductive plates and with complexity factors within the ranges claimed in amended independent claim 16.

For at least the reasons set forth above, Applicant respectfully submits that amended independent claim 16 distinguishes over the cited combination of Ramer, Puente-Baliarda, and Dominquez and is in condition for allowance. Withdrawal of the rejection of amended independent claim 16 is respectfully requested.

Amended independent claim 18 recites, among other things, that the antenna system comprises a first antenna element that supports radiation modes for at least three frequency bands. For similar reasons to those set forth above, the cited combination of Ramer, Puente-Baliarda, and Dominquez fails to disclose at least this feature. Moreover, as in amended independent claim 16, amended independent claim 18 requires that the three frequency bands be

used by at least two different communications standards, in particular, a GSM communication standard and a WCDMA communication standard.

Moreover, none of Ramer, Puente-Baliarda, and Dominquez discloses an antenna contour that has two disjointed subsets, with each subset comprising at least six segments and with one of the subsets being the perimeter of a conductive plate of an antenna element, and with complexity factors within the claimed ranges set forth in amended independent claim 18. Indeed, the grid-dimension curves of Puente-Baliarda do not satisfy the recited features of amended independent claim 18.

Applicant respectfully submits that amended independent claim 18 distinguishes over the cited combination of Ramer, Puente-Baliarda, and Dominquez. Withdrawal of the rejection of independent claim 18 is respectfully requested.

Dependent claims 17 and 19 depend from and further limit independent claims 16 and 18, respectively. Each of these dependent claims is deemed to distinguish over the cited combination of Ramer, Puente-Baliarda, and Dominquez for at least the same reasons as those set forth above with regard to the independent claim from which they depend. Withdrawal of the rejection of dependent claims 17 and 19 is respectfully requested.

Claims 10 and 15 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer and Puente-Baliarda as applied to claim 1 and further in view of U.S. Patent Application Publication No. 2007/0229383 to Koyanagi, et al. ("Koyanagi"). Applicant respectfully submits that Koyanagi fails to cure the deficiencies of the combination of Ramer and Puente-Baliarda discussed above relative to independent claim 1. Dependent claims 10 and 15 depend from and further limit independent claim 1 in a patentable sense. Applicant respectfully submits that each of dependent claims 10 and 15 distinguishes over the combination of Ramer, Puente-Baliarda, and Koyanagi for at least the same reasons as those set forth above with regard to the rejection of independent claim 1. Withdrawal of the rejection of dependent claims 10 and 15 is respectfully requested.

Application No. 11/614,429

Docket No.: 47005-P022US

In view of the above, Applicant respectfully submits that the present application is in condition for allowance. A Notice to that effect is respectfully requested.

Dated: November 23, 2011

Respectfully submitted,

Electronic signature: /Ross T. Robinson/

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	12/21/2006	Carles Puente Baliarda	47005-P022US	9346
61060	7590	05/27/2011		
WINSTEAD PC P.O. BOX 50784 DALLAS, TX 75201			EXAMINER HWANG, STAMFORD	
			ART UNIT 2617	PAPER NUMBER
			MAIL DATE 05/27/2011	DELIVERY MODE PAPER

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

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

Office Action Summary	Application No. 11/614,429	Applicant(s) BALIARDA ET AL.	
	Examiner STAMFORD HWANG	Art Unit 2617	
	-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --		

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

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

Status

1) ☒ Responsive to communication(s) filed on 21 March 2011.

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

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

Disposition of Claims

4) ☒ Claim(s) 1-20 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5) ☐ Claim(s) _____ is/are allowed.

6) ☒ Claim(s) 1-20 is/are rejected.

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

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

Application Papers

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

10) ☒ The drawing(s) filed on 19 February 2007 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

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

a) ☒ All b) ☐ Some * c) ☐ None of:

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

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

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

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

Attachment(s)

1) ☐ Notice of References Cited (PTO-892) 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date <u>03/21/2011</u>	4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date, _____ 5) ☐ Notice of Informal Patent Application 6) ☐ Other: _____
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DETAILED ACTION

Continued Examination Under 37 CFR 1.114

All claims are drawn to the same invention claimed in the application prior to the entry of the submission under 37 CFR 1.114 and could have been finally rejected on the grounds and art of record in the next Office action if they had been entered in the application prior to entry under 37 CFR 1.114. Accordingly, **THIS ACTION IS MADE FINAL** even though it is a first action after the filing of a request for continued examination and the submission under 37 CFR 1.114. See MPEP § 706.07(b). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1 - 3, 6 - 9, 11, 14 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1).

With respect to Claim 1, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**); and
- in antenna system disposed within at least one of the upper body and the lower body (**Col. 8, lines 44 - 49**)

Ramer et al. does not teach:

- and having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate

a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 2, Ramer et al. further teaches wherein the multifunction wireless device has multimedia functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 3, Ramer et al. further teaches wherein the multifunction wireless device has smartphone functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 6, Ramer et al. further teaches wherein the first body and the second body comprise a clamshell configuration (**Fig. 7B**).

With respect to Claim 7, Ramer et al. teaches comprising:

- an image-recording system (**Col. 8, lines 50 - 61**);

Art Unit: 2617

- a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels (**Col. 8, lines 50 - 61**);
- a keyboard (**Figs. 8A - 8C**); and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 8, Ramer et al. teaches comprising:

- a keyboard comprising at least 40 keys (**Fig. 8A**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value less than 1.45 and the complexity factor $F_{sub.32}$ having a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 9, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 11, Ramer et al. teaches wherein the upper body and the lower body are adapted to move relative to each other in a manner selected from the group consisting of a twist manner and a slide manner (**Col. 11, lines 13 - 38**).

With respect to Claim 14, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity factor $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with L_2

= $2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, $L1$, $L2$, $N1$ or $N2$. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 20, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**);
- a display (**Fig. 1, Display 172 and Col. 8, lines 3 - 18**);
- a processing module (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a memory module (**Fig. 1, Data Storage 118**);
- a communication module (**Col. 6, lines 65 - Col. 7, line 25**); and
- a power management module (**Col. 6, lines 65 - Col. 7, line 25**);

- wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body (**Figs. 7A - 7C and Col. 6, lines 65 - Col. 7, line 25**);
- wherein the communication module operates at a first frequency band fully contained within 810 MHz-960 MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710 MHz-1990 MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900 MHz-2170 MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard (**Col. 6, lines 49 - 64 and Col. 8, lines 19 - 43**); and

Ramer et al. does not teach:

- wherein the communication module comprises an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with L2

= $2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, $L1$, $L2$, $N1$ or $N2$. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Claims 4 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Dominguez et al. (U.S. 2002/0175211 A1).

With respect to Claim 4, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a microprocessor (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- at least one memory interoperably coupled to the microprocessor (**Fig. 1, Data Storage 118**);

- an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen (**Figs. 8A - 8C**); and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 5, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);
- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom (**Col. 8, lines 50 - 61**);

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage of at least 1 GB in capacity; and

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Ozden (U.S. 7,183,983 B2).

With respect to Claim 12, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- a microprocessor interoperably coupled to the receiver (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a keyboard (**Figs. 8A - 8C**);

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.45 and the complexity factor $F_{sub.32}$ has a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis (**Fig. 3B and Fig. 3C**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

With respect to Claim 13, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a microphone system adapted to record sound and convert the recorded sound to a digital format (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);
- a keyboard (**Figs. 8A - 8C**);

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

- wherein the complexity factor $F_{sub.21}$ has a value less than 1.45 and the complexity factor $F_{sub.32}$ has a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis **(Fig. 3B and Fig. 3C)**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

Claims 16 - 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2), Puente-Baliarda et al. (U.S. 2004/0119644 A1) and Dominquez et al. (U.S. 2002/0175211 A1).

With respect to Claim 16, Ramer et al. teaches a multifunction wireless device comprising:

- a microprocessor **(Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device)** and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications **(Col. 8, lines 19 - 43)**;
- at least one memory **(Fig. 1, Data Storage 118)** interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 17, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

With respect to Claim 18, Ramer et al. teaches a multifunction wireless device comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom **(Col. 8, lines 50 - 61)**;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- data storage means having a capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization **(Figs. 26 - 29 and Paragraphs [0095] - [0099])**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage means having a capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 19, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

Claims 10 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S.

2004/0119644 A1) as applied to Claims 1 above, and further in view of Koyanagi et al (U.S. 2007/0229383 A1).

With respect to Claim 10, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. does not teach wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm and the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach "wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm".

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

With respect to Claim 15, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a geolocalization system (**Col. 8, lines 19 - 43**);

Ramer et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one

Art Unit: 2617

grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to STAMFORD HWANG whose telephone number is (571)270-5578. The examiner can normally be reached on Monday ~ Friday 9:00AM ET~ 6:00PM ET.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Appiah can be reached on (571)272-7904. 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.

/STAMFORD HWANG/
Examiner, Art Unit 2617

/Charles N. Appiah/
Supervisory Patent Examiner, Art Unit 2617

3-22-11

RCE/FFW



Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Request for Continued Examination (RCE) Transmittal Address to: Mail Stop RCE Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450	Application Number	11/614,429-Conf. #9346
	Filing Date	December 21, 2006
	First Named Inventor	Carles Puente Baliarda
	Art Unit	2617
	Examiner Name	Hwang, Stamford
	Attorney Docket Number	47005-P022US

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. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. 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).

a. ☐ 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.

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

ii. ☐ Other _____

b. ☒ Enclosed

i. ☐ Amendment/Reply

ii. ☐ Affidavit(s)/Declaration(s)

iii. ☒ Information Disclosure Statement (IDS)

iv. ☐ Other _____

2. Miscellaneous

a. ☐ 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)

b. ☐ Other _____

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

a. ☒ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 23-2426.

i. ☒ RCE fee required under 37 CFR 1.17(e)

ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

iii. ☐ Other _____

b. ☐ Check in the amount of \$ _____ enclosed

c. ☐ Payment by credit card (Form PTO-2038 enclosed)

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.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED			
Signature		Date	March 21, 2011
Name (Print/Type)	Shoaib A. Mithani	Registration No.	61,654

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the U.S. Postal Service as Express Mail, Airbill No. EM018959314US, on the date shown below in an envelope addressed to:
MS RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated: March 21, 2011

Signature (Brenda I. Brown)



UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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11/614,429

12/21/2006

Carles Puente Baliarda

47005-P022US

9346

61060

7590

03/07/2011

WINSTEAD PC

P.O. BOX 50784

DALLAS, TX 75201

EXAMINER

HWANG, STAMFORD

ART UNIT

PAPER NUMBER

2617

MAIL DATE

DELIVERY MODE

03/07/2011

PAPER

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

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

Office Action Summary	Application No. 11/614,429	Applicant(s) BALIARDA ET AL	
	Examiner STAMFORD HWANG	Art Unit 2617	

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

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

Status

1) ☒ Responsive to communication(s) filed on 11 February 2011.

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

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

Disposition of Claims

4) ☒ Claim(s) 1-20 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5) ☐ Claim(s) _____ is/are allowed.

6) ☒ Claim(s) 1-20 is/are rejected.

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

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

Application Papers

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

10) ☒ The drawing(s) filed on 19 February 2007 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

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

a) ☒ All b) ☐ Some * c) ☐ None of:

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

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

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

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

Attachment(s)

1) ☐ Notice of References Cited (PTO-892) 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date <u>01/24/2011</u>	4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ 5) ☐ Notice of Informal Patent Application 6) ☐ Other: _____
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DETAILED ACTION

Response to Arguments

Applicant's arguments with respect to claims 1 - 20 have been considered but are moot in view of the new ground(s) of rejection.

With regards to applicant's argument "**I. Rejection Under 35 U.S.C § 103 of Claims 1-3, 6-9, 11, 14 and 20**" the examiner asserts that the combination of Ramer et al. and Puente-Baliarda et al. teaches all the limitations in the claims. Ramer et al. teaches a plurality of mobile communication facility configurations in Fig. 7A - Fig. 7C, including configurations involving clamshell and slide manners, and Ramer et al. also teaches the inclusion of various antennas, including an internal antenna, in the mobile communication facility in Col. 8, lines 44 - 49. The two citations clearly teaches an antenna system disposed within one of the upper body or the lower body as an internal antenna is bound to position within one of the bodies.

Moreover, the combination of Ramer et al. and Puente-Baliarda et al. would have been obvious to one of ordinary skilled in the art because in Paragraph [0013] of Puente-Baliarda et al., the art teaches "The utilization of microstrip antennas is known in mobile telephony handsets (See, Paper by K. Virga and Y. Rahmat-Samii, "Low-Profile Enhanced-Bandwidth PIFA Antennas for Wireless Communications Packaging", published in IEEE Transactions on Microwave theory and Techniques in October 1997), especially in the configuration denoted as PIFA (Planar Inverted F Antennas). "

Further, the grid dimension taught in Puente-Baliarda et al. does indeed disclose the two complexity factors. Claim 1 recites the two complexity factors, however, there is no distinguishing definition for their functions to separate one from another in the claims and both of the complexity factors are defined by the same formula as taught in Puente-Baliarda et al.. Also, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2 to achieve the desired minimum and maximum. See MPEP 2144.04 IV, Part A. Changes in Size/Proportion.

For the above reasons, the rejection is maintained and repeated below.

With regards to applicant's argument **"II. Rejection of Claims 4-5 Under 35 U.S.C § 103"** the examiner asserts that the combination of Ramer et al. and Puente-Baliarda et al., further in view of Dominquez et al., teaches all the limitations in the claims. The applicant argues that Dominquez et al. teaches the dimensions of the apparatus to be incompatible to that of Ramer et al., however, Dominquez et al. in fact teaches "The recording apparatus's depth preferably is less than four inches, the longest dimension of its face preferably is less than twelve inches and its weight preferably is less than five pounds." in Paragraph [0048]. The examiner believes Dominquez et al.'s teaching is indeed compatible with the teachings of Ramer et al.

For the above reason, the rejection is maintained and repeated below.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1 - 3, 6 - 9, 11, 14 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1).

With respect to Claim 1, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**); and
- in antenna system disposed within at least one of the upper body and the lower body (**Col. 8, lines 44 - 49**)

Ramer et al. does not teach:

- and having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one

Art Unit: 2617

grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 2, Ramer et al. further teaches wherein the multifunction wireless device has multimedia functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 3, Ramer et al. further teaches wherein the multifunction wireless device has smartphone functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 6, Ramer et al. further teaches wherein the first body and the second body comprise a clamshell configuration (**Fig. 7B**).

With respect to Claim 7, Ramer et al. teaches comprising:

- an image-recording system (**Col. 8, lines 50 - 61**);
- a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels (**Col. 8, lines 50 - 61**);
- a keyboard (**Figs. 8A - 8C**); and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension

by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 8, Ramer et al. teaches comprising:

- a keyboard comprising at least 40 keys (**Fig. 8A**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value less than 1.45 and the complexity factor $F_{sub.32}$ having a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension

by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 9, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension

by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 11, Ramer et al. teaches wherein the upper body and the lower body are adapted to move relative to each other in a manner selected from the group consisting of a twist manner and a slide manner (**Col. 11, lines 13 - 38**).

With respect to Claim 14, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity factor $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate

a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 20, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**);
- a display (**Fig. 1, Display 172 and Col. 8, lines 3 - 18**);
- a processing module (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a memory module (**Fig. 1, Data Storage 118**);
- a communication module (**Col. 6, lines 65 - Col. 7, line 25**); and
- a power management module (**Col. 6, lines 65 - Col. 7, line 25**);

- wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body (**Figs. 7A - 7C and Col. 6, lines 65 - Col. 7, line 25**);
- wherein the communication module operates at a first frequency band fully contained within 810 MHz-960 MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710 MHz-1990 MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900 MHz-2170 MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard (**Col. 6, lines 49 - 64 and Col. 8, lines 19 - 43**), and

Ramer et al. does not teach:

- wherein the communication module comprises an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with L2

= $2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Claims 4 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Dominquez et al. (U.S. 2002/0175211 A1).

With respect to Claim 4, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a microprocessor (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- at least one memory interoperably coupled to the microprocessor (**Fig. 1, Data Storage 118**);

- an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen (**Figs. 8A - 8C**); and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 5, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);
- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom (**Col. 8, lines 50 - 61**);

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage of at least 1 GB in capacity; and

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Ozden (U.S. 7,183,983 B2).

With respect to Claim 12, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- a microprocessor interoperably coupled to the receiver (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a keyboard (**Figs. 8A - 8C**);

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.45 and the complexity factor $F_{sub.32}$ has a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis (**Fig. 3B and Fig. 3C**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

With respect to Claim 13, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a microphone system adapted to record sound and convert the recorded sound to a digital format (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);
- a keyboard (**Figs. 8A - 8C**);

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

- wherein the complexity factor $F_{sub.21}$ has a value less than 1.45 and the complexity factor $F_{sub.32}$ has a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis **(Fig. 3B and Fig. 3C)**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

Claims 16 - 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2), Puente-Baliarda et al. (U.S. 2004/0119644 A1) and Dominguez et al. (U.S. 2002/0175211 A1).

With respect to Claim 16, Ramer et al. teaches a multifunction wireless device comprising:

- a microprocessor **(Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device)** and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications **(Col. 8, lines 19 - 43)**;
- at least one memory **(Fig. 1, Data Storage 118)** interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 17, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

With respect to Claim 18, Ramer et al. teaches a multifunction wireless device comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom **(Col. 8, lines 50 - 61)**;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- data storage means having a capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization **(Figs. 26 - 29 and Paragraphs [0095] - [0099])**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV, Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage means having a capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 19, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

Claims 10 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S.

2004/0119644 A1) as applied to Claims 1 above, and further in view of Koyanagi et al (U.S. 2007/0229383 A1).

With respect to Claim 10, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. does not teach wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm and the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach "wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm".

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

With respect to Claim 15, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a geolocalization system (**Col. 8, lines 19 - 43**);

Ramer et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one

grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to STAMFORD HWANG whose telephone number is (571)270-5578. The examiner can normally be reached on Monday ~ Friday 9:00AM ET~ 6:00PM ET.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Appiah can be reached on (571)272-7904. 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.

/S.H./
/STAMFORD HWANG/
Examiner, Art Unit 2617

/Charles N. Appiah/
Supervisory Patent Examiner, Art Unit 2617

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4).

Dated: February 11, 2011
Electronic Signature for David A. Lovell: /David A. Lovell/

Docket No. 47005-P022US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Carles Puente Puente-Baliarda et al,

Application No. 11/614,429

Confirmation No. 9346

Filed: December 21, 2006

Art Unit: 2617

For: MULTIPLE-BODY CONFIGURATION
MULTIMEDIA AND SMARTPHONE
MULTIFUNCTION WIRELESS DEVICES

Examiner: S. Hwang

RESPONSE TO NON-FINAL OFFICE ACTION

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

Dear Sir:

INTRODUCTORY COMMENTS

In response to the Office Action dated August 16, 2010, please consider the following:

Remarks/Arguments begin on page 2 of this paper.

REMARKS

Claims 1-20 are currently pending in the application. No claims have been amended, canceled or added. Applicant respectfully requests reconsideration of the application in view of the foregoing remarks.

I. Rejection Under 35 U.S.C. § 103 of Claims 1-3, 6-9, 11, 14, and 20

Claims 1-3, 6-9, 11, 14, and 20 stand rejected under 35 U.S.C. § 103 as being unpatentable over the combination of U.S. Patent No. 7,548,915 to Ramer et al. ("Ramer") in view of U.S. Patent Publication No. 2004/0119644 to Puente-Baliarda et al. ("Puente-Baliarda").

A. The Office Action fails to present a *prima facie* case of obviousness.

The U.S. Supreme Court has held that rigid and mandatory application of the "teaching-suggestion-motivation," or TSM, test is incompatible with its precedents.¹ The Court did not, however, discard the TSM test completely; it noted that its precedents show that an invention "composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art."²

The Court held that the TSM test must be applied flexibly, and take into account a number of factors "in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed."³ Despite this flexibility, however, the Court stated that "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements in the way the claimed new invention does."⁴ "To facilitate review, this analysis should be made explicit."⁵

¹ *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1741 [82 USPQ2d 1385] (2007).

² *Id.*

³ *Id.* at 1740-41.

⁴ *Id.*

⁵ *Id.* See *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) ("*[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness*") (emphasis added). *Id.*

Obviousness cannot be proven merely by showing that the elements of a claimed device were known in the prior art; it must be shown that those of ordinary skill in the art would have had some "apparent reason to combine the known elements in the fashion claimed."⁶ Applicant respectfully submits that, for several independent reasons, the Office Action has failed to present a *prima facie* case of obviousness with respect to independent claim 1. As explained further below, the conclusion of obviousness in the Office Action is based on a series of conclusory statements that fail to consider independent claim 1 as a whole.

The Office Action asserts that Ramer discloses in FIGS 7A-7C the feature of independent claim 1 of "an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner." FIGS. 7A-C illustrate, respectively, a candy-bar phone (i.e., no upper and lower bodies), a flip phone, and a slide phone.⁷ Applicant respectfully notes that Fig. 7A depicts a phone with an external antenna, while Figs. 7B-7C appear to be merely schematic representations that do not provide any information related to antenna systems of the phones shown. Ramer is silent as to whether the embodiments shown in FIGS. 7B-7C carry any particular antenna system.

The Office Action asserts that Ramer discloses, at col. 8, lines 44-49, "an antenna system disposed within at least one of the upper body and the lower body." In col. 8, lines 44-49, Ramer indicates, in the context of FIG. 1, that a mobile communication facility 102 (e.g., a cellular phone) "may transmit and/or receive data ... by utilizing an internal antenna, a stub antenna, a patch antenna, an antenna array, a stub/extendable antenna, or an extendable antenna." In other words, an internal antenna is cursorily referenced in a list of several possible alternatives. Ramer does not disclose an antenna system disposed within an upper body or an antenna system disposed within a lower body. Further, Ramer is silent as to how an antenna system would be disposed within an upper body or a lower body. Ramer fails to disclose any particular disposition of an antenna system.

⁶ *Id.* at 1741.

⁷ Ramer, col. 72 lines 48-52.

Puente-Baliarda focuses on an antenna system for a motor vehicle. Puente-Baliarda fails to disclose "an antenna system disposed within at least one of the upper body and the lower body" as required by independent claim 1. Therefore, Applicant respectfully submits that Puente-Baliarda fails to remedy the deficiencies of Ramer noted above. For at least this reason, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness with respect to independent claim 1.

Further, the Office Action admits, correctly, that Ramer fails to disclose "...a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.9." In an attempt to remedy this admitted deficiency of Ramer, the Office Action relies on Puente-Baliarda and states, in a conclusory manner, that "[i]t would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Puente-Baliarda et al. to obtain the degree of miniaturization." However, as explained above, Ramer does not disclose a disposition of an antenna system in either an upper body or a lower body. Therefore, even if the citation of Puente-Baliarda in the Office Action is taken at face value, there is no "device" as claimed in claim 1 in Ramer to modify "as taught by Puente-Puente-Baliarda et al."

In addition, the Office Action fails to provide a motivation for combination in terms of claim 1 as a whole. Puente-Baliarda relates to antenna systems for motor vehicles.⁸ According to Puente-Baliarda, antenna systems can be integrated within a vehicle component such as, for example, a rearview mirror assembly, a bumper, a windshield or a sunroof. However, such vehicle components have form factors that are not compatible in terms of size, shape or weight with that of a mobile communication facility such as the ones disclosed in Fig. 7 of Ramer (e.g., a cell phone). Puente-Baliarda fails to provide any suggestion that it would be technically feasible to adapt an antenna system integrated in a component of a motor vehicle to a much smaller device as disclosed in Ramer. Therefore, even if it is assumed solely for the sake of

⁸ Puente-Baliarda, par. 2.

argument that the Office Action is correct as to what Ramer and Puente-Baliarda disclose, the Office Action has failed to articulate an apparent reason to combine the known elements in the fashion claimed in claim 1.

Therefore, for the reasons presented above, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness with respect to independent claim 1. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of independent claim 1 be withdrawn.

B. Puente-Baliarda fails to disclose using two complexity factors as claimed.

Independent claim 1 requires "...a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90." In other words, independent claim 1 requires two complexity factors: F_{21} and F_{32} . In various embodiments, F_{21} is generally more related to a number of paths that a structure of the antenna system provides to currents and to the frequency bands and/or radiation modes than can be supported by the antenna structure.⁹ In various embodiments, F_{32} is generally more related to a degree of miniaturization achieved by the antenna system.¹⁰

In contrast to independent claim 1, Puente-Baliarda discloses computing a single factor (the grid dimension) via two grids. Puente-Baliarda also references a third grid that is only used to improve the accuracy of the calculation of the grid dimension.¹¹ Therefore, Puente-Baliarda fails to disclose two complexity factors as required by independent claim 1. Ramer does not supply this claim feature.

For at least this additional reason, Applicant respectfully submits that independent claim 1 patentably distinguishes over the combination of Ramer and Puente-Baliarda. Applicant

⁹ Application as published, pars. 170-171.

¹⁰ See Application as published, pars. 175-176.

¹¹ Puente-Baliarda, pars. 97-99.

respectfully requests that the rejection under 35 U.S.C. § 103 of independent claim 1 be withdrawn.

C. Puente-Baliarda fails to disclose (and teaches away from) setting maximum values for complexity factors as claimed.

According to independent claim 1, an antenna contour has complexity factors that each have a minimum value and a maximum value. In particular, independent claim 1 requires "...a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90." For example, Applicant's specification states that "[a]n antenna contour with a complexity factor F_{32} approximately equal to two, despite achieving substantial size reduction, may not be preferred for the MFWD 100 of the present invention as the antenna system is likely to have reduced capability to operate in multiple frequency bands and/or limited RF performance."¹²

However, Puente-Baliarda teaches that the larger the grid dimension of a grid-dimension curve, the higher the degree of miniaturization that may be achieved in terms of an antenna operating at a specific frequency or wavelength.¹³ Accordingly, Applicant respectfully submits that one of ordinary skill in the art, in an attempt to miniaturize an antenna system, would seek to shape the antenna contour of the antenna system to attain a grid dimension as high as possible. For example, in the example of FIGS. 26–29 of Puente-Baliarda, a grid dimension of two is computed.

Puente-Baliarda contains no disclosure of an antenna contour with a grid dimension below a certain maximum value. Rather, because Puente-Baliarda teaches attaining as high of a grid dimension as possible, Puente-Baliarda teaches away from "...an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90." Further, following the teachings of Puente-

¹² See Application as published, par. 180.

¹³ Puente-Baliarda, par. 96.

Baliarda, one of ordinary skill in the art is likely to select an antenna contour having a grid dimension of approximately two.

For the reasons presented above, Applicant respectfully submits that the combination of Ramer and Puente-Baliarda fail to render independent claim 1 obvious. Moreover, Applicant respectfully submits that the Office Action's *prima facie* case of obvious fails at least due to Puente-Baliarda teaching away from "...an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90." Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of independent claim 1 be withdrawn.

D. Independent Claim 20 and Dependent Claims 2-3, 6-9, 11, and 14

For reasons similar to those presented above with respect to independent claim 1, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness of independent claim 20. In addition, for reasons similar to those presented above with respect to independent claim 1, Applicant respectfully submits that the combination of Ramer and Puente-Baliarda fails to render independent claim 20 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of independent claim 20 be withdrawn.

Dependent claims 2-3, 6-9, 11, and 14 depend from and further patentably restrict independent claim 1. For at least the reasons presented above with respect to independent claim 1, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness of dependent claims 2-3, 6-9, 11, and 14. In addition, for reasons similar to those presented above with respect to independent claim 1, Applicant respectfully submits that the combination of Ramer and Puente-Baliarda fails to render any of dependent claims 2-3, 6-9, 11, and 14 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 2-3, 6-9, 11, and 14 be withdrawn.

II. Rejection of Claims 4-5 Under 35 U.S.C. § 103

Claims 4-5 stand rejected under 35 U.S.C. § 103 as being unpatentable over Ramer and Puente-Baliarda in view of U.S. Patent Publication No. 2003/0175211 to Dominquez et al. ("Dominquez"). Dominquez relates to a system and method for recording and verifying information about employees and other individuals for accounting and payroll purposes.¹⁴ Dominquez's system includes a recording apparatus having an internal computer that includes a processor and an internal data storage device providing a minimum storage capacity of one gigabyte of data.¹⁵

Dependent claim 4 requires, *inter alia*, "...at least one memory having a total capacity of at least 1 GB." Dependent claim 5 requires, *inter alia*, "data storage of at least 1 GB in capacity." For each of these features, the Office Action cites Dominquez's recording apparatus. With respect to claims 4 and 5, the Office Action states, in a conclusory manner, that "[i]t would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device in Ramer et al. and Puente-Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data."

However, Dominquez's recording apparatus has a form factor that is not compatible with that of a mobile communication facility as disclosed, for example, in FIGS. 7 and 8 of Ramer (e.g., a cell phone or a PDA). In particular, the casing of the recording apparatus may have transversal dimensions of up to 12 inches and a thickness of up to 4 inches. Moreover, its weight can be up to 5 pounds.¹⁶ Applicant respectfully points out that these dimensions and weight are incompatible with those of a typical cell phone such as those described in Ramer.

This difference in dimensions with respect to those of a typical cell phone is graphically illustrated in FIG. 6C of Dominquez, in which the recording apparatus appears to be larger than

¹⁴ Dominquez, par. 2.

¹⁵ Dominquez, par. 40.

¹⁶ Dominquez, par. 48.

the head of the employee of whom is having a picture taken.¹⁷ Moreover, the casing of the recording apparatus preferably comprises a handle and a collapsible support for positioning the apparatus in an upright position on a flat surface.¹⁸ These additional features are not typically found in cell phones such as those described in Ramer.

The Office Action's conclusory motivation for combination and rationale for obviousness fails to consider claims 4 and 5 as wholes and thus fails to address, for example, the fact that the mobile communication facility of Ramer and the recording apparatus of Dominguez have very different form factors. The Office Action fails to provide any motivation as to why one of ordinary skill in the art would turn to the teachings of Dominguez to find the feature "the at least one memory having a total capacity of at least 1 GB." Furthermore, there is no suggestion in Dominguez that it is technically feasible to add such a large-capacity memory in a much smaller device as disclosed by Ramer.

Additionally, the Office Action fails to present a *prima facie* case of obviousness of claims 4-5. In addition to the deficiencies identified above, Dominguez further fails to disclose an antenna system having complexity factors within certain ranges specified by claims 4-5. The Office Action asserts that such features are disclosed by Puente-Baliarda. However, the Office Action appears to address such features in a piecemeal fashion that fails to consider claims 4-5 as wholes.

In various embodiments, the reduced space of a multifunction wireless device presents a space limitation, for example, on other structural elements and functionalities that may be included in the multifunction wireless device. In various embodiments, the space limitation may make it advantageous to accommodate an antenna system able to perform satisfactorily while occupying little space. Dominguez fails to address, for example, size constraints for the recording apparatus or performance constraints for a wireless modem within the recording apparatus. The Office Action fails to reconcile these issues at least in part because the Office

¹⁷ Dominguez, par. 58.

¹⁸ Dominguez, pars. 16 and 48.

Action fails to articulate a rationale for obviousness in terms of either of claims 4 and 5 as a whole.

For the reasons presented above, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness and that, moreover, the combination of Ramer, Puente-Baliarda, and Dominquez fails to render either of claims 4 and 5 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 4-5 be withdrawn.

III. Rejection Under 35 U.S.C. § 103 of Claims 12-13

Claims 12 and 13 stand rejected under 35 U.S.C. § 103 as being unpatentable over Ramer and Puente-Baliarda in view of U.S. Patent No. 7,183,983 to Ozden ("Ozden"). Applicant respectfully traverses for the reasons presented below.

The Office Action acknowledges that Ramer fails to disclose "the antenna system being mounted on the lower body below the keyboard" as required by each of dependent claims 12 and 13. In addressing this feature, the Office Action states, in a conclusory manner, that "[it] would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device in Ramer and Puente Baliarda to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna." However, Applicant respectfully submits that the Office Action fails to provide a *prima facie* case of obviousness and that, moreover, Ozden is deficient.

Ozden discloses an antenna system that can be arranged on either end of a housing (i.e., either on the end near a hinge or on the opposite end). However, Ozden fails to disclose an antenna system that is arranged on a lower body of a two-body device below a keyboard, as required via antecedent basis to independent claim 1. For at least this reason, Applicant respectfully submits that dependent claims 12 and 13 patentably distinguish over the combination of Ramer, Puente-Baliarda, and Ozden.

Additionally, the Office Action fails to present a *prima facie* case of obviousness of claims 12-13. In addition to the deficiencies identified above, Ozden also fails to disclose an antenna system having complexity factors within certain ranges specified by claims 12-13. The Office Action asserts that such features are disclosed by Puente-Baliarda. However, the Office Action appears to address such features in a piecemeal fashion that fails to consider claims 12-13 as wholes.

In various embodiments, the reduced space of a multifunction wireless device presents a space limitation, for example, on other structural elements and functionalities that may be included in the multifunction wireless device. In various embodiments, the space limitation may make it advantageous to accommodate an antenna system able to perform satisfactorily while occupying little space. In the context of claims 12-13, that may mean that the antenna system is on the lower body below the keyboard while, at the same time, the antenna contour of the antenna system attains certain values for the complexity factors for improved performance. The Office Action fails to reconcile these issues at least in part because the Office Action fails to articulate a rationale for obviousness in terms of either of claims 12 and-13 as a whole.

For the reasons presented above, Applicant respectfully submits that the Office Action has failed to present a *prima facie* case of obviousness of claims 12-13 and that, moreover, the combination of Ramer, Puente-Baliarda, and Ozden fails to render claims 12-13 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 12-13 be withdrawn.

IV. Rejection Under 35 U.S.C. § 103 of Claims 16-19

Claims 16-19 stand rejected under 35 U.S.C. § 103 as being unpatentable over Ramer, Puente-Baliarda, and Dominquez. For reasons similar to those presented above with respect to independent claim 1 and dependent claims 4-5, Applicant respectfully submits the Office Action has failed to present a *prima facie* case of obviousness with respect to independent claims 16 and 18 and that, moreover, the combination of Ramer, Puente-Baliarda, and Dominquez fails to

render either of independent claims 16 and 18 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of independent claims 16 and 18 be withdrawn.

Dependent claims 17 and 19 depend from and further patentably restrict independent claims 16 and 18, respectively. For at least the reasons presented above with respect to independent claims 16 and 18, Applicant respectfully submits the Office Action has failed to present a *prima facie* case of obviousness with respect to dependent claims 17 and 19 and that, moreover, the combination of Ramer, Puente-Baliarda, and Dominquez fails to render dependent claims 17 and 19 obvious. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 17 and 19 be withdrawn.

V. Rejection Under 35 U.S.C. § 103 of Claims 10 and 15

Dependent claims 10 and 15 stand rejected under 35 U.S.C. § 103 as being unpatentable over Ramer, Puente-Baliarda, and U.S. Patent Publication No. 2004/0119644 to Koyanagi et al. ("Koyanagi"). Dependent claims 10 and 15 each depend from and further patentably restrict independent claim 1. For at least the reasons presented above with respect to independent claim 1, Applicant respectfully submits the Office Action has failed to present a *prima facie* case of obviousness and that, moreover, the combination of Ramer and Puente-Baliarda fails to render dependent claims 10 and 15 obvious. Koyanagi fails to remedy any of the deficiencies of Ramer and Puente-Baliarda noted above with respect to independent claim 1. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 10 and 15 be withdrawn.

Additionally, the Office Action fails to present a *prima facie* case of obviousness of claims 10 and 15 for the reasons presented below. In particular, Koyanagi fails to disclose an antenna system having complexity factors within certain ranges specified by claims 10 and 15. The Office Action asserts that such features are disclosed by Puente-Baliarda. However, the Office Action appears to address such features in a piecemeal fashion that fails to consider claims 10 and 15 as wholes.

In various embodiments, the reduced space of a multifunction wireless device presents a space limitation, for example, on other structural elements and functionalities that may be included in the multifunction wireless device. In various embodiments, the space limitation may make it advantageous to accommodate an antenna system able to perform satisfactorily while occupying little space. In the context of claims 10 and 15, that may mean that the upper body and the lower body each have thickness values within specified ranges while, at the same time, the antenna contour of the antenna system attains certain values for the complexity factors for improved performance. The Office Action fails to reconcile these issues at least in part because the Office Action fails to articulate a rationale for obviousness in terms of either of claims 10 and 15 as a whole.

For these additional reasons, Applicant respectfully submits that the Office Action fails to present a *prima facie* case of obviousness of claims 10 and 15. Applicant respectfully requests that the rejection under 35 U.S.C. § 103 of dependent claims 10 and 15 be withdrawn.

VI. Conclusion

In view of the above remarks, Applicant respectfully submits that the present application is in condition for allowance. A Notice to that effect is respectfully requested.

Dated: February 11, 2011

Respectfully submitted,

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/614,429	12/21/2006	Carles Puente Baliarda	47005-P022US	9346
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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.

Office Action Summary	Application No. 11/614,429	Applicant(s) BALIARDA ET AL	
	Examiner STAMFORD HWANG	Art Unit 2617	

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

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

Status

1) ☒ Responsive to communication(s) filed on 21 December 2006.

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

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

Disposition of Claims

4) ☒ Claim(s) 1-20 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5) ☐ Claim(s) _____ is/are allowed.

6) ☒ Claim(s) 1-20 is/are rejected.

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

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

Application Papers

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

10) ☒ The drawing(s) filed on 19 February 2007 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

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

a) ☒ All b) ☐ Some * c) ☐ None of:

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

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

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

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

Attachment(s)

1) ☒ Notice of References Cited (PTO-892) 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date <u>See Continuation Sheet</u>	4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date, _____ 5) ☐ Notice of Informal Patent Application 6) ☐ Other: _____
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Continuation of Attachment(s) 3). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :06/11/2010, 04/02/2010, 02/05/2010, 03/12/2009, 11/07/2008, 09/19/2008, 09/02/2008, 06/10/2008, 04/21/2008, 01/28/2008, 11/05/2007, 09/13/2007, 08/06/2007, 07/19/2007 and 05/07/2007.

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1 - 3, 6 - 9, 11, 14 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1).

With respect to Claim 1, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**); and
- in antenna system disposed within at least one of the upper body and the lower body (**Col. 8, lines 44 - 49**)

Ramer et al. does not teach:

- and having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 2, Ramer et al. further teaches wherein the multifunction wireless device has multimedia functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 3, Ramer et al. further teaches wherein the multifunction wireless device has smartphone functionality (**Col. 8, lines 19 - 43 and lines 50 - 61**).

With respect to Claim 6, Ramer et al. further teaches wherein the first body and the second body comprise a clamshell configuration (**Fig. 7B**).

With respect to Claim 7, Ramer et al. teaches comprising:

- an image-recording system (**Col. 8, lines 50 - 61**);
- a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels (**Col. 8, lines 50 - 61**);
- a keyboard (**Figs. 8A - 8C**); and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 8, Ramer et al. teaches comprising:

- a keyboard comprising at least 40 keys (**Fig. 8A**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value less than 1.45 and the complexity factor $F_{sub.32}$ having a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 9, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

With respect to Claim 11, Ramer et al. teaches wherein the upper body and the lower body are adapted to move relative to each other in a manner selected from the group consisting of a twist manner and a slide manner (**Col. 11, lines 13 - 38**).

With respect to Claim 14, Ramer et al. further teaches comprising:

- a hinge connecting the upper body to the lower body (**Fig. 7B**); and

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor $F_{sub.21}$ having a value greater than 1.20 and the complexity factor $F_{sub.32}$ having a value of at least 1.55.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with L_2

Art Unit: 2617

= $2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, $L1$, $L2$, $N1$ or $N2$. See MPEP 2144.04 IV, Part A. Changes in Size/Proportion.

With respect to Claim 20, Ramer et al. teaches a multifunction wireless device comprising:

- an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Figs. 7A - 7C**);
- a display (**Fig. 1, Display 172 and Col. 8, lines 3 - 18**);
- a processing module (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a memory module (**Fig. 1, Data Storage 118**);
- a communication module (**Col. 6, lines 65 - Col. 7, line 25**); and
- a power management module (**Col. 6, lines 65 - Col. 7, line 25**);

- wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body (**Figs. 7A - 7C and Col. 6, lines 65 - Col. 7, line 25**);
- wherein the communication module operates at a first frequency band fully contained within 810 MHz-960 MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710 MHz-1990 MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900 MHz-2170 MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard (**Col. 6, lines 49 - 64 and Col. 8, lines 19 - 43**); and

Ramer et al. does not teach:

- wherein the communication module comprises an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factors $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with L_2

Art Unit: 2617

= $2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, $L1$, $L2$, $N1$ or $N2$. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Claims 4 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Dominquez et al. (U.S. 2002/0175211 A1).

With respect to Claim 4, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a microprocessor (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- at least one memory interoperably coupled to the microprocessor (**Fig. 1, Data Storage 118**);

- an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen (**Figs. 8A - 8C**); and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.39 and the complexity factor $F_{sub.32}$ has a value greater than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part

A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 5, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);
- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom (**Col. 8, lines 50 - 61**);

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Ramer et al. does not teach:

- data storage of at least 1 GB in capacity; and
- wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor $F_{sub.21}$ having a value greater than 1.45 and the complexity factor $F_{sub.32}$ having a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies

Art Unit: 2617

different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage of at least 1 GB in capacity; and

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S. 2004/0119644 A1) as applied to Claims 1 above, and further in view of Ozden (U.S. 7,183,983 B2).

With respect to Claim 12, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- a microprocessor interoperably coupled to the receiver (**Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device**);
- a keyboard (**Figs. 8A - 8C**);

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.45 and the complexity factor $F_{sub.32}$ has a value greater than 1.75.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis **(Fig. 3B and Fig. 3C)**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

With respect to Claim 13, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 11 as discussed above. Ramer et al. further teaches comprising:

- a microphone system adapted to record sound and convert the recorded sound to a digital format **(Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29)**;
- a keyboard **(Figs. 8A - 8C)**;

Ramer et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

- wherein the complexity factor $F_{sub.21}$ has a value less than 1.45 and the complexity factor $F_{sub.32}$ has a value less than 1.50.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the antenna system is mounted on the lower body below the keyboard; and

Ozden teaches placing the antenna portion on the ground housing and the antenna portion could be placed either near the hinge axis or away from the hinge axis **(Fig. 3B and Fig. 3C)**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to place an antenna on the ground housing, as taught by Ozden, to provide better protection for the antenna.

Claims 16 - 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2), Puente-Baliarda et al. (U.S. 2004/0119644 A1) and Dominquez et al. (U.S. 2002/0175211 A1).

With respect to Claim 16, Ramer et al. teaches a multifunction wireless device comprising:

- a microprocessor **(Col. 6, lines 65 - Col. 7, line 25; A processor is inherent to exist in a wireless device)** and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications **(Col. 8, lines 19 - 43)**;
- at least one memory **(Fig. 1, Data Storage 118)** interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N_1 and N_2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L_1 and L_2 with $L_2 = 2 * L_1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or D_g to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of D_g as one applies different numbers to one of the variables, L_1 , L_2 , N_1 or N_2 . See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 17, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

With respect to Claim 18, Ramer et al. teaches a multifunction wireless device comprising:

- a receiver of at least one of analog and digital sound signals (**Col. 17, lines 34 - 41 and Col. 38, lines 12 - 29**);

- an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom **(Col. 8, lines 50 - 61)**;
- an antenna system **(Col. 8, lines 44 - 49)**; and

Ramer et al. does not teach:

- data storage means having a capacity of at least 1 GB;
- wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor $F_{sub.21}$ having a value of at least 1.05 and not greater than 1.80 and by complexity factor $F_{sub.32}$ having a value of at least 1.10 and not greater than 1.90.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization **(Figs. 26 - 29 and Paragraphs [0095] - [0099])**.

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- data storage means having a capacity of at least 1 GB;

Dominquez et al. teaches the use of a storage device coupled to a processor and that the storage device has a minimum capacity of one gigabyte of data (**Fig. 2 and Paragraph [0040]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to include a storage device with a minimum of one gigabyte of data, as taught by Dominquez et al., to store a great amount of data.

With respect to Claim 19, Ramer et al. further teaches comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner (**Col. 11, lines 13 - 38**).

Claims 10 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Ramer et al. (U.S. 7,548,915 B2) and Puente-Baliarda et al. (U.S.

2004/0119644 A1) as applied to Claims 1 above, and further in view of Koyanagi et al (U.S. 2007/0229383 A1).

With respect to Claim 10, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. does not teach wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm and the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization. Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV. Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach "wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm".

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

With respect to Claim 15, the combination of Ramer et al. and Puente-Baliarda et al. teaches all of the limitations in Claim 1 as discussed above. Ramer et al. further teaches comprising:

- a geolocalization system (**Col. 8, lines 19 - 43**);

Ramer et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and
- wherein the complexity factor $F_{sub.21}$ has a value greater than 1.43 and the complexity factor $F_{sub.32}$ has a value greater than 1.63.

Puente-Baliarda et al. teaches the use of variables that relate to the number of cells (for example, N1 and N2) in grids of different sizes. The grids are of sizes that one

Art Unit: 2617

grid includes four times the number of cells as another, and therefore the length of each cell in the one grid is half the length of the another grid (for example, L1 and L2 with $L2 = 2 * L1$). Furthermore, Puente-Baliarda et al. teaches the use of a formula to calculate a grid dimension or Dg to obtain the degree of miniaturization (**Figs. 26 - 29 and Paragraphs [0095] - [0099]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. to calculate the grid dimension by using the coverage of antenna with grids of different sizes, as taught by Puente-Baliarda et al., to obtain the degree of miniaturization.

Furthermore, it is an obvious variation that one of ordinary skilled in the art to vary the result of Dg as one applies different numbers to one of the variables, L1, L2, N1 or N2. See MPEP 2144.04 IV, Part A. Changes in Size/Proportion.

Ramer et al., in combination with Puente-Baliarda et al. does not teach:

- wherein the upper body and the lower body each have a thickness value of at least 5 mm and not greater than 9 mm; and

Koyanagi et al. teaches that a mobile telephone, since it is placed in a pocket, the thickness of the housing is limited to 30mm or less (**Paragraph [0002]**).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the device in Ramer et al. and Puente-Baliarda et al. to limit the thickness of the housing of a mobile telephone, as taught by Koyanagi et al., to conveniently place a mobile telephone in one's pocket.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to STAMFORD HWANG whose telephone number is (571)270-5578. The examiner can normally be reached on Monday ~ Friday 9:00AM ET~ 6:00PM ET.

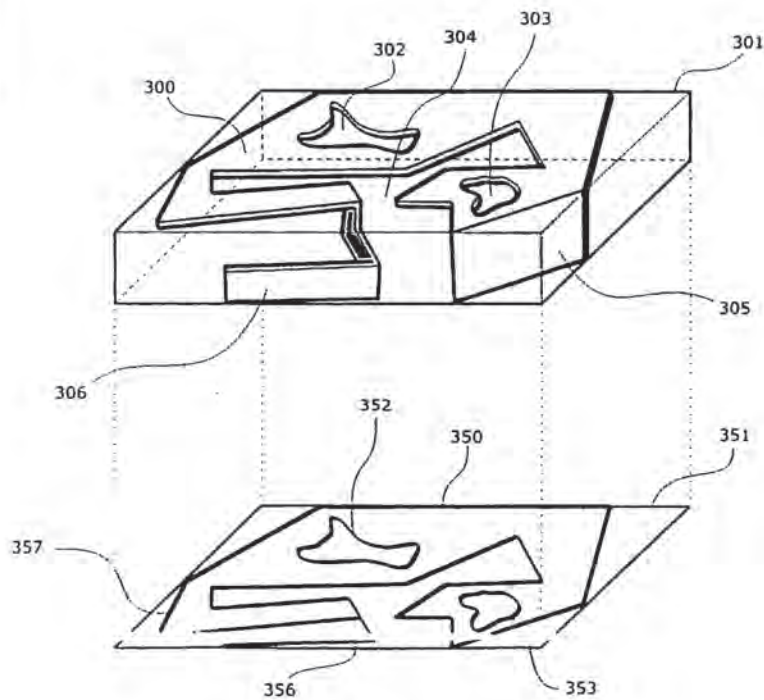
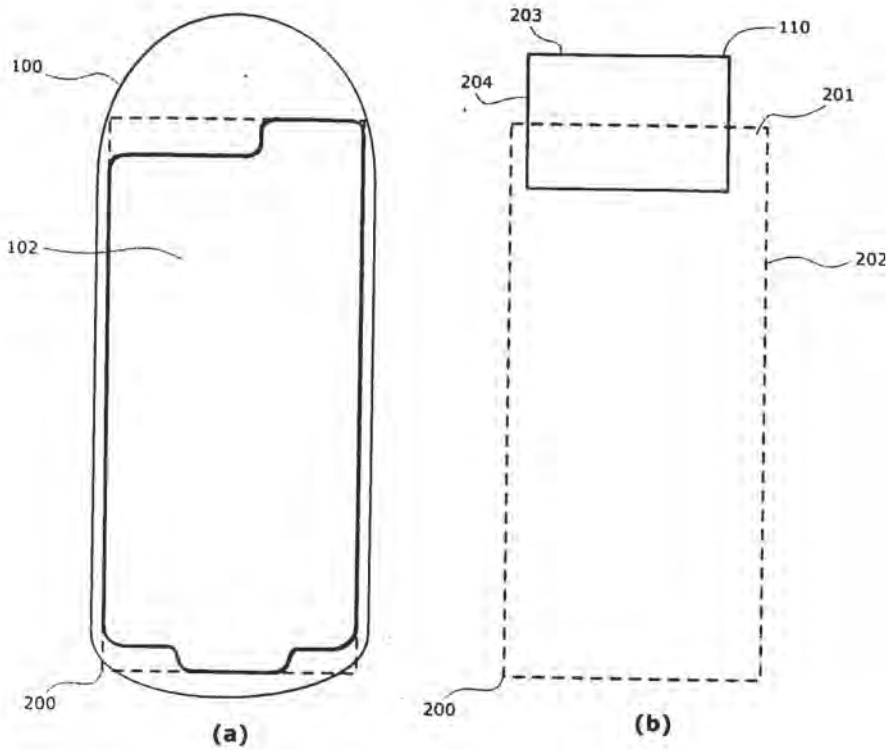
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Appiah can be reached on (571)272-7904. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system.

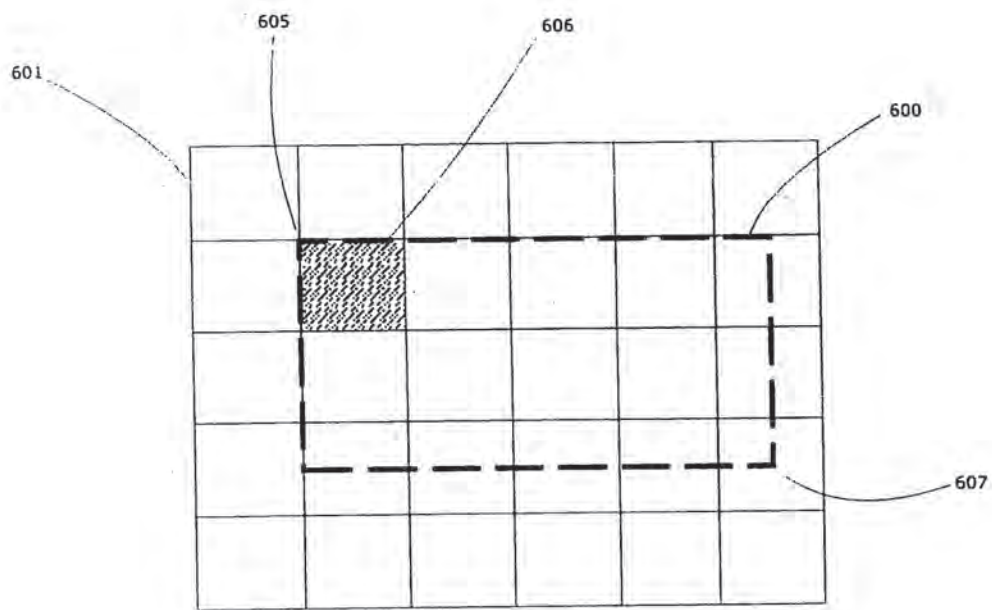
Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access 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.

/S.H./

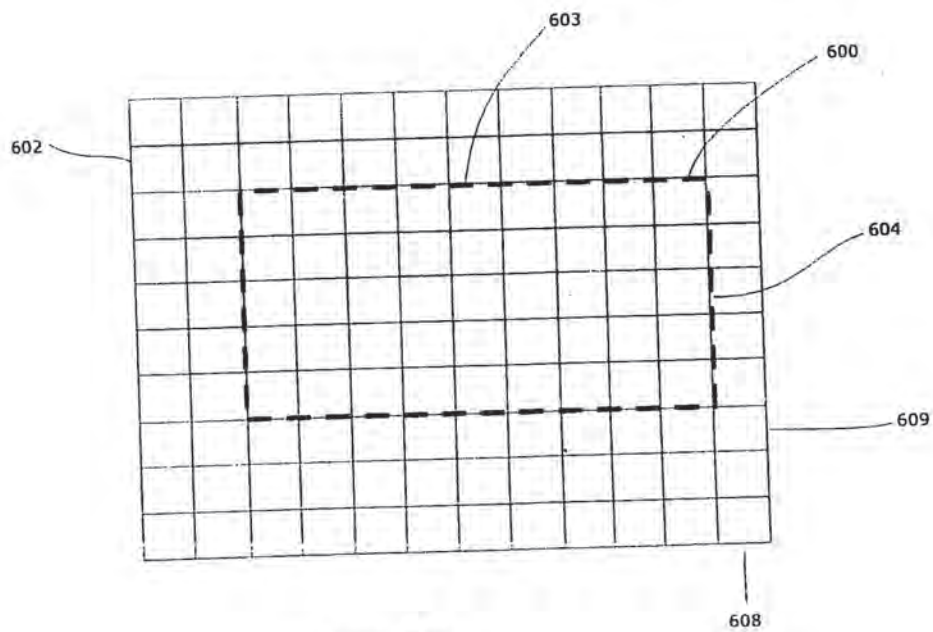
/Charles N. Appiah/
Supervisory Patent Examiner, Art Unit 2617



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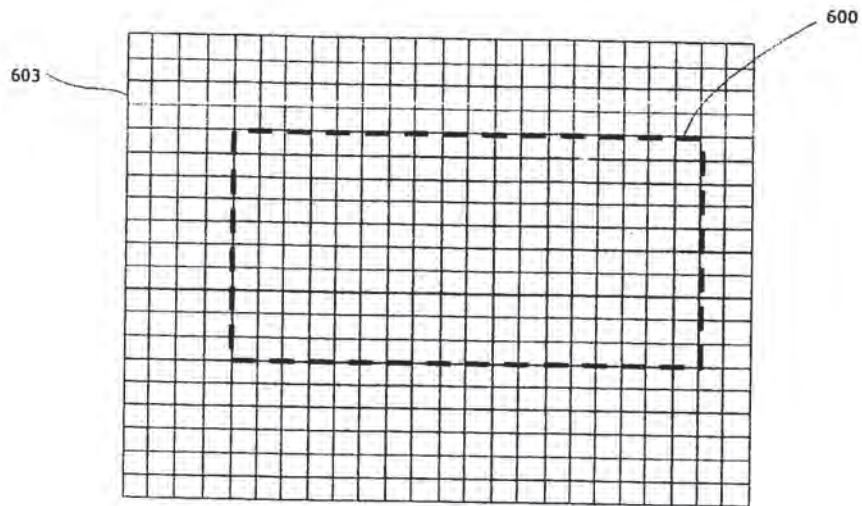


[FIG. 6a]

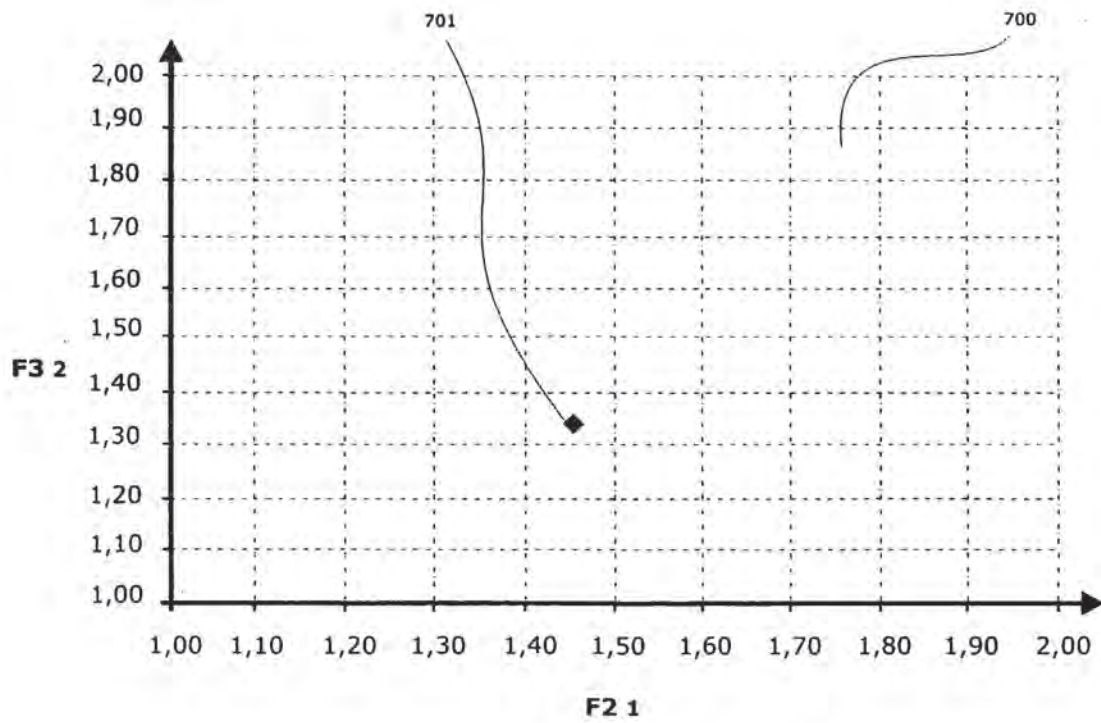


[FIG. 6b]

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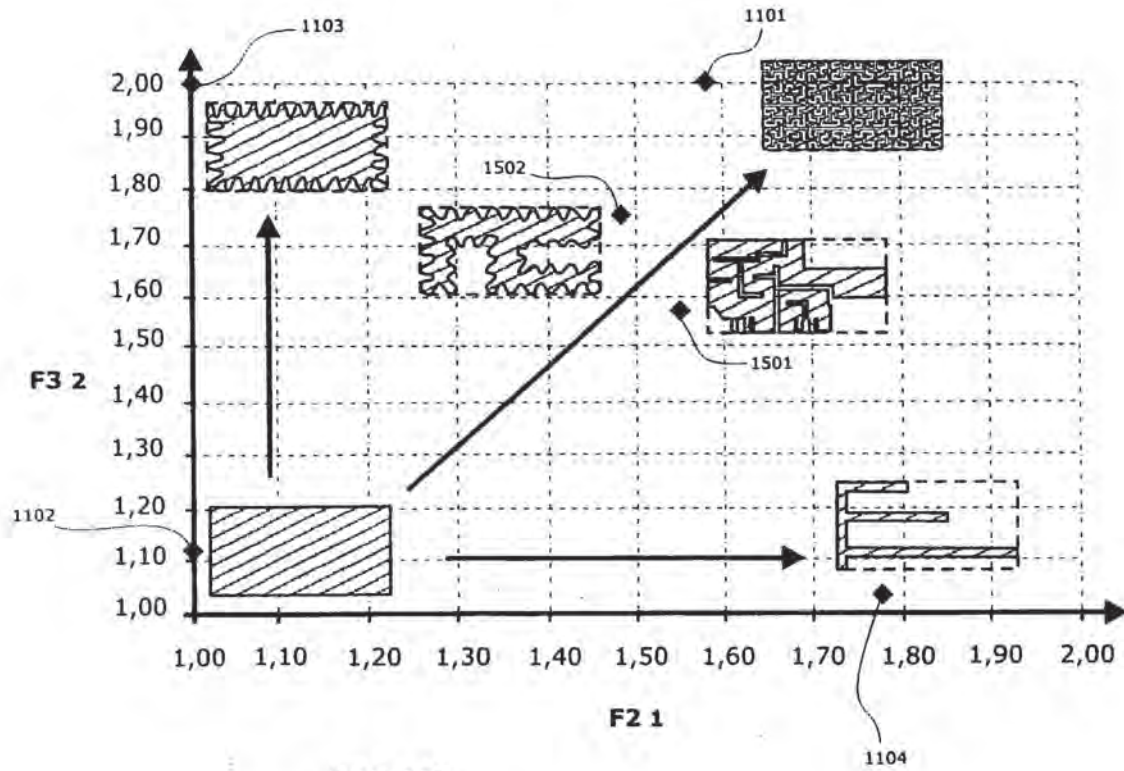


[FIG. 6c]

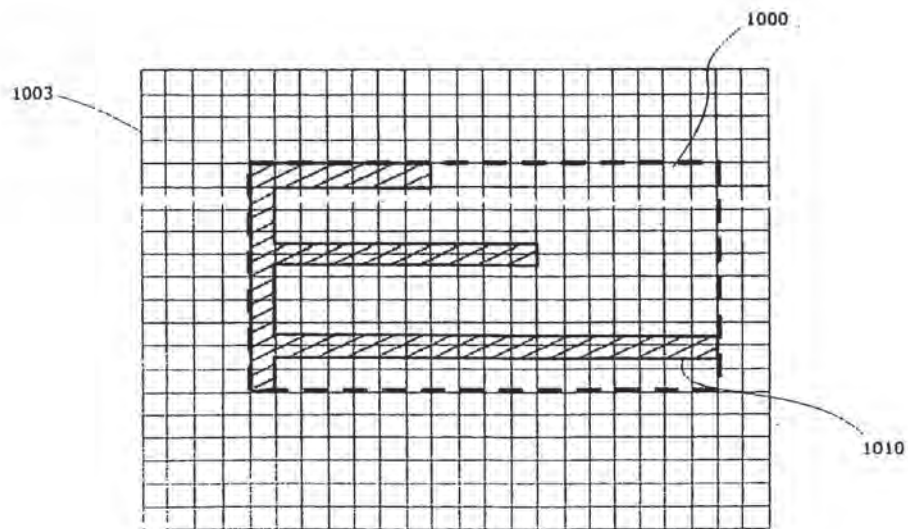


[FIG. 7]

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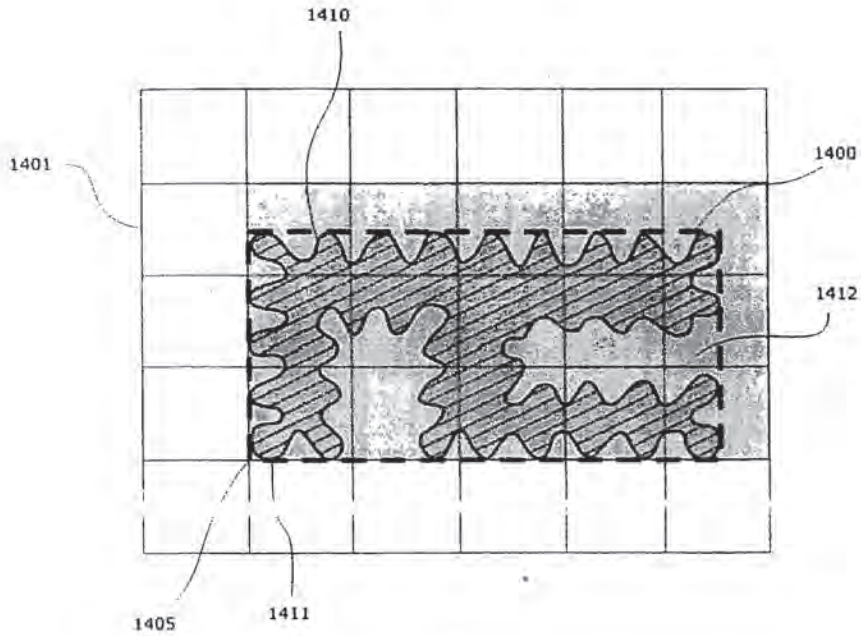


[FIG. 11]

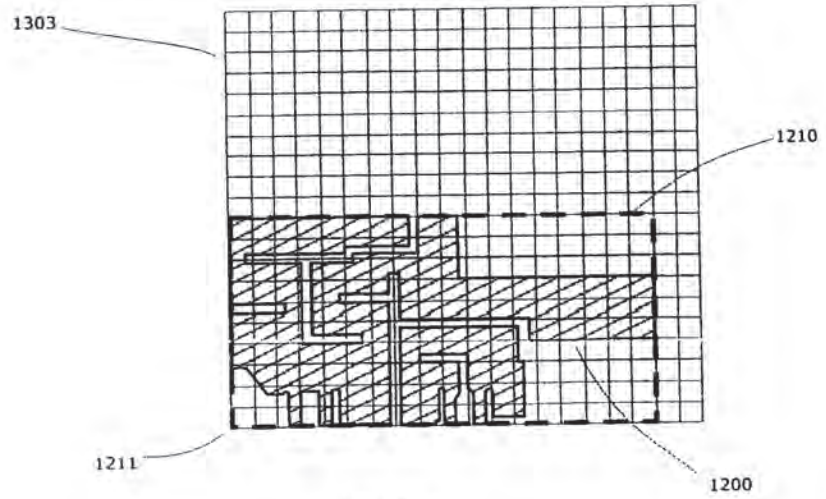


[FIG. 10c]

REPLACEMENT SHEET

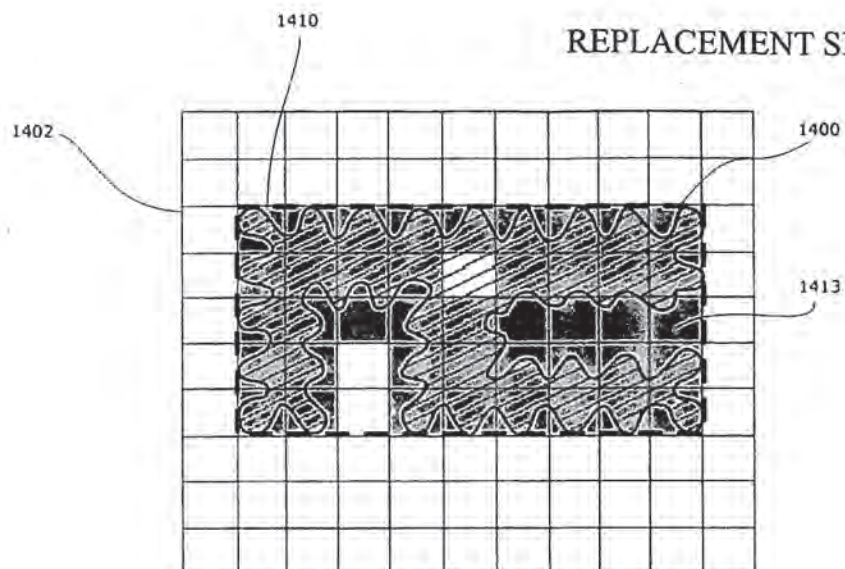


[FIG. 14a]

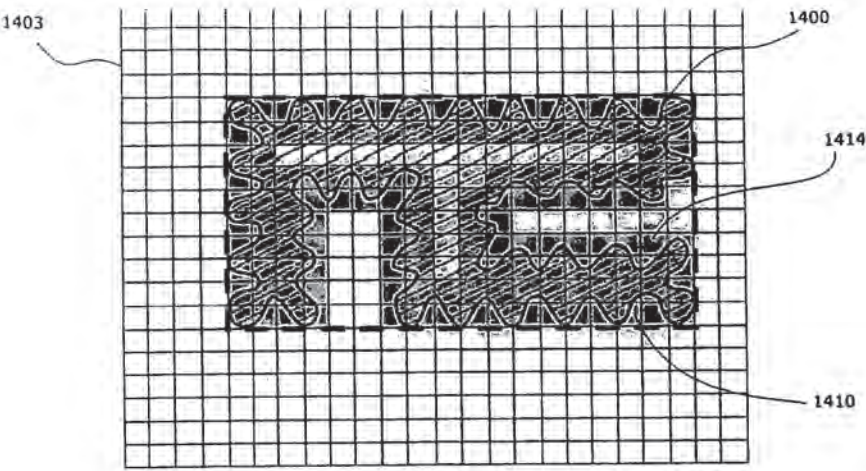


[FIG. 13c]

REPLACEMENT SHEET



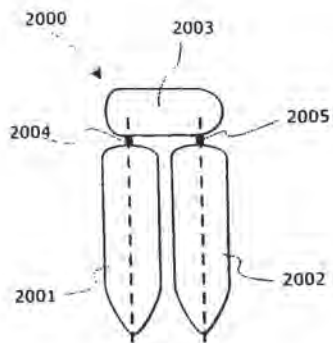
[FIG. 14b]



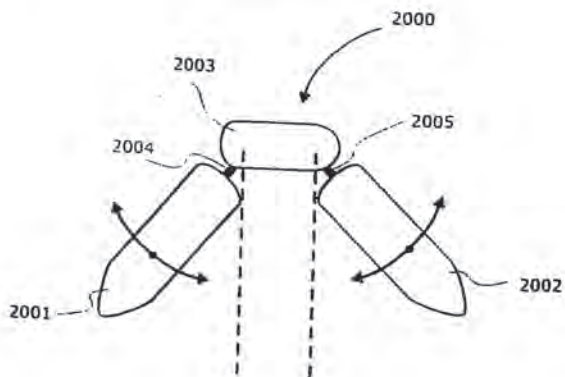
[FIG. 14c]

FIG. 20

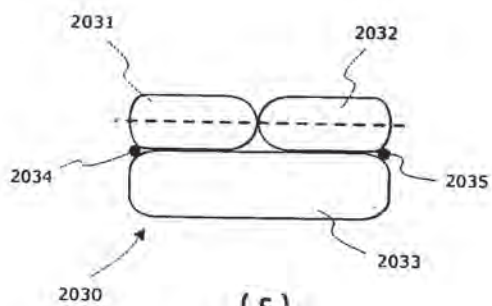
REPLACEMENT SHEET



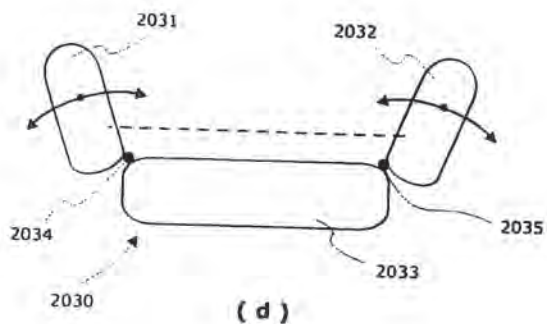
(a)



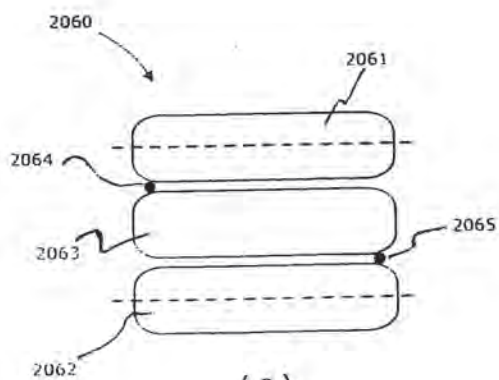
(b)



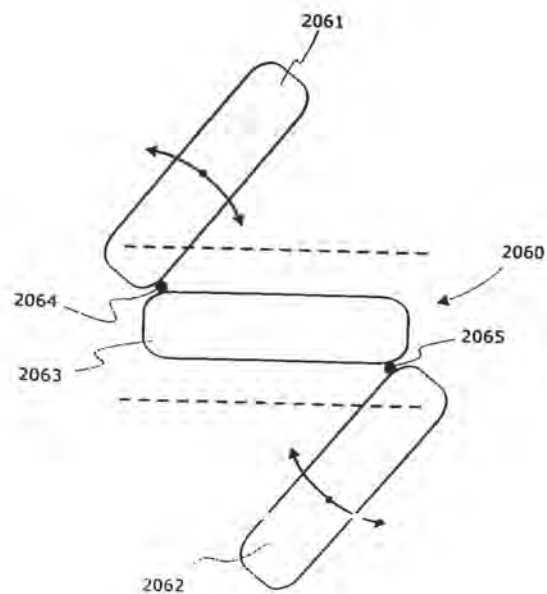
(c)



(d)



(e)



(f)



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11/614,429	12/21/2006	2821	1200	68349-00046USPT	27	20	4

CONFIRMATION NO. 9346

FILING RECEIPT

23932
JENKENS & GILCHRIST, PC
1445 ROSS AVENUE
SUITE 3200
DALLAS, TX 75202

Date Mailed: 01/23/2007

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Applicant(s)

Carlos Puente Baliarda, Residence Not Provided;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This appln claims benefit of 60/831,544 07/18/2006
and claims benefit of 60/856,410 11/03/2006

Foreign Applications

EUROPEAN PATENT OFFICE (EPO) 06117352.2 07/18/2006

If Required, Foreign Filing License Granted: 01/22/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is
US11/614,429

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No

Title

MULTIPLE-BODY-CONFIGURATION MULTIMEDIA AND SMARTPHONE
MULTIFUNCTION WIRELESS DEVICES

Preliminary Class

343

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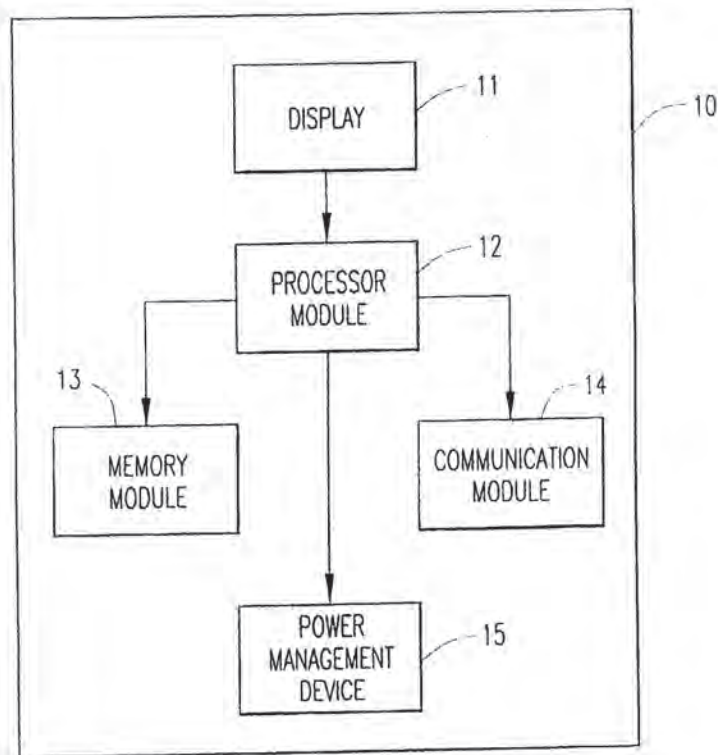


FIG. 1A

Figures

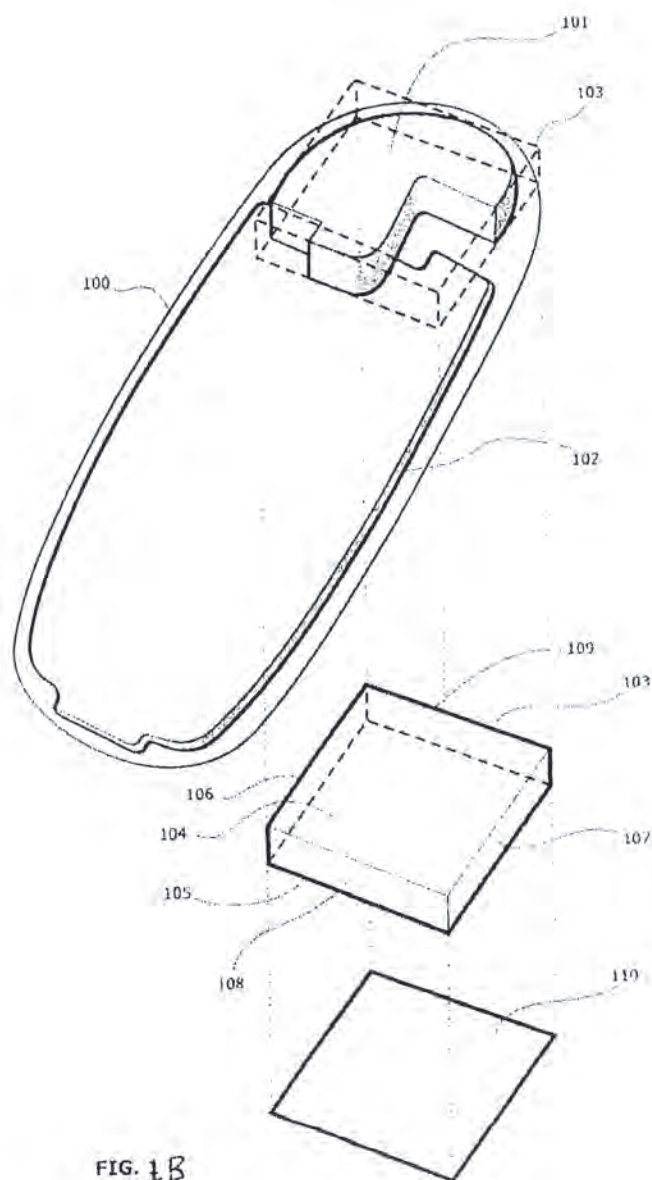


FIG. 1B

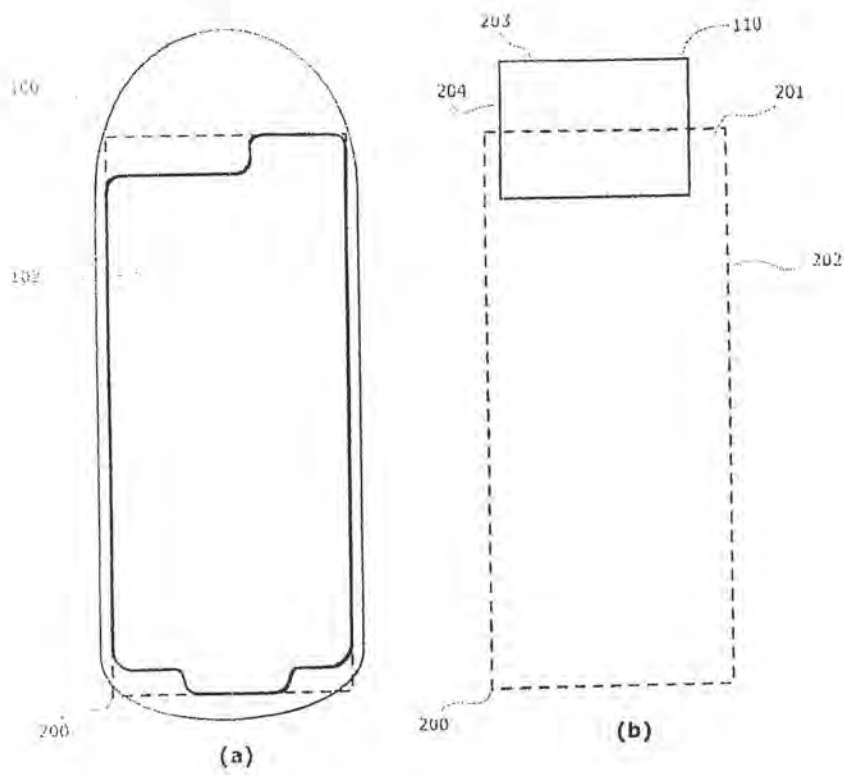


FIG. 2

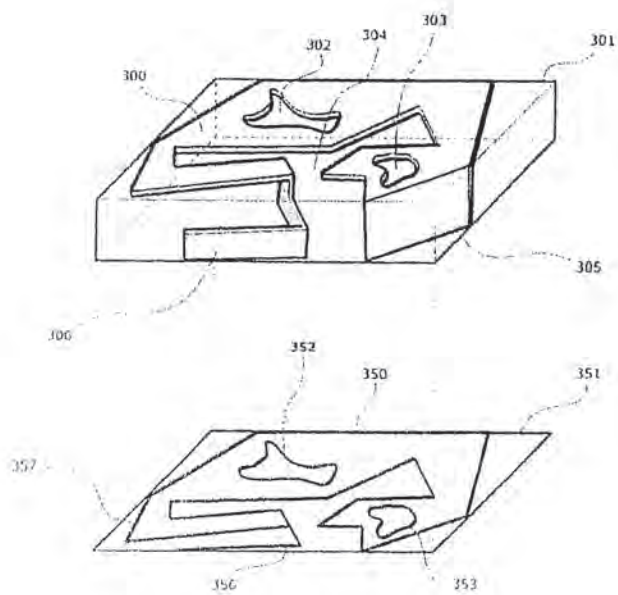


FIG. 3

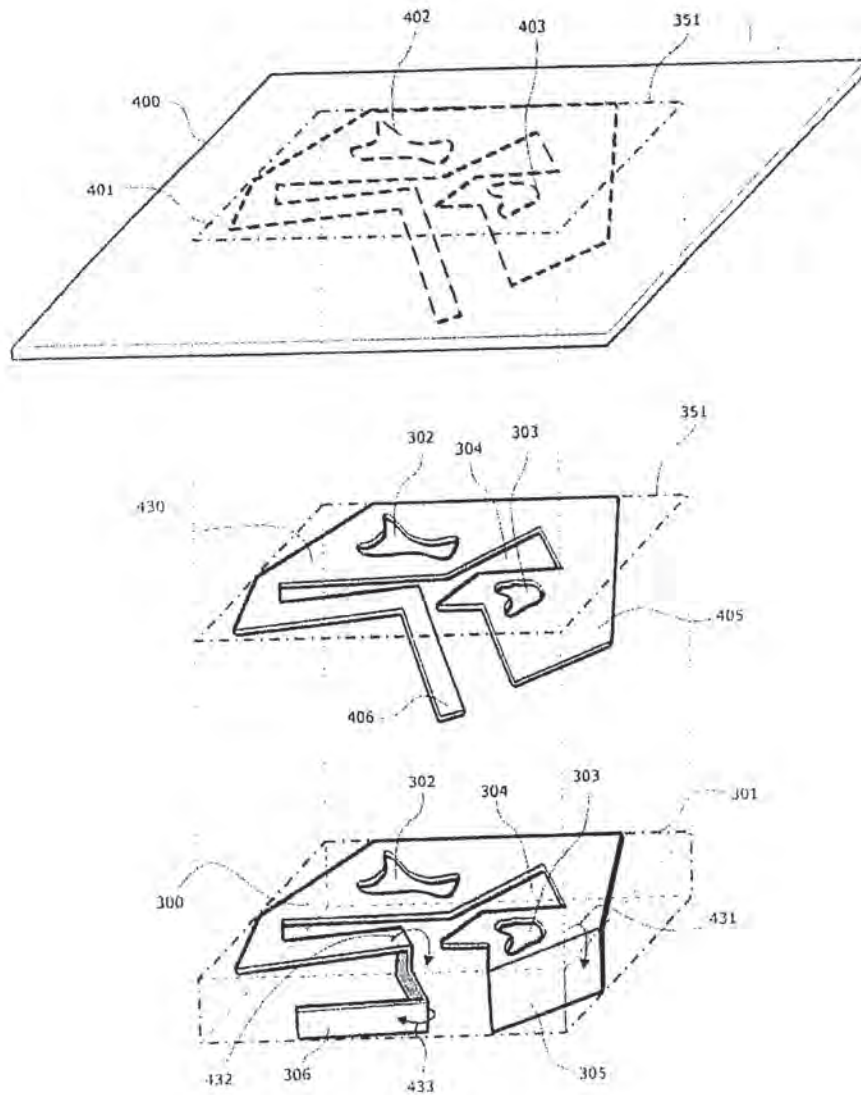


FIG. 4

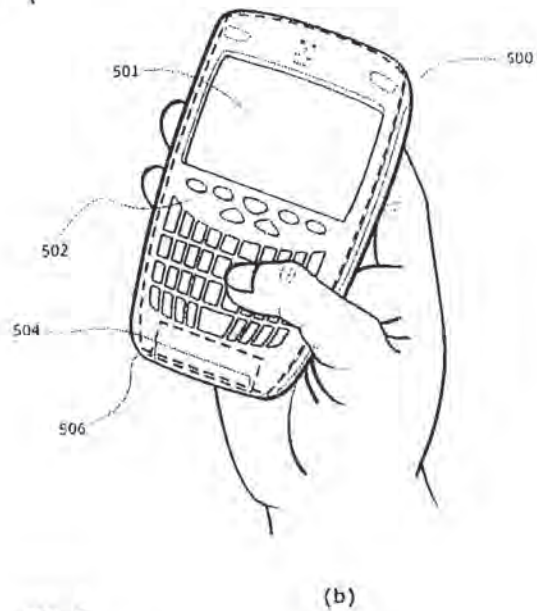
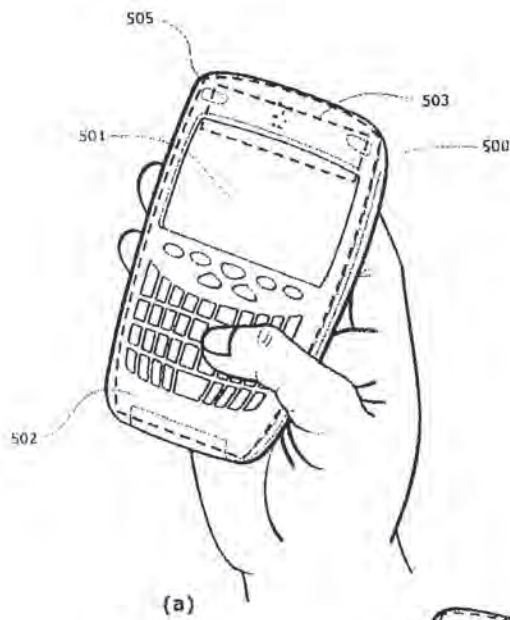
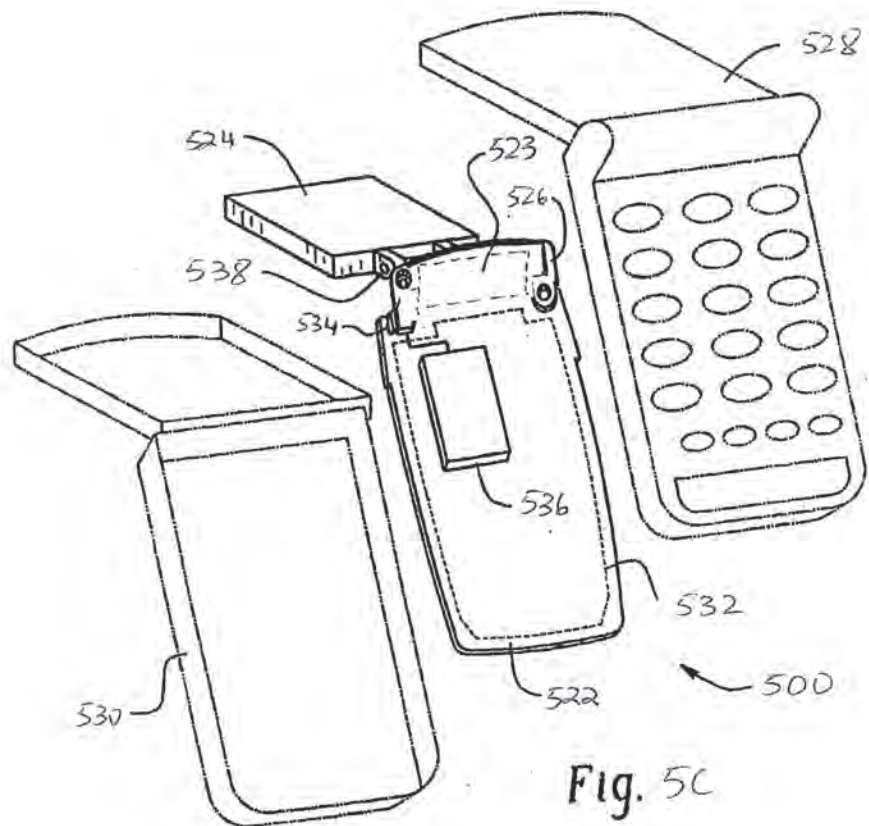
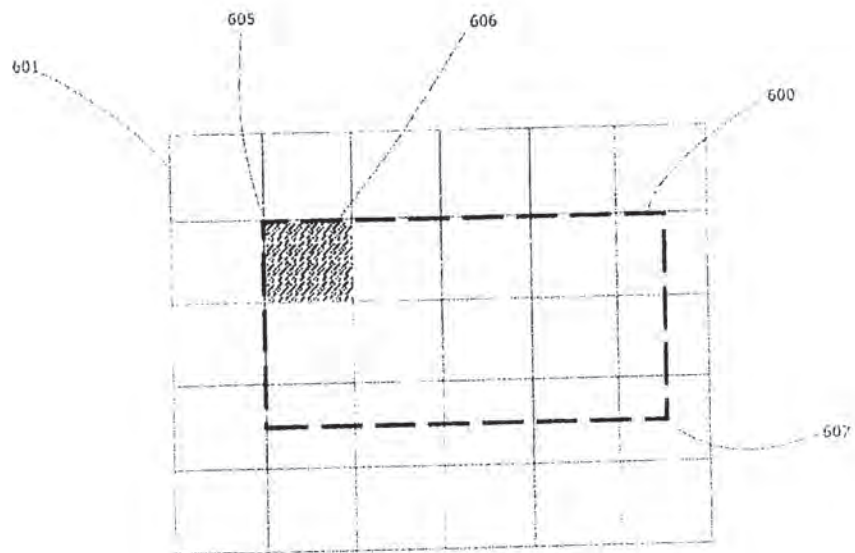
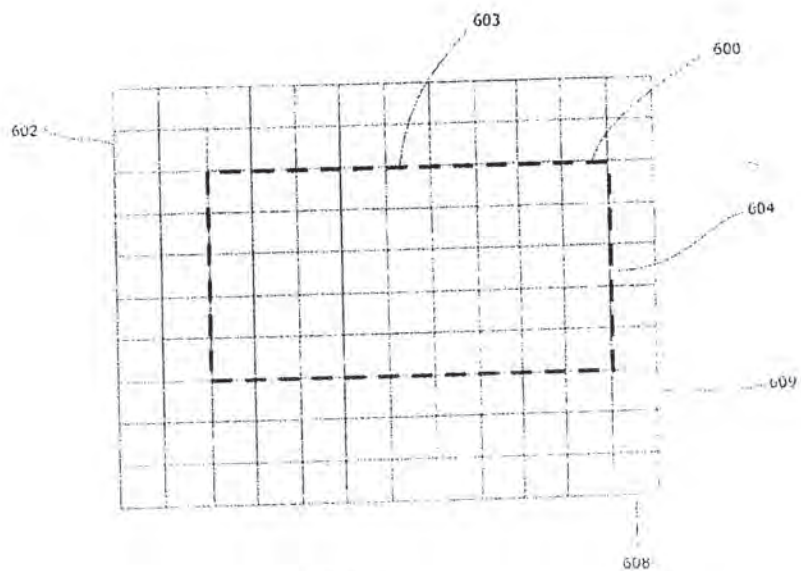


FIG. 5

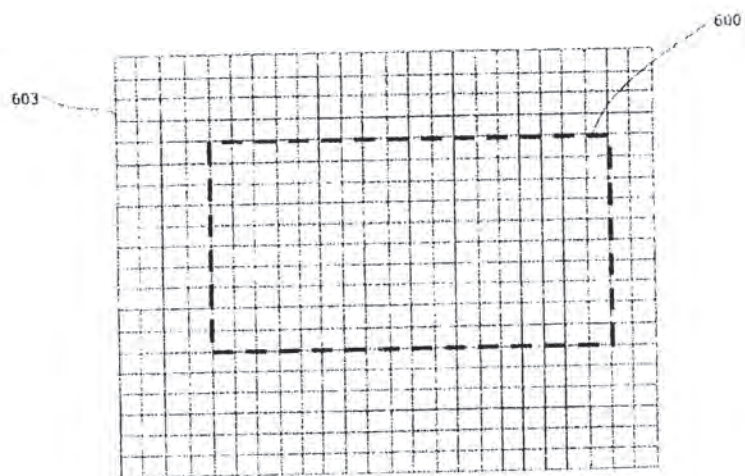




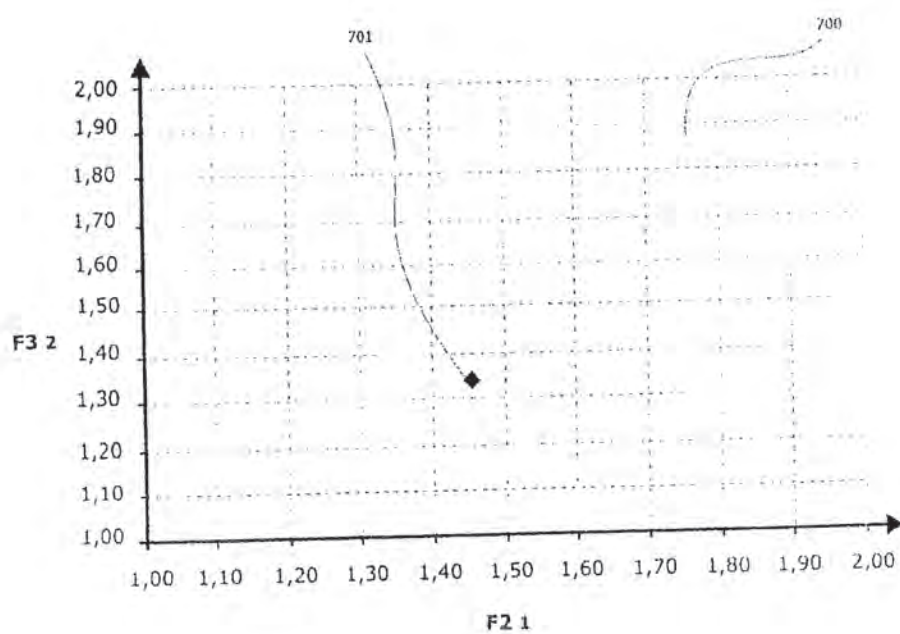
[FIG. 6a]



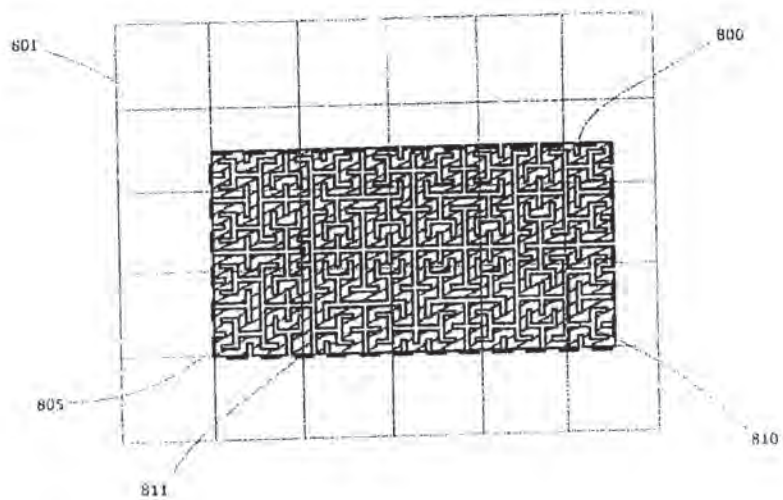
[FIG. 6b]



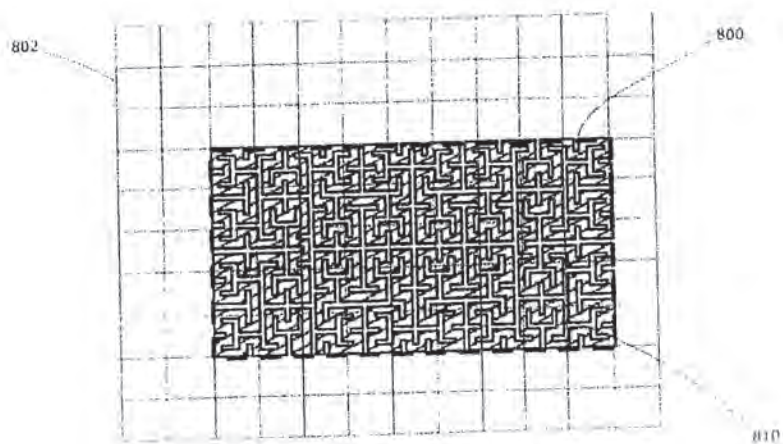
[FIG. 6c]



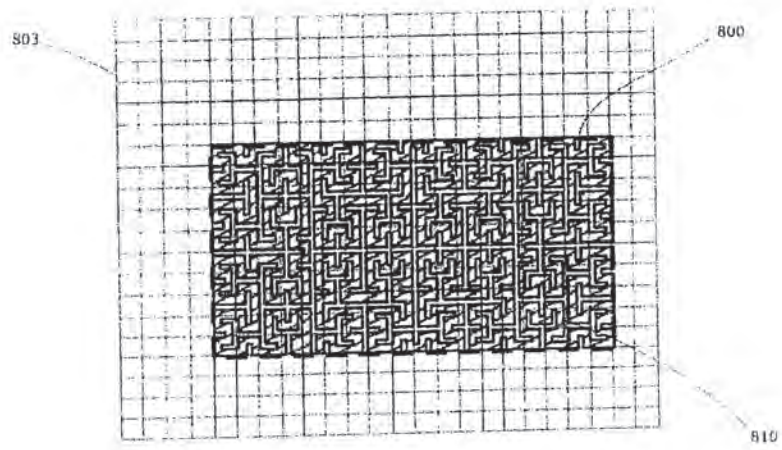
[FIG. 7]



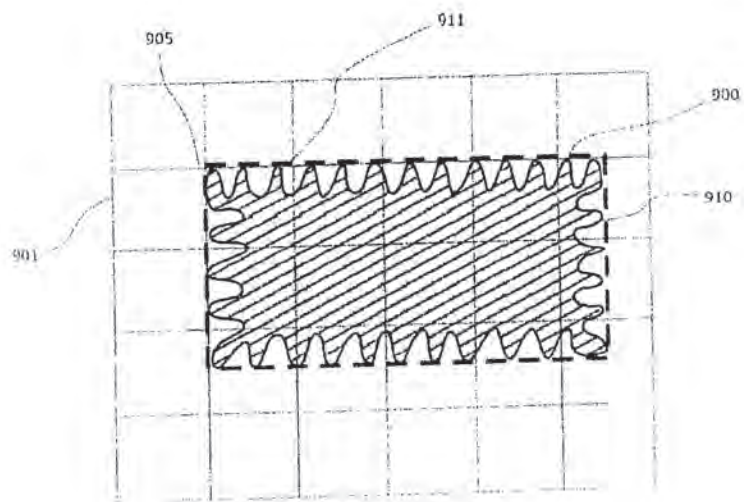
[FIG. 8a]



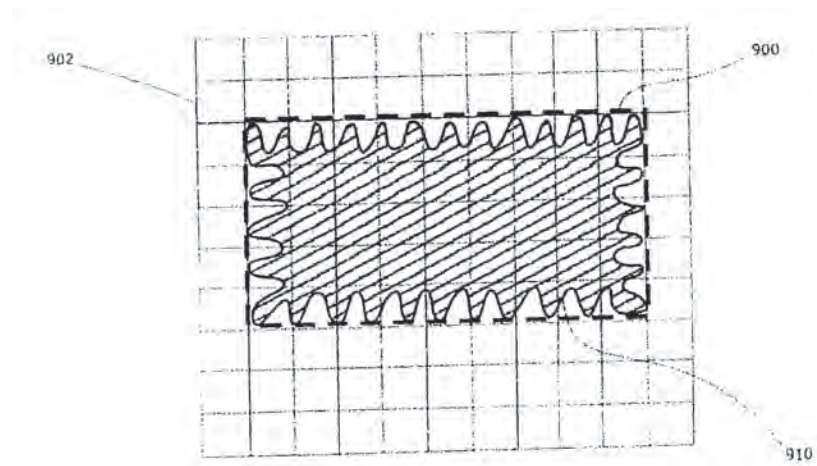
[FIG. 8b]



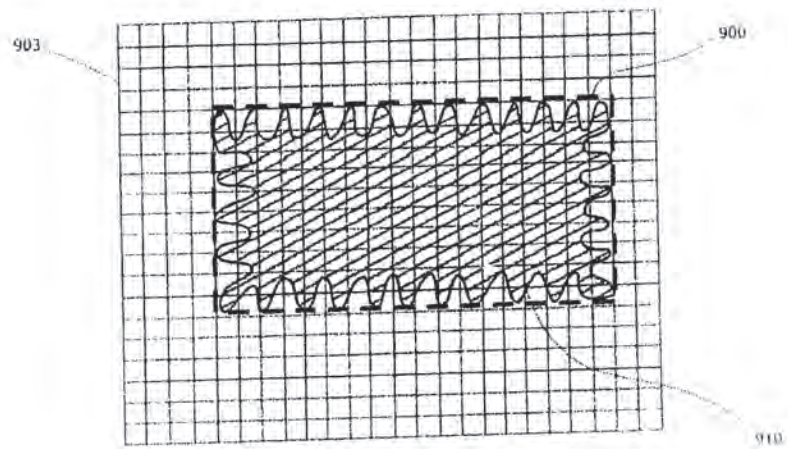
[FIG. 8c]



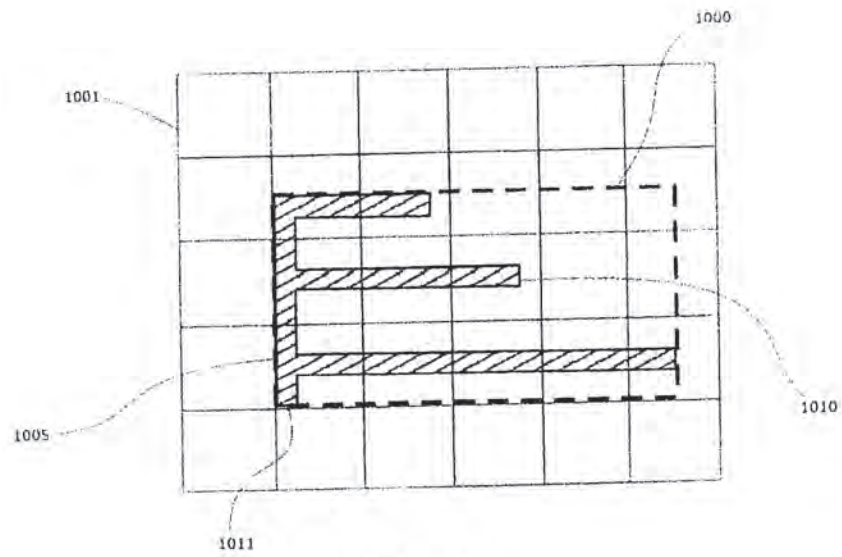
[FIG. 9a]



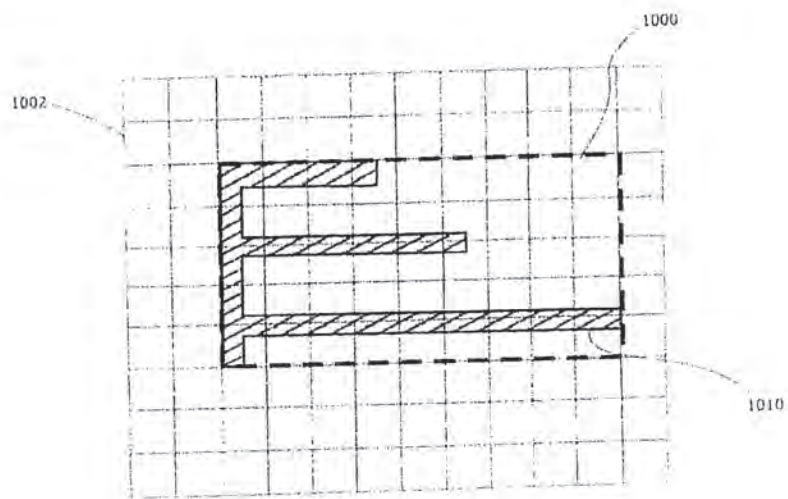
[FIG. 9b]



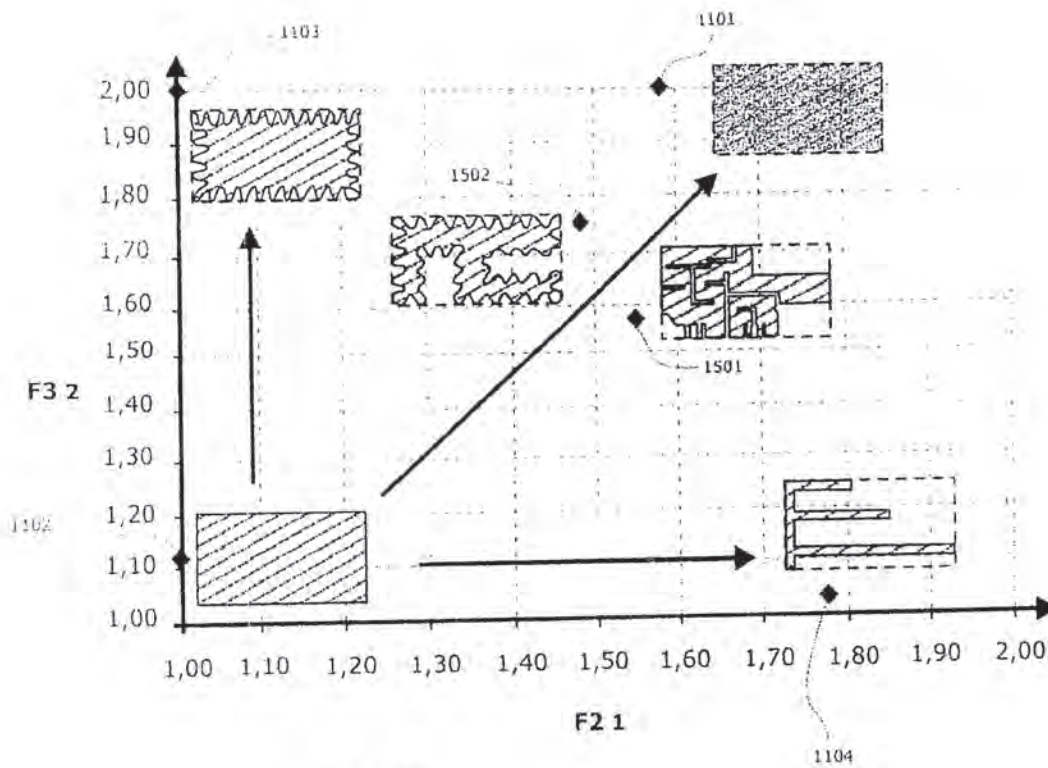
[FIG. 9c]



[FIG. 10a]

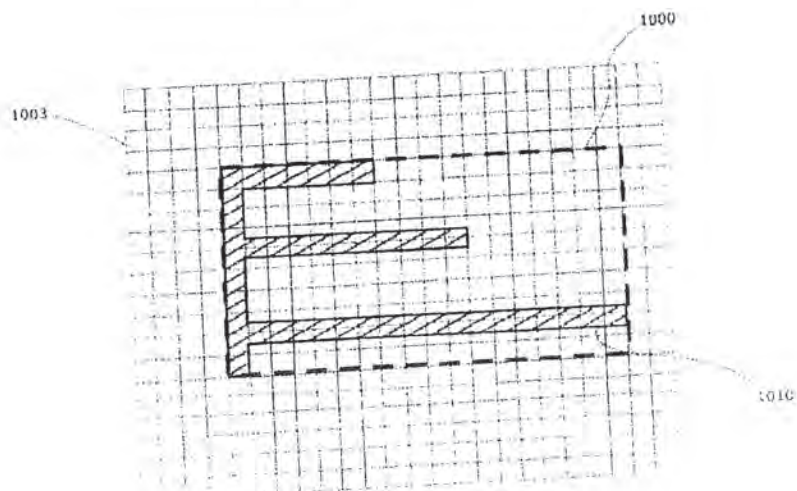


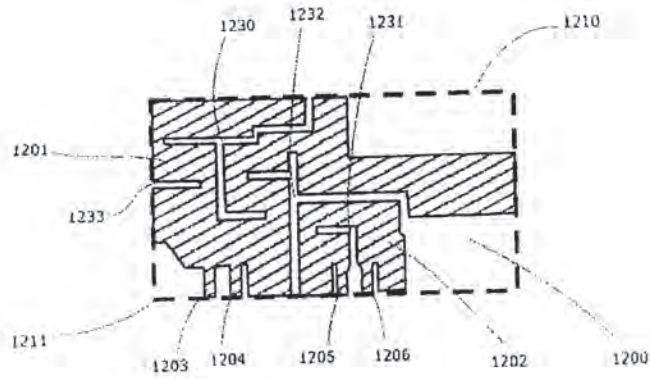
[FIG. 10b]



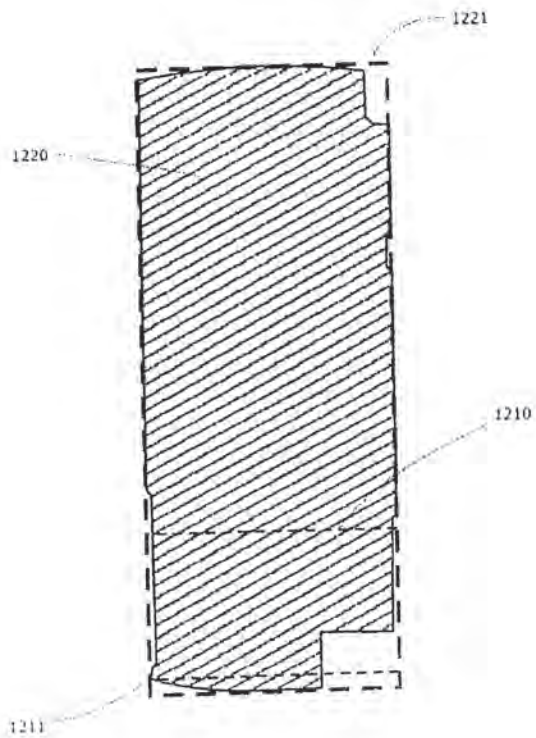
[FIG. 11]

FIG. 10c

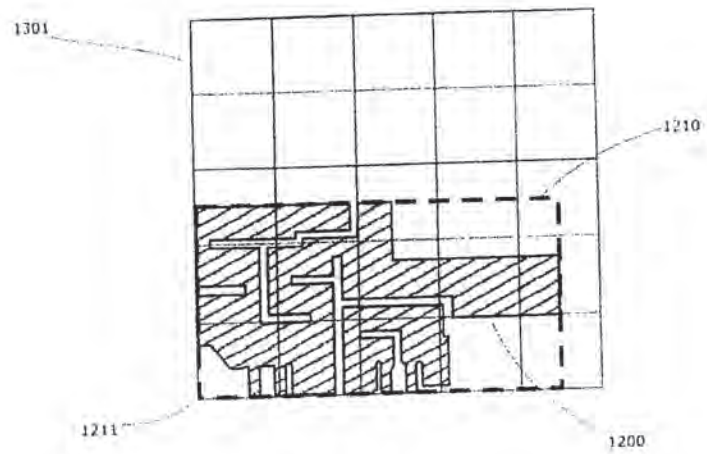




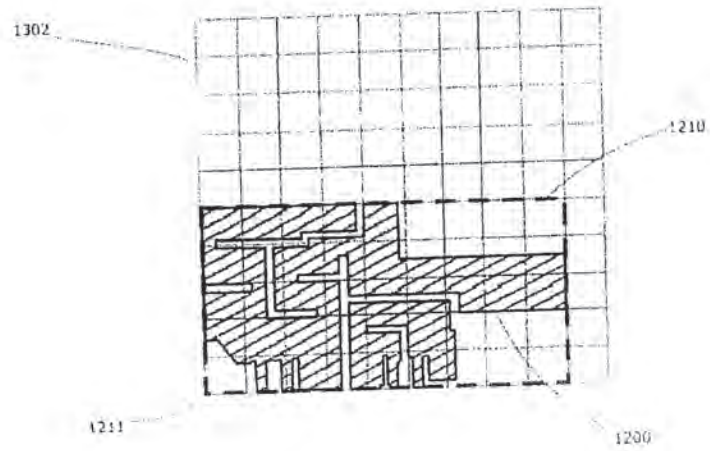
[FIG. 12a]



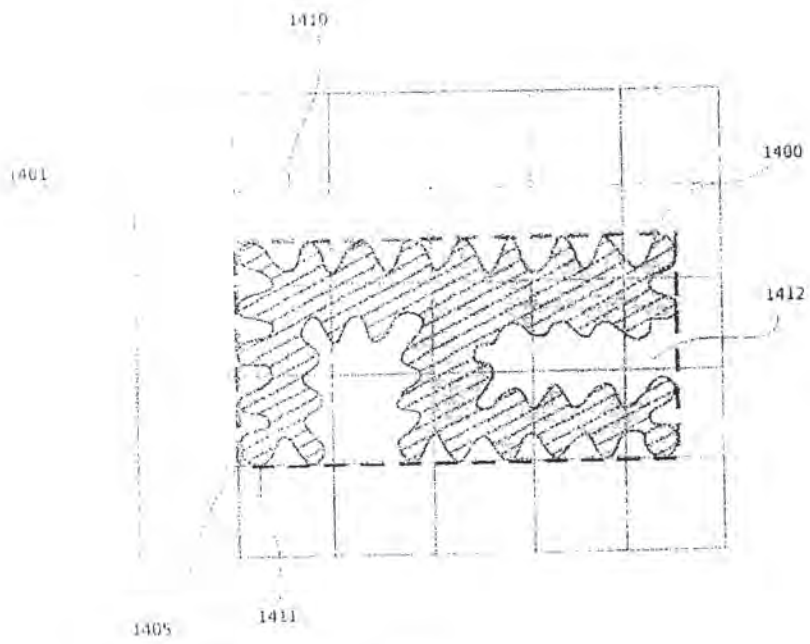
[FIG. 12b]



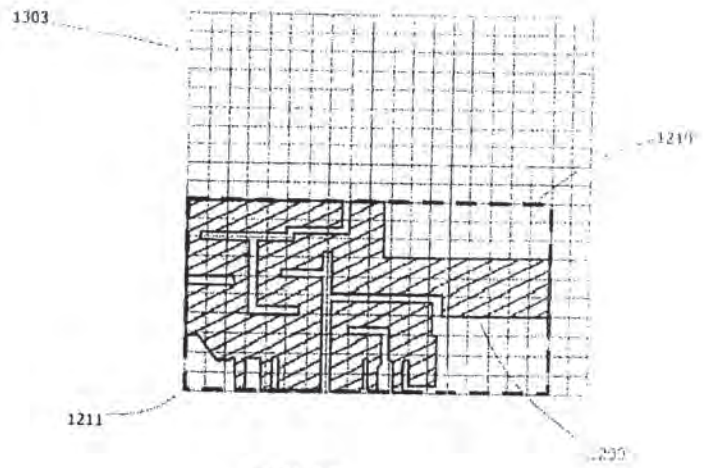
[FIG. 13a]



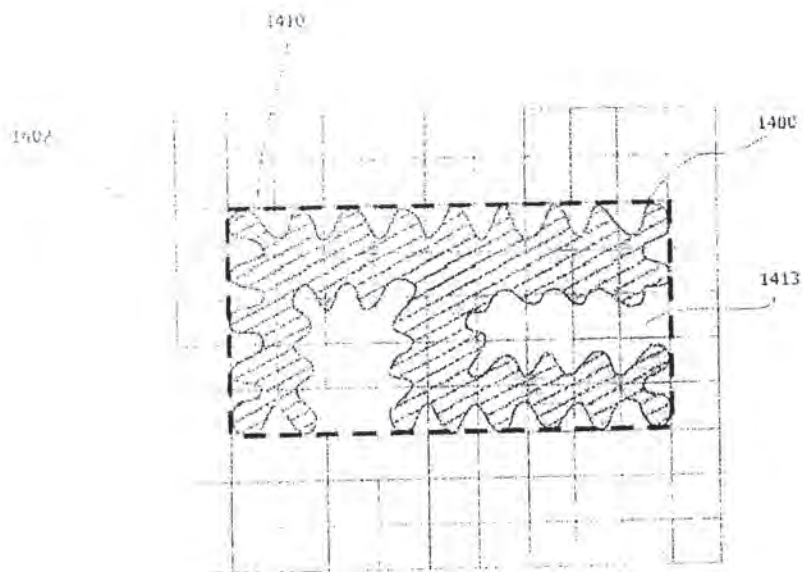
[FIG. 13b]



[FIG. 14a]

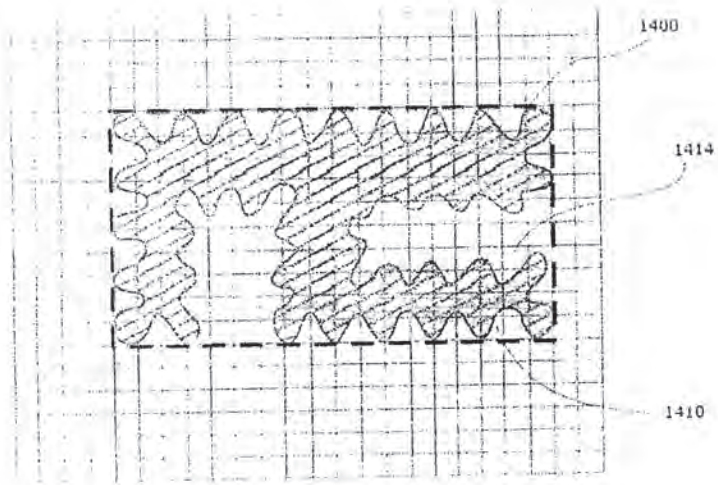


[FIG. 13c]

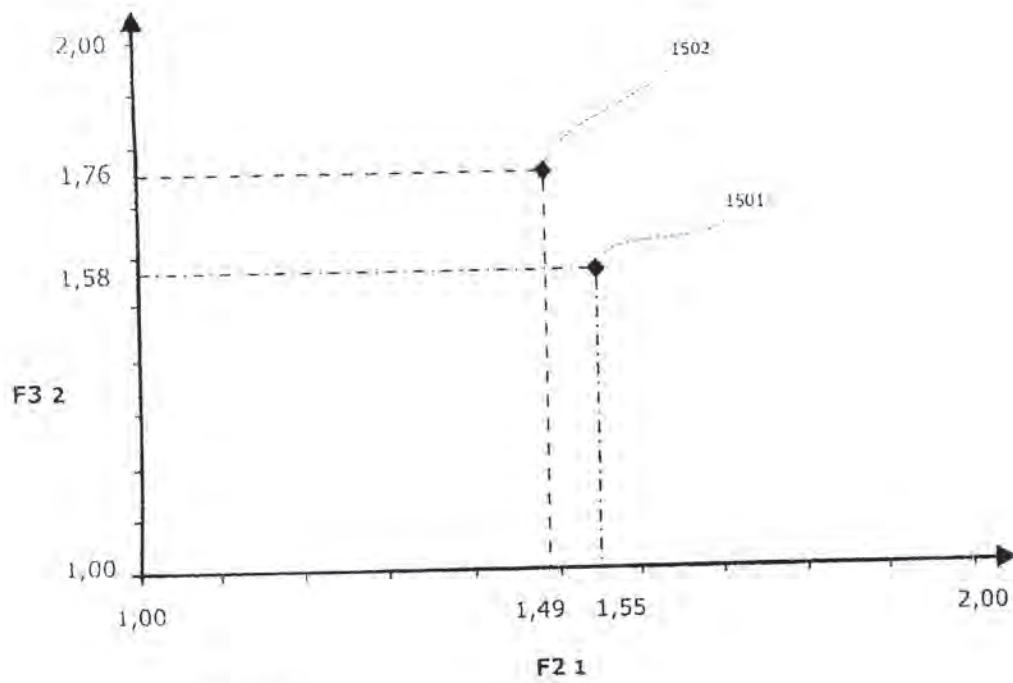


[FIG. 14b]

1402



[FIG. 14c]



[FIG. 15]

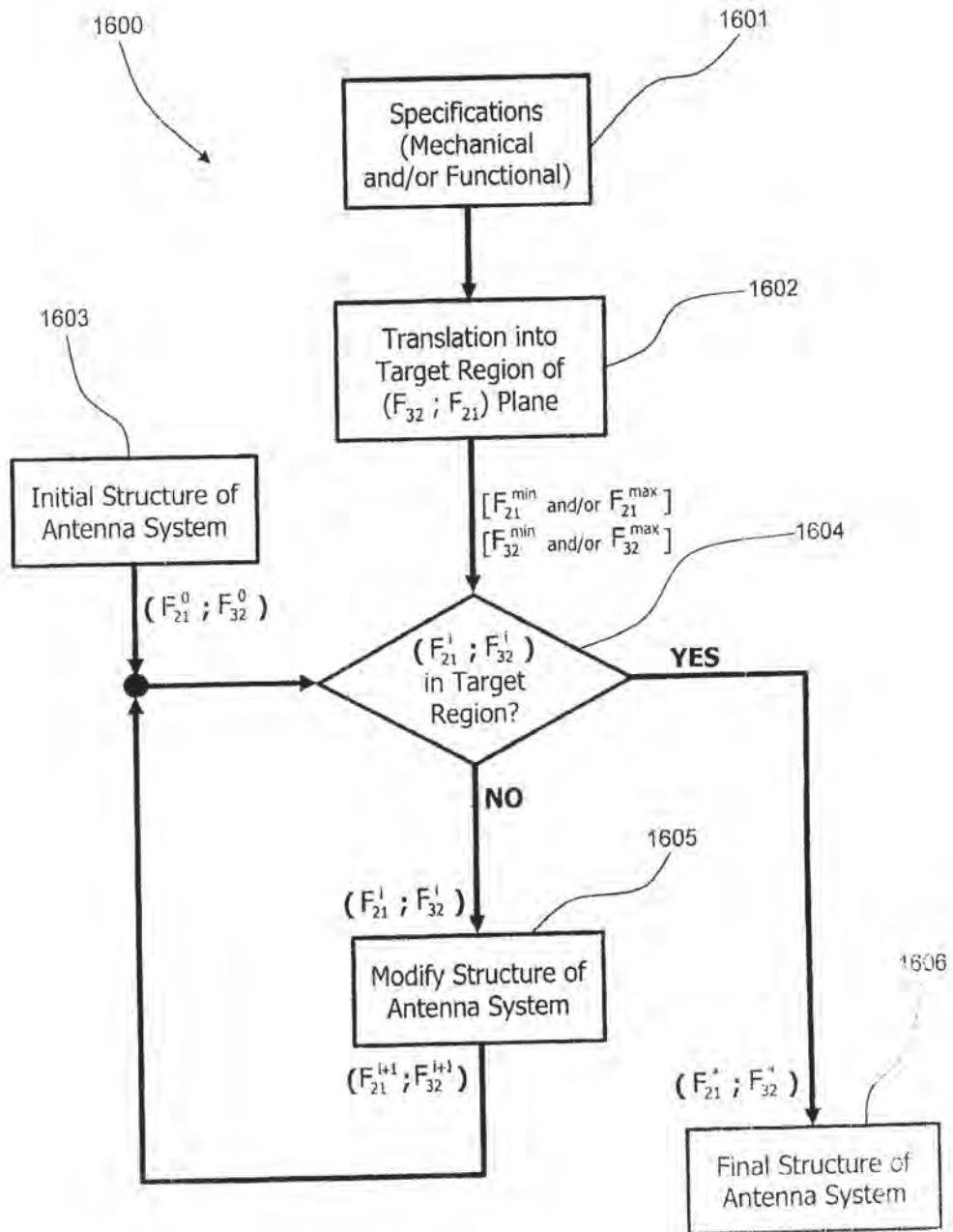


FIG. 16

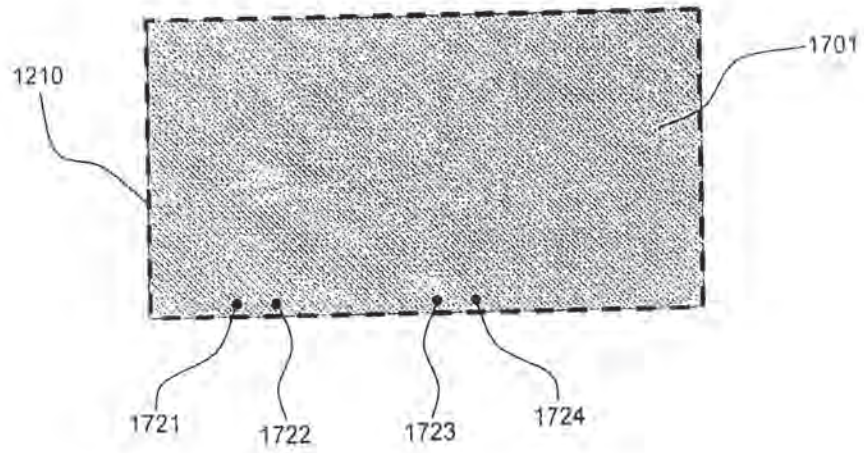


FIG. 17a

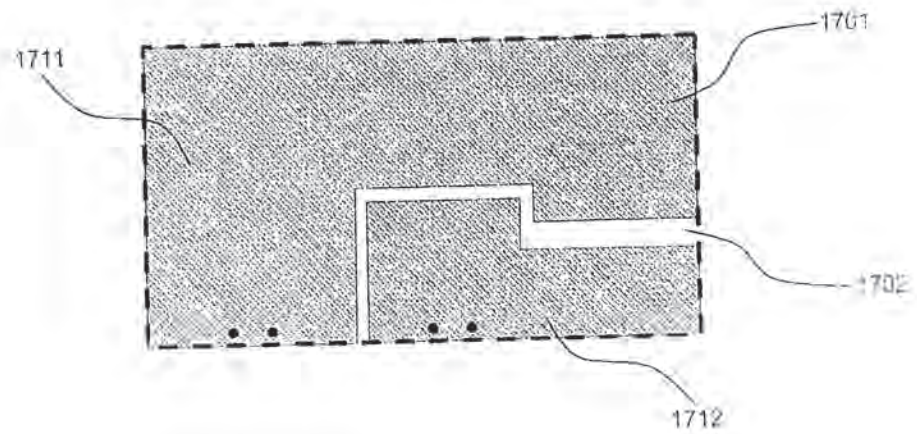


FIG. 17b

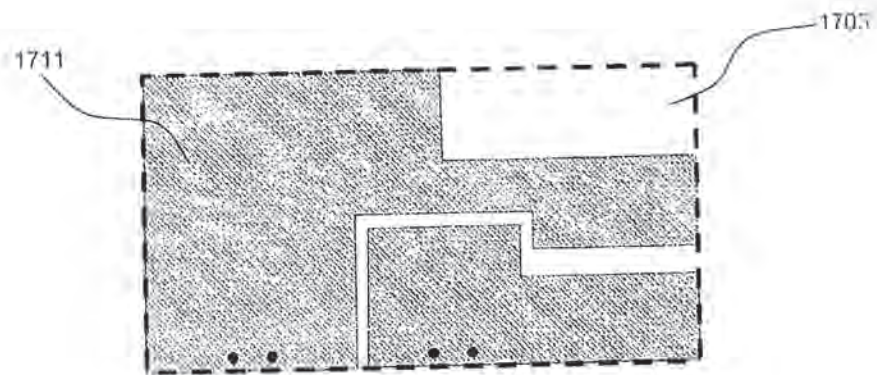


FIG. 17c

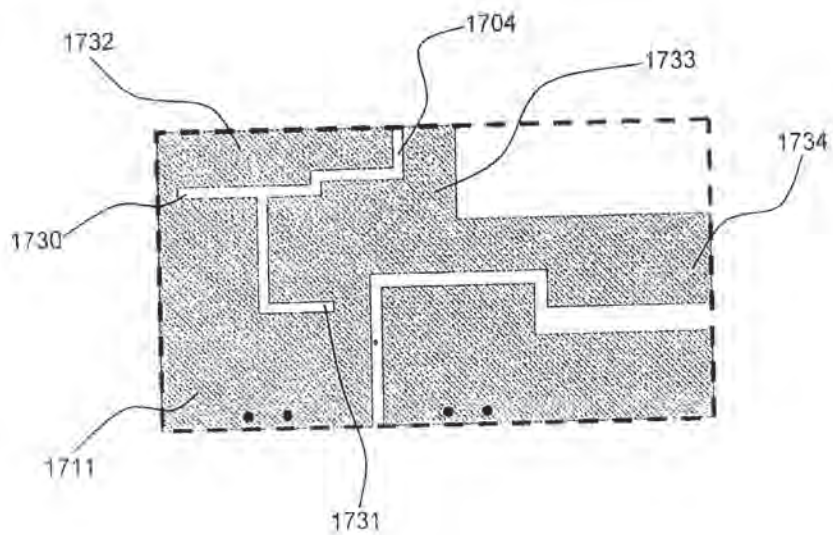


FIG. 17d

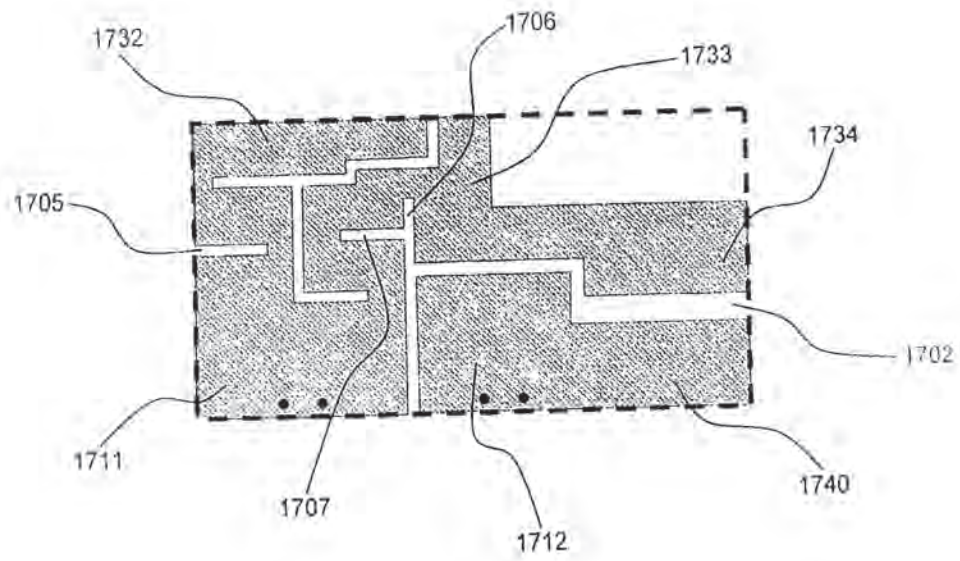


FIG. 17e

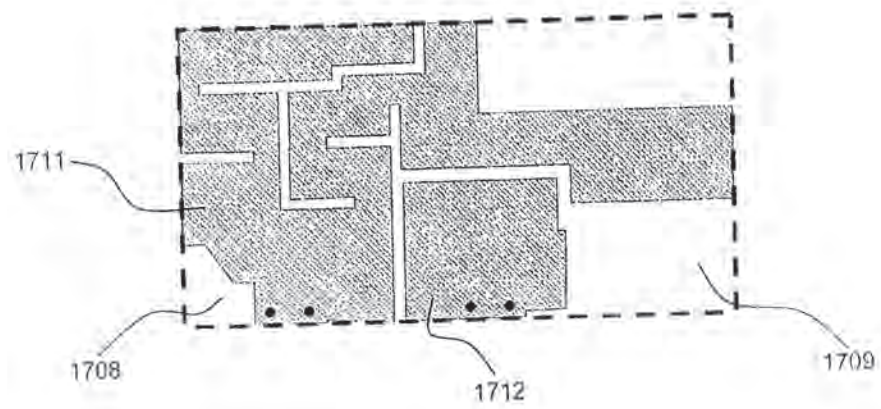


FIG. 17f

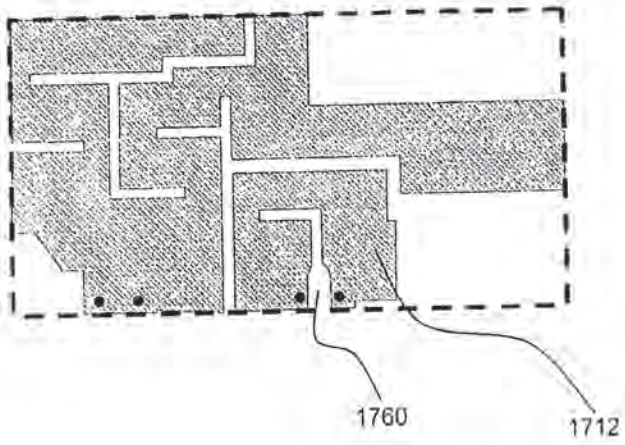


FIG. 17g

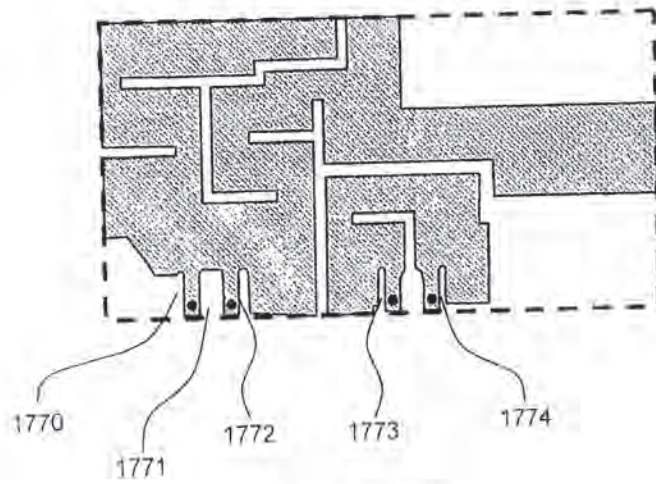


FIG. 17h

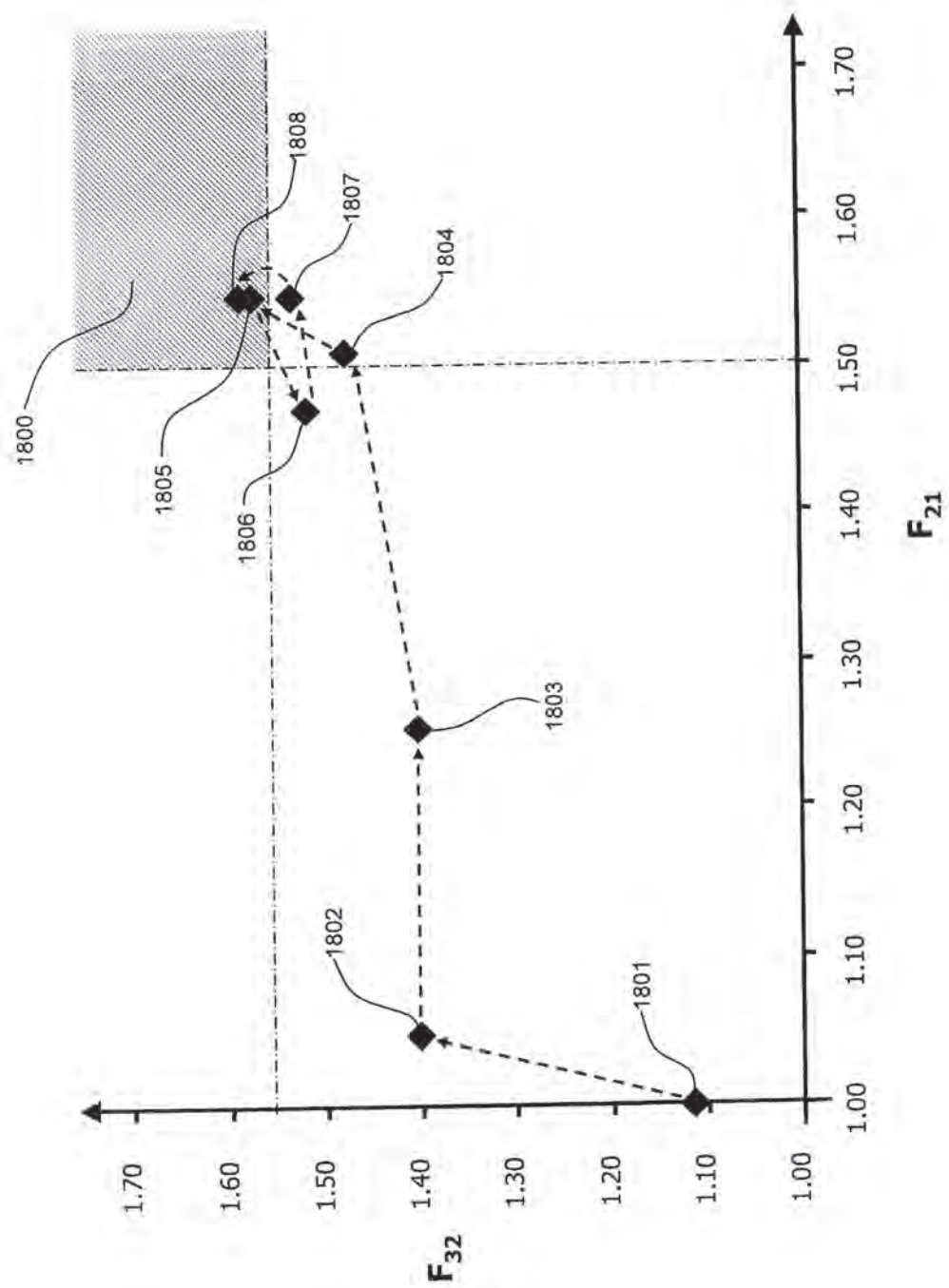


FIG. 18

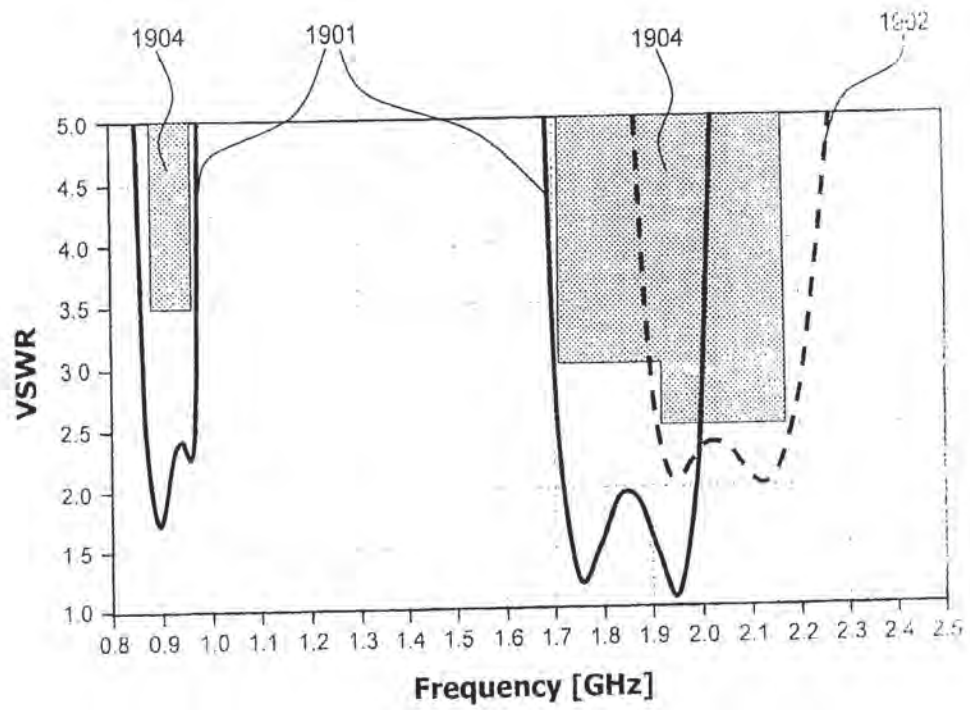


FIG. 19a

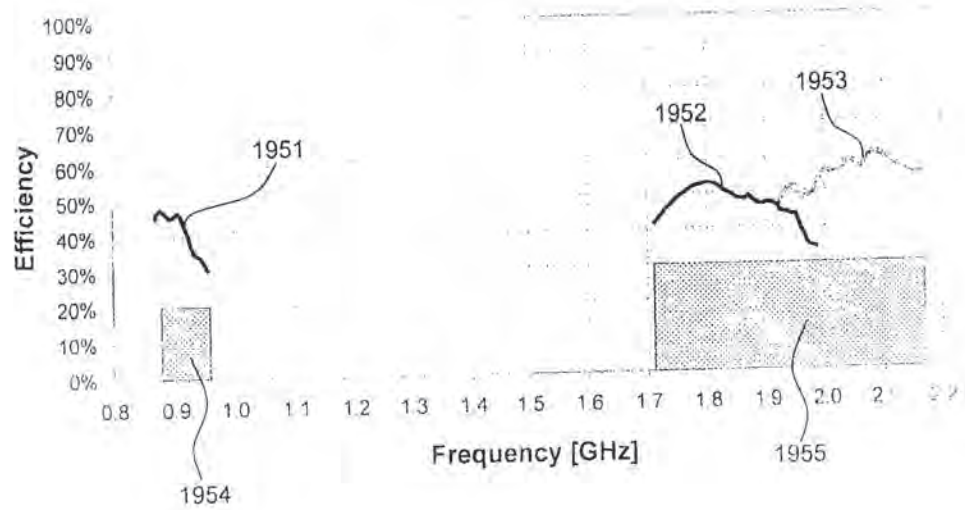
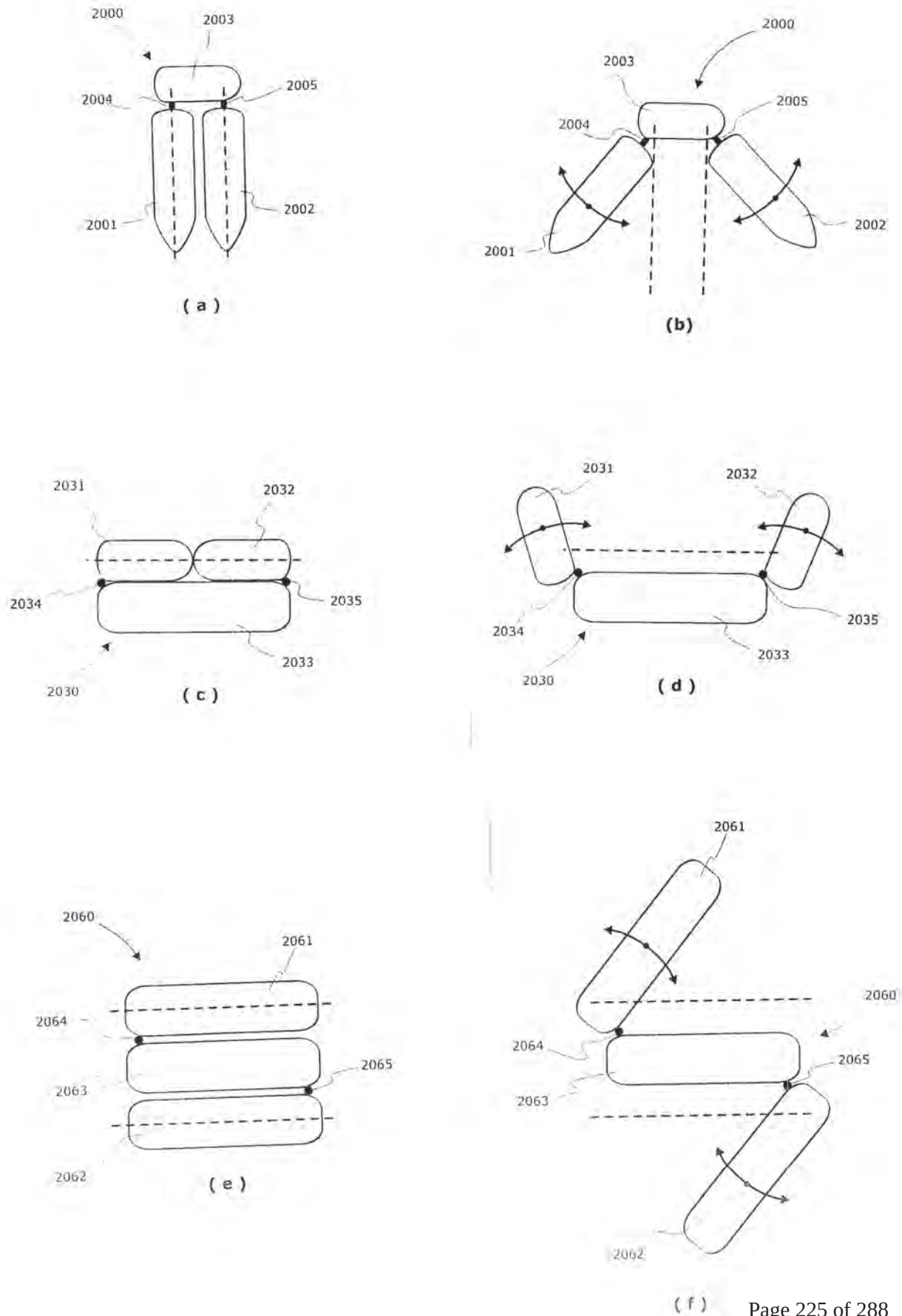


FIG. 19b

FIG. 20



PATENT APPLICATION

**TITLE: MULTIPLE-BODY-CONFIGURATION MULTIMEDIA AND
 SMARTPHONE MULTIFUNCTION WIRELESS DEVICES**

INVENTORS: Josep Mumbrú, Carles Puente, Jordi Ilario

OWNER: FRACTUS S.A.

**MULTIPLE-BODY-CONFIGURATION MULTIMEDIA AND SMARTPHONE
MULTIFUNCTION WIRELESS DEVICES**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from, and incorporates by reference the entire disclosure of U.S. Provisional Patent Application No. 60/831,544, filed July 18, 2006, and U.S. Provisional Patent Application No. 60/856,410, filed November 3, 2006. This patent application further claims priority from, and incorporates by reference the entire disclosure of European Patent Application No. EP 06117352.2, filed July 18, 2006.

Technical Field

[0002] The present invention relates to a multifunction wireless device (MFWD), and, more particularly, but not by way of limitation, to a multifunction wireless device and antenna designs thereof combining into a single unit mobile data and voice services with at least one of multimedia capabilities (multimedia terminal (MMT) and personal computer capabilities, (i.e., smartphone) or with both MMT and smartphone (SMRT) capabilities (MMT+SMRT).

History of Related Art

[0003] MFWDs are usually individually adapted to specific functions or needs of a certain type of users. In some cases, it may be desirable that the MFWD is either e.g. small while in other cases this is not of importance since e.g. a keyboard or screen is provided by the MFWD which already requires a certain size.

[0004] Many of the demands for modern MFWDs also translate to specific demands for the antennas thereof. For example, one design demand for antennas of multifunctional wireless devices is usually that the antenna be small in order to occupy as little space as possible within the MFWD which then allows for smaller MFWDs or for more specific equipment to provide certain function of the MFWD. At the same time, it is sometimes required for the antenna to be flat since this allows for slim MFWDs or in particular, for MFWDs which have two parts that can be shifted or twisted against each other.

[0005] In the context of the present application, a device is considered to be slim if it has a thickness of less than about 14 mm, 13 mm, 12 mm, 11 mm, 10 mm, 9 mm or 8 mm. A slim MFWD should be mechanically stable, mechanical stability being more difficult to achieve in slim devices.

[0006] Additionally, antennas in some embodiments are required to be multi-band antennas and to cover different frequency bands and/or different communication system

bands. Beyond that, some of the bands have to be particularly broad like the UMTS band which has a bandwidth of 12.2%. For a good wireless connection, high gain and efficiency are further required. Other more common design demands for antennas are the voltage standing wave ratio (VSWR) and the impedance which is typically about 50 ohms.

[0007] Furthermore of particular importance, is omni-directional coverage which means that the antenna radiates with a substantially donut-shaped radiation pattern such that e.g. terrestrial base stations of mobile telephone communication systems can be contacted within any direction in the horizontal plane.

[0008] However, for satellite communication (for example, for receiving GPS-signals), other radiation patterns are preferred, in particular, those which radiate into the upper hemisphere. Here radiation into the horizontal plane is usually less desired. The polarization of the emitted or received radiation also has to be taken into consideration. Other demands for antennas for modern MFWDs are low cost and a low specific absorption rate (SAR).

[0009] Furthermore, an antenna has to be integrated into a device such as MFWD such that an appropriate antenna may be integrated therein which puts constraints upon the mechanical fit, the electrical fit and the assembly fit of the antenna within the device. Of further importance, usually, is the robustness of the antenna which means that the antenna does not change antenna properties in response to smaller shocks to the device.

[0010] As can be imagined, a simultaneous improvement of all features described above is a major challenge for persons skilled in the art. A typical exemplary design problem is the generally uniform line of thinking that due to the limits of diffraction, a substantial increase in gain and directivity can only be achieved through an increase in the antenna size.

[0011] On the other hand, a MFWD that has a high directivity and hence, a high gain, has to be properly oriented towards a transceiver-base station. This, however, is not always practical since portable device users need to have the freedom to move and change direction with respect to a base station without losing coverage and, therefore, losing the wireless connection. Therefore, less gain is usually accepted in order to obtain an omni-directional (donut-like) radiation pattern.

[0012] It has to be taken into account that a palmtop, laptop, or desktop portable device might require a radiation pattern that enhances radiation in the upper hemisphere, i.e., pointing to the ceiling and the walls rather than pointing to the floor, since transceiver stations such as a hotspot antenna or a base station are typically located above or on the side of the portable device. If, however, such a device is used for a voice phone call it will be

held substantially upright close to the user's head in which case an omni-directional pattern is preferred which is oriented so that the donut-like shape of the radiation pattern lies in the horizontal.

[0013] While it might appear desirable to provide an antenna with a uniform radiation pattern (sphere-like) for voice calls such a pattern turns out to have substantial drawbacks in terms of a desired low specific absorption rate since it sometimes leads to an increased absorption of radiation within the hand and the head of the user during a voice phone call.

[0014] In every MFWD, the choice of the antenna, its placement in the device and its interaction with the surrounding elements of the device will have an impact on the overall wireless connection performance making its selection non-trivial and subject to constraints due to particular target use, user and market segments for every device.

[0015] As established by L.J. Chu in "Physical Limitations of Omni-Directional Antennas", Journal of Applied Physics, Vol. 19, Dec, 1948, pg. 1163-1175, and Harold A. Wheeler, in "Fundamental Limitations of Small Antennas", Proceedings of the I.R.E., 1947, pgs. 1479-1488, small antennas may not exceed a certain bandwidth. The bandwidth of the antenna decreases in proportion to the volume of the antenna. The bandwidth, however, is proportional to the maximum data rate the wireless connection can achieve and, therefore, a reduction in the antenna size is additionally linked to a reduction in the speed of data transmission.

[0016] Furthermore, a reduction of the antenna size can be achieved, for example, by loading the antenna with high dielectric materials for instance by stuffing, backing, coating, filling, printing or over-molding a conductive antenna element with a high dielectric material. Such materials tend to concentrate a high dielectric and magnetic field intensity into a smaller volume. This concentration leads to a high quality factor which, however, leads to a smaller bandwidth. Further, such a high concentration of electromagnetic field in the material leads to inherent electrical losses. Those losses may be compensated by a higher energy input into the antenna which then leads to a portable wireless device with a reduced standby or talk/connectivity time. In the design of MFWDs, every micro Joule of energy available in the battery has to be used in the most efficient way.

[0017] Multi-band antennas require a certain space since for each band a resonating physical structure is usually required. Such additional resonating physical structures occupy additional space which then increases the size of the antenna. It is therefore particularly difficult to build antennas which are both small and multi-band at the same time.

[0018] As already mentioned above, there exists a fundamental limit established by Chu and Wheeler between the bandwidth and antenna size. Therefore, many small antennas have great difficulty in achieving a desired large bandwidth.

[0019] Broadband operation may be achieved by two closely neighboring bands which then require additional space for the resonating physical structure of each of the bands. Further, those two antenna portions may not be provided too close together since, due to electric coupling between the two elements, the merging of the two bands into a single band is not achieved, but rather splitting the resonant spectrum into independent sub-bands which is not acceptable for meeting the requirements of wireless communication standards.

[0020] Furthermore, for broadband operation the resonating physical structure needs a certain width. This width, however, requires additional space which further shows that small broadband antennas are difficult to achieve.

[0021] It is known to achieve a broadband operation with parasitic elements which, however, require additional space. Such parasitic elements may also not be placed too close to other antenna portions since this will also lead to splitting the resonant spectrum into multiple sub-bands.

[0022] An antenna type which may be particularly suitable for slim multifunctional devices or those composed of two parts which can be moved against each other (such as twist, clamshell or slide devices) is a patch antenna (and particularly a PIFA antenna). However patch antennas, are unfortunately known to have poor gain and narrow bandwidths, typically in the range of 1% to 5% which is unsuitable for coverage of certain bands such as the UMTS band.

[0023] Although it is known that the bandwidth may be increased by changing the separation between the patch and its ground plane, this then destroys the advantage of patch antennas being flat. This also leads to a distortion of the radiating pattern, for instance, due to surface wave effects.

[0024] For patch antennas it is known that by providing a high dielectric material between the patch and the ground plane, it is possible to reduce the antenna size. As mentioned above, such high dielectric materials tend to reduce the bandwidth which is then disadvantageous for patch antennas. Such materials also generally increase losses.

[0025] Further difficulties in antenna design occur when trying to build multi-band antennas. While it is possible to separate different antenna portions from each other with appropriate slots or the like, currents and charges in the respective parts always interact with one another by strong and far-reaching electromagnetic fields. Those different antenna

branches are, therefore, never completely independent of one another. Trying to add a new branch to an existing antenna structure to produce a new antenna frequency of resonance therefore changes entirely the previous antenna frequencies. Therefore, it is difficult to simply take a working antenna and try to add one more band by just adding one more antenna portion. All previously achieved optimizations for already established frequency bands are lost by such an approach.

[0026] Trying to design an antenna with three or more bands gives rise to a linear or, in the worst case an exponential, rise in the number of parameters to consider or problems to resolve. For each band, resonant frequency, bandwidth, and other above-mentioned parameters such as impedance, polarization, gain, and directivity must all be controlled simultaneously. Furthermore, multi-band antennas may be coupled with two or more radio frequency devices. Such coupling raises the issue of isolation between the different radio frequency devices, which are both connected to the same antenna. Isolation of this type is a very difficult task.

[0027] Physical changes intended to optimize one parameter of one antenna band change other antenna parameters, most likely in a counter-productive way. It is usually not obvious how to control the counter-productive effects or how to compensate for them without creating still more problems.

[0028] Mechanical considerations must also be taken into account in antenna design. For example, the antenna needs to be firmly held in place within a device. However, the materials that are in very close proximity to the metal piece or the conductive portion which forms an antenna or antenna portion, have a great impact on the antenna characteristics. Sometimes extensions or small recesses in the metal piece are provided to firmly hold the antenna in place, however such means which are intended for giving mechanical robustness to the antenna also interact with and change the electric properties of the antenna.

[0029] All these different design problems of antennas may only be solved in the design of the geometry of the antenna. All parameters such as size, flatness, multi-band operation, broadband operation, gain, efficiency, impedance, radiation patterns, specific absorption rate, robustness and polarization are highly dependent on the geometry of the antenna. Nevertheless, it is practically impossible to identify at least one or two geometric features which affect only one or two of the above-mentioned antenna characteristics. Thus, there is no individual geometry feature which can be identified in order to optimize one or two antenna characteristics, without also influencing all other antenna characteristics.

[0030] Any change to the antenna geometry may harm more than it helps without knowing in advance how and why it happens or how it can be avoided.

[0031] Additionally, every platform of a wireless device is different in terms of form factor, market and technical requirements and functionality which requires different antennas for each device.

[0032] One problem is solved by providing the MFWD with an RF system and an antenna system with the capability of fully functioning in one, two, three or more communication standards (such as e.g. GSM 850, GSM 900, GSM 1800, GSM 1900, UMTS, CDMA, W-CDMA, etc.), and in particular mobile or cellular communication standards, each standard allocated in one or more frequency bands, each of said frequency bands being fully contained within one of the following regions of the electromagnetic spectrum:

the 810MHz – 960MHz region,
the 1710MHz – 1990MHz region,
and the 1900MHz – 2170MHz region

such that the MFWD is able to operate in three, four, five, six or more of said bands contained in at least said three regions.

[0033] One problem to be solved by the present invention is therefore to provide an enhanced wireless connectivity. Another effect of the invention is to provide antenna design parameters that tend to optimize the efficiency of an antenna for a MFWD device while observing the constraints of small device size and enhanced performance characteristics.

Summary of the Invention

[0034] A multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the multifunction wireless device including an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner. The multifunction wireless device further includes an antenna system disposed within at least one of the upper body and the lower body and having a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.

[0035] A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device including a microprocessor and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications, and at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB. The multifunction wireless

device further includes an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least 1.05 and not greater than 1.80 and by complexity factor F_{32} having a value of at least 1.10 and not greater than 1.90.

[0036] A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device including a receiver of at least one of analog and digital sound signals, an image recording system comprising at least one of an image sensor having at least 2 Megapixels in size, a flash light, an optical zoom, and a digital zoom, and data storage means having a capacity of at least 1 GB. The multifunction wireless device further includes an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least 1.05 and not greater than 1.80 and by complexity factor F_{32} having a value of at least 1.10 and not greater than 1.90.

[0037] The present invention is related to a portable multifunction wireless device (MFWD) and in particular to a handheld multifunction wireless device. In some embodiments, the MFWD will take the form of a handheld multimedia terminal (MMT) including wireless connectivity to mobile networks. In some embodiments, the MFWD will take the form of a handheld device combining personal computer capabilities, mobile data and voice services into a single unit (smartphone, SMRT), while in others the MFWD will combine both multimedia and smartphone capabilities (MMT+SMRT).

[0038] It is an object of the present invention to provide wireless connectivity to an MFWD that takes the form of a handheld multimedia terminal (MMT). In some embodiments, the MMT will include means to reproduce digital music and sound signals, preferably in a data compressed format such as for instance a MPEG standard such as MP3 (MPEG3) or MP4 (MPEG4). In some embodiments, the MMT will include a digital camera to record still (pictures, photos) and/or moving images (video), combined with a microphone or microphone system to record live sound and convert it to a digital compressed format. The present invention will be particularly suitable for those MMT embodiments combining both music and image capabilities, by providing means to efficiently integrate music, images, live video and sound recording and playing into a very small, compact and lightweight handheld device.

[0039] It is an object of the present invention as well, to provide wireless connectivity to an MFWD that takes the form of a smartphone (SMRT). In some embodiments, the smartphone will consist of a handheld electronic unit comprising a microprocessor and

operating system (such as for instance but not limited to Pocket PC, Windows Mobile, Windows CE, Symbian, Palm OS, Brew, Linux) with the capability of downloading and installing multiple software applications and enhanced computing capabilities compared to a typical state of the art mobile phone. Typically, SMRT will comprise a small, compact (handheld) computer device with the capability of sharing, opening and editing typical word processing, spreadsheets and slide files that are handled by a personal computer (for instance a laptop or desktop). Although many current mobile phones feature some very basic electronic agenda functions (calendars, task lists and phonebooks) and are even able to install small Java or Brew games, they are not considered here to be smartphones (SMRT).

[0040] It is one purpose of the present invention to provide enhanced wireless capabilities to any of the MFWD devices described above. In some embodiments though, providing a wide geographical coverage will be a priority rather than enhanced multimedia or computing capabilities, while in others the priority will become to provide a high-speed connection and/ or a seamless connection to multiple networks and standards.

Brief Description of the Drawings

[0041] Further characteristics and advantages of the invention will become apparent in view of the detailed description which follows of some preferred embodiments of the invention given for purposes of illustration only and in no way meant as a definition of the limits of the invention, made with reference to the accompanying drawings:

[0042] **Figure 1A** shows a block diagram of a MFWD of the present invention illustrating the basic functional blocks thereof;

[0043] **Figure 1B** shows a perspective view of a MFWD including a space for the integration of an antenna system, and its corresponding antenna box and antenna rectangle;

[0044] **Figure 2A** shows an example MFWD comprising a ground plane layer included in a PCB, and its corresponding ground plane rectangle;

[0045] **Figure 2B** shows the ground plane rectangle of the MFWD of Figure 2a in combination with an antenna rectangle for an antenna system;

[0046] **Figure 3** shows an example of an antenna contour of an antenna system for a MFWD;

[0047] **Figure 4** from top to down shows an example of a process (for instance a stamping process) followed to shape a rectangular conducting plate to create the structure of an antenna system for a MFWD;

[0048] Figures 5A-B show an example of MFWD being held typically by a right-handed user to originate a phone call, and how the feeding point corner of the antenna rectangle of said MFWD may be selected;

[0049] Figure 5C shows an exploded view of an exemplary clamshell-type MFWD;

[0050] Figure 6A shows an example of a first grid to compute the complexity factors of an antenna contour;

[0051] Figure 6B shows an example of a second grid to compute the complexity factors of an antenna contour;

[0052] Figure 6C shows an example of a third grid to compute the complexity factors of an antenna contour;

[0053] Figure 7 shows the two-dimensional representation of the F_{32} vs. F_{21} space;

[0054] Figure 8A shows an example of an antenna contour inspired in a Hilbert curve under a first grid to compute the complexity factors of said antenna contour;

[0055] Figure 8B shows the example of the antenna contour of Figure 8a under a second grid to compute the complexity factors of said antenna contour;

[0056] Figure 8C shows the example of the antenna contour of Figure 8a under a third grid to compute the complexity factors of said antenna contour;

[0057] Figure 9A shows an example of a quasi-rectangular antenna contour featuring a great degree of convolution in its perimeter under a first grid to compute the complexity factors of said antenna contour;

[0058] Figure 9B shows the example of the quasi-rectangular antenna contour featuring a great degree of convolution of Figure 9a under a second grid to compute the complexity factors of said antenna contour;

[0059] Figure 9C shows the example of the quasi-rectangular antenna contour featuring a great degree of convolution of Figure 9a under a third grid to compute the complexity factors of said antenna contour;

[0060] Figure 10A shows an example of a triple branch antenna contour under a first grid to compute the complexity factors of said antenna contour;

[0061] Figure 10B shows the example of the triple branch antenna contour of Figure 10a under a second grid to compute the complexity factors of said antenna contour;

[0062] Figure 10C shows the example of the triple branch antenna contour of Figure 10a under a third grid to compute the complexity factors of said antenna contour;

[0063] Figure 11 shows the mapping of the antenna contour of Figures 6, 8, 9 and 10 in the F_{32} vs. F_{21} space;

[0064] **Figure 12A** shows an example of antenna contour of the antenna system of a MFWD according to the present invention;

[0065] **Figure 12B** shows an example of a PCB of a MFWD including a layer that serves as the ground plane to the antenna system of Figure 12a;

[0066] **Figure 13A** shows the antenna contour of Figure 12a placed under a first grid to compute the complexity factors of said antenna contour;

[0067] **Figure 13B** shows the antenna contour of Figure 12a placed under a second grid to compute the complexity factors of said antenna contour;

[0068] **Figure 13C** shows the antenna contour of Figure 12a placed under a third grid to compute the complexity factors of said antenna contour;

[0069] **Figure 14A** shows an antenna contour according to the present invention placed under a first grid to compute the complexity factors of said antenna contour;

[0070] **Figure 14B** shows the antenna contour according to the present invention of Figure 14a placed under a second grid to compute the complexity factors of said antenna contour;

[0071] **Figure 14C** shows the antenna contour according to the present invention of Figure 14a placed under a third grid to compute the complexity factors of said antenna contour;

[0072] **Figure 15** shows the mapping of the antenna contour of Figures 12 and 14 in the F_{32} vs. F_{21} space;

[0073] **Figure 16** illustrates a flow diagram for optimizing the geometry of an antenna system to obtain superior performance within a wireless device;

[0074] **Figures 17A-17H** illustrate the progressive modification of an antenna system through the different steps of the optimization process in accordance with the principles of the present invention;

[0075] **Figure 18** is a complexity factor plain graphically illustrating the complexity factors of Figures 18A-18H;

[0076] **Figure 19A** is a graphical representation of the VSWR of the antenna system relative to frequency;

[0077] **FIGURE 19B** is a graphical representation of the efficiency of the antenna system as a function of the frequency; and

[0078] **Figures 20A-20F** illustrate cross-sectional views of exemplary MFWDs comprising three bodies.

DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0079] Referring first to Figure 1A, a multifunction wireless device (MFWD) of the present invention 100 advantageously comprises five functional blocks: display 11, processing module 12, memory module 13, communication module 14 and power management module 15. The display 11 may be, for example, a high resolution LCD or equivalent is an energy consuming module and most of the energy drain comes from the backlight use. The processing module 12, that is the microprocessor or CPU and the associated memory module 13, are also major sources of power consumption. The fourth module responsible of energy consumption is the communication module 14, an essential part of which is the antenna system. The MFWD 100 has a single source of energy and it is the power management module 15 mentioned above that provides and manages the energy of the MFWD 100. In a preferred embodiment, the processing module 12 and the memory module 13 have herein been listed as separate modules. However, in another embodiment, the processing module 12 and the memory module 13 may be separate functionalities within a single module or a plurality of modules. In a further embodiment, two or more of the five functional blocks of the MFWD 100 may be separate functionalities within a single module or a plurality of modules.

[0080] The MFWD 100 generally comprises one, two, three or more multilayer printed circuit boards (PCBs) on which to carry and interconnect the electronics. At least one of the PCBs includes feeding means and/or grounding means for the antenna system.

[0081] At least one of the PCBs, preferably the same one as the at least one PCB including feeding means and/or grounding means, includes a layer that serves as a ground plane of the antenna system.

[0082] The antenna system within the communication module 14 is an essential element of the MFWD 100, as it provides the MFWD 100 with wide geographical and range coverage, high-speed connection and/or seamless connection to multiple networks and standards. Thus, a volume of space within the MFWD 100 needs to be made available to the integration of the antenna system. However, the integration of the antenna system is complicated by the fact that the MFWD 100 also includes one or more advanced functions provided by at least one, two, three or more additional electronic subsystems within and/or modulation to the various modules 11-15 such as:

- a receiver of analog and/or digital sound signals (e.g. for FM, DAB, XDARS, SDARS, or the like).
- a receiver of digital broadcast TV signals (such as DVB-H, DMB)

- a module to download and play streamed video,
- an advanced image recording system (comprising e.g. one, two, three or more of: optical or digital zoom; flash light; one, two or more image sensors, one, two or more of which maybe more than 2 Megapixels in size),
- data storage means in excess of 1 GB (fixed and/or removable; hard disk drive; non volatile (e.g. magnetic, ferroelectric or electronic) memory),
- a high resolution image and/or character and graphic display (more than 100 times 100 pixels or more than 320 times 240 pixels (e.g. more than 75,000 pixels) and/or 65,000 color levels or more),
- a full keyboard (e.g. number keys and character keys separated therefrom and/or at least 26, 30, 36, 40 or 50 keys; the keyboard may be integrated within the MFWD or may be connectable to the MFWD by a cable or a short range wireless connectivity system),
- a touch screen with a size of at least half of the overall device
- a geolocalization system (such as e.g. GPS or Galileo or a mobile network related terrestrial system),
- and/or a module to handle an internet access protocol and/or messaging capabilities (such as email, instant messaging, SMS, MMS or the like).

[0083] In some examples, the integration of an antenna system into the MFWD 100 is further complicated by the presence in the MFWD 100 of additional antennas, such as for example antennas for reception of broadcast radio and/or TV, antennas for geolocalization services, and/or antennas for wireless connectivity systems.

[0084] The MFWD 100 according to one embodiment achieves an efficient integration of an antenna system alongside other electronic modules and/or subsystems that provide sophisticated functionality to the MFWD 100, (and possibly also in conjunction with additional antennas), in a way that the MFWD meets size, weight and/or battery consumption constraints critical for a portable small-sized device.

[0085] The MFWD 100 according to one embodiment is preferably able to provide both voice and high-speed data transmission and receive services through at least one or more of said frequency regions in the spectrum. For that purpose, a MFWD will include the RF capabilities, antenna system and signal processing hardware to connect to a mobile network at a speed of preferably at least 350 Kbits/s, while in some embodiments the data transfer will be performed with at least 1 Mbit/s, 2 Mbit/s or 10 Mbit/s or beyond. For this purpose, a MFWD will preferably include at least 3G (such as for instance UMTS, UMTS-FDD,

UMTS-TDD, W-CDMA, cdma2000, TD-SCDMA, Wideband CDMA) and/or 3.5G and/or 4G services (including for instance HSDPA, WiFi, WiMax, WiBro and other advanced services) in one or more of said frequency regions. In some embodiments a MFWD will include also 2G and 2.5G services such as GSM, GPRS, EDGE, TDMA, PCS, CDMA, cdmaOne. In some embodiments a MFWD will include 2G and or 2.5G services at one or both of the first two frequency regions (810-960 MHz and 1710-1990 MHz) and a 3G or a 4G service in the upper frequency region (1900-2170 MHz). In particular, some MFWD devices will provide 3 GSM/GPRS services (GSM900, GSM1800, GSM1900 or PCS) and UMTS/W-CDMA, while some others will provide 4 GSM/GPRS services (GSM850, GSM900, GSM1800, GSM1900 or PCS) and UMTS and/or W-CDMA to ensure seamless connectivity to multiple networks in several geographical domains such as for instance Europe and North America. In some embodiments, a MFWD will include 3G, 3.5G, 4G or a combination of such services in said three frequency regions.

[0086] In some embodiments of the invention, the MFWD 100 includes wireless connectivity to other wireless devices or networks through a wireless system such as for instance WiFi (IEEE802.11 standards), Bluetooth, ZigBee, UWB in some additional frequency regions such as for instance an ISM band (for instance around 430 MHz or 868 MHz, or within 902-928 MHz or in the 2400-2480 MHz range, or in the 5.1-5.9 GHz frequency range or a combination of them) and/or within a ultra wide-band range (UWB) such as the 3-5 GHz or 3-11 GHz frequency range.

[0087] In some embodiments of the invention, the MFWD 100 provides voice over IP services (VoIP) through a wireless connection using one or more wireless standards such as WiFi, WiMax and WiBro, within the 2-11 GHz frequency region or in particular the 2.3-2.4 GHz frequency region.

[0088] The MFWD 100 may have a bar shape, which means that it is given by a single body. It may also have a two-body structure such as a clamshell, flip or slider structure. It may further or additionally have a twist structure in which a body portion e.g. with a screen can be twisted (rotated with two or more axes of rotation which are preferably not parallel).

[0089] The MFWD 100 may operate simultaneous in two or more wireless services (e.g. a short range wireless connectivity service and a mobile telephone service, a geolocalization service and a mobile telephone service, etc.).

[0090] For any wireless service, more than one antenna (system) may be provided in order to obtain a diversity system and/or a multiple input/multiple output system.

[0091] In a MFWD 100 according to an embodiment of the present invention, the structure of the antenna system is advantageously shaped to efficiently use the volume of physical space made available for its integration within the MFWD 100 in order to obtain a superior RF performance of the antenna system (such as for example, and without limitation, input impedance level, impedance bandwidth, gain, efficiency, and/or radiation pattern) and/or superior RF performance of the MFWD 100 (such as for example and without limitation, radiated power, received power and/or sensitivity) in at least one of the communication standards of operation in at least one of the frequency regions. Alternatively, the antenna system can be advantageously shaped to minimize the volume required within the MFWD 100 yet still achieve a certain RF performance.

[0092] As a consequence, the resulting MFWD 100 may exhibit in some examples one, two, three or more of the following features:

- increased communication range,
- improved quality of the communication or quality of service (QoS),
- extended battery life for higher autonomy of the device,
- reduced device profile and/or the size (an aspect particularly critical for slim phones and/or twist phones),
- and/or reduced weight of the device (aspect particularly critical for multimedia phones and/or smart phones),

all of which are qualities that translate into increased user acceptance of the MFWD 100.

[0093] The antenna system also comprises at least one feeding point and may optionally comprise one, two or more grounding points. In some examples of MFWDs, the antenna system may comprise more than one feeding point, such as for example two, three or more feeding points.

[0094] The MFWD 100 comprises one, two, three, four, five or more contact terminals. A contact terminal couples the feeding means included in a PCB of the MFWD 100 with a feeding point of the antenna system. The feeding means comprise one, two, three or more RF transceivers coupled to the antenna system through contact terminals.

[0095] Similarly, a contact terminal can also couple the grounding means included in a PCB of the MFWD 100 with a grounding point of the antenna system. A contact terminal may take for instance the form of a spring contact with a corresponding landing area, or a pogo pin with a corresponding landing area, or a couple of pads held in electrical contact by fastening means (such as a screw) or by pressure means.

[0096] A volume of space within the MFWD 100 of one embodiment of the invention is dedicated to the integration of the antenna system into the device. An antenna box for the MFWD 100 is herein defined as being the minimum-sized parallelepiped of square or rectangular faces that completely encloses the antenna volume of space and wherein each one of the faces of the minimum-sized parallelepiped is tangent to at least one point of the volume. Moreover, each possible pair of faces of the minimum-size parallelepiped shares an edge forming an inner angle of 90°.

[0097] For example, the antenna box shown at 103 of Figure 1B delimits the volume of space within the MFWD 100 dedicated to the antenna system in the sense that, although other elements of the MFWD 100 (such as for instance an electronic module or subsystem) can be within the antenna box, no portion of the antenna system can extend outside the antenna box.

[0098] Therefore, although the volume within the MFWD 100 dedicated to the integration of the antenna system will generally be irregularly shaped, the antenna box itself will have the shape of a right prism (i.e., a parallelepiped with square or rectangular faces and with the inner angles between two faces sharing an edge being 90°).

[0099] An antenna system of the MFWD 100 of one embodiment of the invention has a structure able to support different radiation modes so that the antenna system can operate with good performance and reduced size in the communication standards allocated in multiple frequency bands within at least three different regions of the electromagnetic spectrum. Such an effect is achieved by appropriately shaping the structure of the antenna system in a way that different paths are provided to the electric currents that flow on the conductive parts of said structure of the antenna system, and/or to the equivalent magnetic currents on slots, apertures or openings within said structure, thereby exciting radiation modes for the multiple frequency bands of operation. In some cases the structure of an antenna system will comprise a first portion that provides a first path for the currents associated with a radiation mode in a first frequency band within a first region of the electromagnetic spectrum, a second portion that provides a second path for the currents associated with a radiation mode in a second frequency band within a second region of the electromagnetic spectrum and a third portion that provides a third path for the currents associated with a radiation mode in a third frequency band within a third region of the electromagnetic spectrum.

[00100] Some of these basic concepts of antenna design are set forth in co-pending U. S. Patent Application Serial No. 11/179,257, filed July 12, 2005 and entitled "Multi-Level

Antenna” and in co-pending U. S. Patent Application Serial No. 11/179,250, filed July 12, 2005 and entitled “Space-Filing Miniature Antenna” both of which are hereby incorporated by reference herein.

[00101] In some embodiments of the invention the first, second and third portions are overlapping partially or completely with each other, while in other embodiments the three portions are essentially non-overlapping. In some embodiments only two of the three portions overlap either partially or completely and in some cases one portion of the three portions is the entire antenna system.

[00102] In some examples, at least one of the paths has an electrical length substantially close to one time, three times, five times or a larger odd integer number of times a quarter of the wavelength at a frequency of the associated radiation mode. In other examples, at least one of the paths has an electrical length approximately equal to one time, two times, three times or a larger integer number of times a half of the wavelength at a frequency of the associated radiation mode.

[00103] A structure of an antenna system of the MFWD 100 according to the present invention is able to support different radiation modes. Such an effect is advantageously achieved by means of one of, or a combination of, the following mechanisms:

- creating slots, apertures and/or openings within the structure,
- bending and/or folding the structure,

because an edge-rich, angle-rich and/or discontinuity-rich structure is obtained in which different portions of the structure offer longer and more winding paths for the electric currents and/or the equivalent magnetic currents associated with different frequency bands of operation than would the path of a simpler structure that uses neither one of the aforementioned mechanisms.

[00104] The process of shaping the structure of the antenna system into a configuration that supports different radiation modes can be regarded as the process of lowering the frequency of a first radiation mode associated with a first frequency band, and/or subsequently including additional radiation modes associated with additional frequency bands, to an antenna formed of a substantially square or rectangular conducting plate (or a substantially planar structure) that occupies the largest face of the antenna box.

[00105] The geometry of a substantially square or rectangular conducting plate occupying a largest face of the antenna box is an advantageous starting point for the design of the geometry of the structure of the antenna system since such a structure offers *a priori* the longest path for the currents of a radiation mode corresponding to a lowest frequency band,

together with the maximum antenna surface. Antenna designers have frequently encountered difficulty in maintaining the performance of small antennas. There is a fundamental physical limit between size and bandwidth in that the bandwidth of an antenna is generally directly related with the volume that the antenna occupies. Thus, in antenna design it may be preferable to pursue maximization of the surface area of an antenna in order to achieve maximum bandwidth. The geometry of an antenna comprised of a substantially square or rectangular conducting plate can be modified by at least one of the following:

- creating slots, gaps or apertures within the extension of the plate,
- removing peripheral parts of the plate,
- folding or bending parts of said plate, so that the folded or bent parts are no longer on the plane defined originally by the plate,
- and/or including additional conducting parts in the antenna box that are not contained on the plane originally defined by the plate;

in order to adapt the antenna system to the frequency bands of operation, to the space required by additional electronic modules or subsystems, and/or to other space constraints of the MFWD 100 (as for example those imposed by the ergonomics, or the aesthetics of the MFWD).

[00106] In some examples within embodiments of the present invention, one or several modifications of the structure of an antenna system are aimed at lengthening the path of the electric currents and/or the equivalent magnetic currents of a particular radiation mode to decrease its associated frequency band. In other examples, one or several modifications of the structure of an antenna system are aimed at splitting, or partially diverting, the electric currents and/or the equivalent magnetic currents on different parts of the structure of the antenna system to enhance multimode radiation, which may be advantageous for wideband behavior.

[00107] The resulting antenna structure (i.e., after modifying its geometry) includes a plurality of portions that allow the operation of the antenna system in multiple frequency bands. Generally, the structure of the antenna system comprises one, two, three, four or more antenna elements with each element being formed by a single conducting geometric element, or by a plurality of conducting geometric elements that are in electrical contact with one another (i.e., there is electrical continuity for direct or continuous current flow). One antenna element may comprise one or more portions of the structure of the antenna system and one portion of the antenna system may comprise one, two, three or more antenna elements. Different antenna elements may be electromagnetically coupled (either capacitively coupled or inductively coupled). Generally an antenna element of the antenna system is not

connected by direct contact to another antenna element of said antenna system, unless such contact is optionally done through the ground plane of the antenna system. In some examples, an antenna system with a structure comprising several antenna elements is advantageous to increase the number of frequency bands of operation of said antenna system and/or to enhance the RF performance of said antenna system or that of a MFWD including said antenna system.

[00108] In some examples, slots, gaps or apertures created between different antenna elements, or between parts of a same antenna element, serve to decrease electromagnetic coupling between the antenna elements, or the parts of the same antenna element. In other examples, the structure of the antenna system seeks to create proximity regions between antenna elements, or between parts of a same antenna element, to enhance the coupling between the antenna elements, or the parts of a same antenna element.

[00109] The design of the structure of the antenna system is intended to use efficiently as much of the volume of the space within the antenna box as possible in order to obtain a superior RF performance of the antenna system and/or superior RF performance of the MFWD 100 in at least one frequency band. In particular, according to the present invention, the structure of the antenna system comes into contact with each of the six (6) faces of the antenna box in at least one point of each face to make better use of the available volume. However, it is generally advantageous to position the geometrical complexity of the structure predominantly on a largest face of the antenna box, and use the third dimension of the antenna box (i.e., the dimension not included in said largest face) to separate the antenna system from other elements of the MFWD 100 (such as for instance, and without limitation, a ground plane, a grounded shield can, a loudspeaker module, a vibrating module, a memory card socket, a hard disk drive, and/or a connector) that may degrade the RF performance of the antenna system and/or the RF performance of the MFWD 100.

[00110] For one purpose of the design of the antenna system, an antenna rectangle is defined as being the orthogonal projection of the antenna box along the normal to the face with largest area of the antenna box.

[00111] In some exemplary MFWDs, one of the dimensions of the antenna box can be substantially smaller than any of the other two dimensions, or even be close to zero. In such cases, the antenna box collapses to a practically two-dimensional structure (i.e., the antenna box becomes approximately the antenna rectangle).

[00112] The antenna rectangle has a longer side and a shorter side. The length of the longer side is referred to as the width of the antenna rectangle (W), and the length of the

shorter side is referred to as the height of the antenna rectangle (H). The aspect ratio of the antenna rectangle is defined as the ratio between the width and the height of the antenna rectangle.

[00113] In addition to the antenna rectangle, a ground plane rectangle is defined as being the minimum-sized rectangle that encompasses the ground plane of the antenna system included in the PCB of the MFWD 100 that comprises the feeding means responsible for the operation of the antenna system in its lowest frequency band. That is, the ground plane rectangle is a rectangle whose edges are tangent to at least one point of the ground plane.

[00114] The area ratio is defined as the ratio between the area of the antenna rectangle and the area of the ground plane rectangle.

[00115] In some examples, the antenna system of the present invention advantageously places a feeding point of the antenna system, preferably a feeding point responsible for the operation of the antenna system in its lowest frequency band, near a corner of the antenna rectangle, because it may provide a longer path on the structure of the antenna system for the electric currents and/or the equivalent magnetic currents coupled to the antenna system through the feeding point.

[00116] In other examples, the antenna system of the present invention advantageously places a feeding point of the antenna system, preferably a feeding point responsible for the operation of the antenna system in its lowest frequency band, in such a way that a contact terminal of the MFWD 100 is located near an edge of a ground plane encompassed by the ground plane rectangle. Preferably that edge is common with a side of the ground plane rectangle, and preferably the side is a short side of the ground plane rectangle. Such placement of the feeding point of the antenna system, and that of the contact terminal of the MFWD 100 associated with the feeding point, may provide a longer path for electric and/or magnetic currents flowing on the ground plane of the antenna system enhancing the RF performance of the antenna system, or that of the MFWD 100, in at least the lowest frequency band. This becomes particularly relevant in those MFWD 100 having form factors that require a small size of the ground plane rectangle and, consequently, a small size of the whole device.

[00117] The structure of the antenna system becomes geometrically more complex as the number of frequency bands in which the MFWD 100 has to operate increases, and/or the size of the antenna box decreases, and/or the RF performance requirements are made more stringent in at least one frequency band of operation. In a MFWD 100 according to the present invention, the structure of the antenna system is geometrically defined by its antenna

contour. The antenna contour of the antenna system is a set of joint and/or disjoint segments comprising:

the perimeter of one or more antenna elements placed in the antenna rectangle,

the perimeter of closed slots and/or closed apertures defined within the antenna elements, and/or the orthogonal projection onto the antenna rectangle of perimeters of antenna elements, or perimeters of or parts of antenna elements that are placed in the antenna box but not in the antenna rectangle.

[00118] The antenna contour, i.e., its peripheral both internally and externally, can comprise straight segments, curved segments or a combination thereof. Not all the segments that form the antenna contour need to be connected (i.e., to be joined). In some cases, the antenna contour comprises two, three, four or more disjointed subsets of segments. A subset of segments is defined by one single segment or by a plurality of connected segments. In other cases, the entire set of segments that form the antenna contour are connected together defining a single set of joined segments (i.e., the antenna contour has only one subset of segments).

[00119] Along the contour different segments can be identified e.g. by a corner between two segments, wherein the corner is given by a point on the contour where no unique tangent can be identified. At the corners the contour has an angle. The segments next to a corner may be straight or curved or one straight and the other curved. Further, segments may be separated by a point where the curvature changes from left to right or from right to left. In a sine curve, for example such points are given where the curve intersects the horizontal axis (x-axis, abscissa, $\sin(x) = 0$).

[00120] It is preferred that right and left curved segments are provided (when following the contour) and/or that at corners angles to the left and to the right (when following the contour) are provided. Preferably the numbers of left and right curved segments respectively, (if provided) do not differ by more than 80%, 70%, 60%, 50%, 40%, 30%, 20% or 10% of the larger of the two numbers. Also the number of corner angles between adjacent segments which following the contour go to the right and those that go to the left do not differ by more than 80%, 70%, 60%, 50%, 40%, 30%, 20% or 10% of the larger of the two numbers. Further preferably the number of the left curved segments plus the number of the corners where the contour turns left and the number of the right curved segments plus the number of corners where the contour turns right do not differ by more than 80%, 70%, 60%, 50%, 40%, 30%, 20% or 10% of the larger of the two numbers.

[00121] Generally, one, two, three or more subsets of segments of the antenna contour advantageously each comprise at least a certain minimum number of segments that are connected in such a way that each segment forms an angle with any adjacent segments or a curved segment interposed between such segments, such that no pair of adjacent segments defines a larger straight segment. The angles at corners or curved segments increase the degree of convolution of the curves formed by the segments of each of said subsets leading to an antenna contour that is geometrically rich in at least one of edges, angles, corners or discontinuities, when considered at different levels of detail. Possible values for the minimum number of segments of a subset include 5, 6, 7, 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45 and 50. Also a maximum number of segments of a subset may be given. Possible values of said maximum number are 10, 15, 20, 25, 30, 40, 50, 75, 100, 150, 200, 250 and 500.

[00122] Additionally, to shape the structure of an antenna system in some embodiments the segments of the antenna contour should be shorter than at least one fifth of a free-space wavelength corresponding to the lowest frequency band of operation, and possibly shorter than one tenth of said free-space wavelength. Moreover, in some further examples the segments of the antenna contour should be shorter than at least one twentieth of said free-space wavelength.

[00123] The antenna contour needs to make efficient use of the area of the antenna rectangle in order to attain enough geometrical complexity to make the resulting structure of an antenna system suitable for the MFWD 100. In particular, according to the present invention, the antenna contour preferably comes into contact with each of the four (4) sides of the antenna rectangle in at least one point of each side of the antenna rectangle. The antenna contour should include at least ten segments in order to provide some multiple frequency band behavior, and/or size reduction, and/or enhanced RF performance to the resulting antenna system. However, a larger number of segments may be used, such as for instance 15, 20, 25, 30, 35, 40, 45, 50 or more segments. In general, the larger the number of segments of the antenna contour and the narrower the angles between connected segments, the more convoluted the structure of the antenna system becomes. The number of segments of the antenna contour may be less than 20, 25, 30, 40, 50, 75, 100, 150, 200, 250 or 500.

[00124] The length of the antenna contour of an antenna system is defined as the sum of the lengths of each one of the disjointed subsets that make up the antenna contour. The larger the length of the antenna contour, the higher the richness of the antenna contour in at

least one of edges, angles, corners or discontinuities, making the resulting structure of an antenna system suitable for a MFWD.

[00125] In some examples the length of the antenna contour is larger than 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30, 40, or more times the length of the diagonal of the antenna rectangle or less than any of those values.

[00126] Each of the one or more antenna elements comprised in the antenna system might be arranged according to different antenna topologies, such as for instance any one of the topologies selected from the following list: monopole antenna, dipole antenna, folded dipole antenna, loop antenna, patch antenna (and its derivatives for instance PIFA antennas), IFA antenna, slot antenna. Any of such antenna arrangements might comprise a dielectric material with a high dielectric constant (for instance larger than 3) to influence the operating frequency, impedance or both aspects of the antenna system.

[00127] In accordance with embodiments of the invention, the level of complexity of an antenna contour can be advantageously parameterized by means of two complexity factors, hereinafter referred to as F_{21} and F_{32} , which capture and characterize certain aspects of the geometrical details of the antenna contour (such as for instance its edge-richness, angle-richness and/or discontinuity-richness) when viewed at different levels of scale.

[00128] For the computation of F_{21} and F_{32} of a particular antenna, a first, a second, and a third grid (hereinafter called grid G_1 , grid G_2 and grid G_3 respectively) of substantially square or rectangular cells are placed on the antenna rectangle. The three grids are adaptive to the antenna rectangle. That is, the size and aspect ratio of the cells of each one of said three grids is determined by the size and aspect ratio of the antenna rectangle itself. The use of adaptive grids is advantageous because it provides a sufficient number of cells within the antenna rectangle to fully capture the geometrical features of the antenna contour at differing levels of detail.

[00129] Moreover, the three grids are selected to span a range of levels of scale corresponding to two octaves: A cell of grid size G_2 is half the size of a cell of grid G_1 (i.e., a $\frac{1}{2}$ scaling factor or an octave of scale); a cell of grid size G_3 is half the size of a cell of grid G_2 , or one fourth the size of a cell of grid G_1 (i.e., a $\frac{1}{4}$ scaling factor or two octaves of scale). A range of scales of two octaves provides a sufficient variation in the size of the cells across the three grids as to capture gradually from the coarser features of the antenna contour to the finer ones.

[00130] Grids G_1 and G_3 are constructed from grid G_2 , which needs to be defined in the first place.

[00131] As far as the second grid (or grid G_2) is concerned, the size of a cell and its aspect ratio (i.e., the ratio between the width and the height of the cells) are first chosen so that the antenna rectangle is perfectly tessellated with an odd number of columns and an odd number of rows.

[00132] In the present invention, columns of cells are associated with the longer side of an antenna rectangle, while rows of cells are associated with a shorter side of the antenna rectangle. In other words, a longer side of the antenna rectangle spans a number of columns, with the columns being parallel to the shorter side of the antenna rectangle. In the same way a shorter side of the antenna rectangle spans a number of rows, with the rows being parallel to the longer side of the antenna rectangle.

[00133] If the antenna rectangle is tessellated with an excessive number of columns, then the size of the resulting cells is much smaller than the range of typical sizes of the features necessary to shape the antenna contour. However, if the antenna rectangle is tessellated with an insufficient number of columns, then the size of the resulting cells is much larger than the range of typical sizes of the features necessary to shape the antenna contour. It has been found that setting to nine (9) the number of columns that tessellate the antenna rectangle provides an advantageous compromise, for the preferred sizes of an MFWD, and the corresponding available volumes for the antenna system, according to the present invention. Therefore, a cell width (W_2) is selected to be equal to a ninth ($1/9$) of the length of the longer side of the antenna rectangle (W).

[00134] Moreover, it is also advantageous to use cells that have an aspect ratio close to one. In other words, the number of columns and rows of cells of the second grid that tessellate the antenna rectangle are selected to produce a cell as square as possible. A grid formed by cells having an aspect ratio close to one is preferred in order to perceive features of the antenna contour using approximately a same level of scale along two orthogonal directions defined by the longer side and the shorter side of the antenna rectangle. Therefore, preferably, the cell height (H_2) is obtained by dividing the length of the shorter side of the antenna rectangle (H) by the odd integer number larger than one (1) and smaller than, or equal to, nine (9), that results in an aspect ratio W_2/H_2 closest to one.

[00135] In the particular case that two different combinations of a number of columns and rows of cells of the second grid produce a cell as square as possible, a second grid is selected such that the aspect ratio is larger than 1.

[00136] Thus, the antenna rectangle is tessellated perfectly with 9 by $(2n+1)$ cells of grid G_2 , wherein n is an integer larger than zero (0) and smaller than five (5).

[00137] A first grid (or grid G_1) is obtained by combining four (4) cells of the grid G_2 . Each cell of the grid G_1 consists of a 2-by-2 arrangement of cells of grid G_2 . Therefore, a cell of the grid G_1 has a cell width equal to twice (2) the width of a cell of the second grid (W_2) (i.e., $W_1=2 \times W_2$); and a cell height (H_1) equal to twice (2) the height of a cell of the second grid (H_2) (i.e., $H_1=2 \times H_2$).

[00138] Since grid G_2 tessellates perfectly the antenna rectangle with an odd number of columns and an odd number of rows, an additional row and an additional column of cells of said grid G_2 are necessary to have enough cells of the grid G_1 as to completely cover the antenna rectangle.

[00139] In order to uniquely define the tessellation of the antenna rectangle with grid G_1 a corner of said antenna rectangle is selected to start placing the cells of the grid G_1 .

[00140] A feeding point corner is defined as being the corner of the antenna rectangle closest to a feeding point of the antenna system responsible for the operation of the antenna system in its lowest frequency band. In case that the feeding point is placed at an equal distance from more than one corner of the antenna box, then the corner closest to a perimeter of the ground plane of the PCB of the MFWD 100 is selected, preferably the corner closest to a shorter edge of the ground-plane rectangle. In case both corners are placed at the same distance from the feeding point and from the shorter edge of the ground-plane rectangle, the feeding point corner will be chosen. For reasons of ergonomics and taking into account the absorption of radiation in the hand of the MFWD user, and considering that there is a predominance of right hand users, it has been observed that in some embodiments it is convenient to place a feeding point and/or to designate the feeding point corner on the corner of the antenna rectangle which is closer to a left corner of the ground plane rectangle. That is, the left side of the ground plane rectangle being the closest to the left side of the MFWD 100 as seen by a right-handed user typically holding the MFWD 100 with the right hand to originate a phone call, while facing a display of the MFWD 100. Also, the selection of the feeding point corner on the top or bottom corner on the left side of the MFWD 100 depends on the position of the antenna system with respect to a body of the MFWD 100. That is, an upper-left corner of the antenna rectangle is preferred in those cases in which the antenna system is placed substantially near the top part of the body of the MFWD (usually, above and/or behind a display) and a lower-left corner of the antenna rectangle is preferred in those cases in which the antenna system is placed substantially near the bottom part of the body of the MFWD 100 (usually, below and/or behind a keypad). Again, due to ergonomics reasons, a top and a bottom part of a body of a MFWD are defined as seen by a right-handed user

holding MFWD typically with the right hand to originate a phone call, while facing a display 501 as seen in Figures 5 (a) and 5 (b).

[00141] A first cell of the grid G_1 is then created by grouping four (4) cells of grid G_2 in such a manner that a corner of the first cell is the feeding point corner, and the first cell is positioned completely inside the antenna rectangle.

[00142] Once the first cell of the grid G_1 is placed, other cells of said grid G_1 can be placed uniquely defining the relative position of the grid G_1 with respect to the antenna rectangle. The antenna rectangle spans 5 by (n+1) cells of the grid G_1 , (when G_2 includes 9 columns) requiring the additional row and the additional column of cells of the grid G_2 that meet at the corner of the antenna rectangle that is opposite to the feeding point corner, and that are not included in the antenna rectangle.

[00143] The complexity factor F_{21} is computed by counting the number of cells N_1 of the grid G_1 that are at least partially inside the antenna rectangle and include at least a point of the antenna contour (in the present invention the boundary of the cell is also part of the cell), and the number of cells N_2 of the grid G_2 that are completely inside the antenna rectangle and include at least a point of the antenna contour, and then applying the following formula:

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log(\frac{1}{2})}$$

[00144] Complexity factor F_{21} is predominantly characterized by capturing the complexity and degree of convolution of features of the antenna contour that appear when the contour is viewed at coarser levels of scale. As it is illustrated in the example of Figures 8A-C, the election of grid G_1 801 and grid G_2 802, and the fact that with grid G_2 802 the antenna rectangle 800 is perfectly tessellated by an odd number of columns and an odd number of rows, results in a value of the factor F_{21} equal to one for an antenna contour shaped as the antenna rectangle 800. On the other hand, an antenna contour whose shape is inspired in a Hilbert curve that fills the antenna rectangle 800 features a value of the factor F_{21} smaller than two. Therefore the factor F_{21} is geared more towards assessing an overall complexity of an antenna contour (i.e., whether the degree of convolution of an antenna contour distinguishes sufficiently from a simple rectangular shape when looked at from a zoomed-out view), rather than estimating if the full complexity of an antenna contour (i.e., the complexity of the antenna contour when looked at from a zoomed-in view) approaches that of a highly-convoluted curve such as the Hilbert curve.

[00145] Moreover, in some embodiments the factor F_{21} is related to the number of paths that a structure of the antenna system provides to electric currents and/or the equivalent magnetic currents to excite radiation modes (i.e., factor F_{21} tends to increase with the number of antenna portions within the structure of the antenna system and/or the number of antenna elements that form the antenna system). In general, the more frequency bands and/or radiation modes that need to be supported by the antenna structure of the MFWD 100, the higher the value of the factor F_{21} that needs to be attained by the antenna contour of the antenna system of the MFWD 100.

[00146] A third grid (or grid G_3) is readily obtained by subdividing each cell of grid G_2 into four cells, with each of the cells having a cell width (W_3) equal to one half ($1/2$) of the width of a cell of the second grid (W_2) (i.e., $W_3=1/2 \times W_2$); and a cell height (H_3) equal to one half ($1/2$) of the height of a cell of the second grid (H_2) (i.e., $H_3=1/2 \times H_2$).

[00147] Therefore, since each cell of the grid G_2 is replaced with 2-by-2 cells of the grid G_3 , then 18 by $(4n+2)$ cells of grid G_3 are thus required to tessellate completely the antenna rectangle.

[00148] The complexity factor F_{32} is computed by counting the number of cells N_2 of grid G_2 that are completely inside the antenna rectangle and include at least a point of the antenna contour, and the number of cells N_3 of the grid G_3 that are completely inside the antenna rectangle and include at least a point of the antenna contour, and applying then the following formula:

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log(1/2)}$$

[00149] Complexity factor F_{32} is predominantly characterized by capturing the complexity and degree of convolution of features of the antenna contour that appear when the contour is viewed at finer levels of scale. As it is illustrated in the example of Figures 8A-C, the election of grid G_2 802 and grid G_3 803 is such that an antenna contour whose shape is inspired in a Hilbert curve that fills the antenna rectangle 800 features a value of the factor F_{32} equal to two. On the other hand, an antenna contour shaped as the antenna rectangle 800 features a value of the factor F_{32} larger than one. Therefore the factor F_{32} is geared more towards evaluating the full complexity of an antenna contour (i.e., whether the degree of convolution of an antenna contour tends to approach that of a highly-convoluted curve such as the Hilbert curve), rather than discerning if said antenna contour is substantially different from a rectangular shape.

[00150] Moreover, the factor F_{32} is in some embodiments related to the degree of miniaturization achieved by the antenna system. In general, the smaller the antenna box of the MFWD 100, the higher the value of the factor F_{32} that needs to be attained by the antenna contour of the antenna system of the MFWD 100.

[00151] The complexity factors F_{21} and F_{32} span a two-dimensional space on which the antenna contour of the antenna system of the MFWD 100 is mapped as a single point with coordinates (F_{21}, F_{32}) . Such a mapping can be advantageously used to guide the design of the antenna system by tailoring the degree of convolution of the antenna contour until some preferred values of the factors F_{21} and F_{32} are attained, so that the resulting antenna system: (a) provides the required number of frequency bands in which the MFWD operates; (b) meets MFWD size and/or integration constraints; and/or (c) enhances the RF performance of the antenna system and/or that of the MFWD in at least one of the frequency bands of operation.

[00152] In a preferred embodiment of the present invention, the MFWD 100 comprises an antenna system whose antenna contour features a complexity factor F_{21} larger than one and a complexity factor F_{32} larger than one. In a preferred embodiment, the MFWD 100 comprises an antenna system whose antenna contour features a complexity factor F_{21} larger than or equal to 1.1 and a complexity factor F_{32} larger than or equal to 1.1.

[00153] In some examples the antenna contour features a complexity factor F_{32} larger than a certain minimum value in order to achieve some degree of miniaturization.

[00154] An antenna contour with a complexity factor F_{32} approximately equal to two, despite achieving substantial size reduction, may not be preferred for the MFWD 100 of the present invention as the antenna system is likely to have reduced capability to operate in multiple frequency bands and/or limited RF performance. Therefore in some examples of embodiments of the present invention the antenna contour features a complexity factor F_{32} smaller than a certain maximum value in order to achieve enhanced RF performance.

[00155] In some cases of embodiments of the present invention the antenna contour features a complexity factor F_{32} larger than said minimum value but smaller than said maximum value.

[00156] Said minimum and maximum values for the complexity factor F_{32} can be selected from the list of values comprising: 1.10, 1.15, 1.20, 1.25, 1.30, 1.35, 1.40, 1.45, 1.50, 1.55, 1.60, 1.65, 1.70, 1.75, 1.80, 1.85, and 1.90.

[00157] Similarly, in some examples an antenna contour advantageously features a complexity factor F_{21} larger than a lower bound and/or smaller than an upper bound. The lower and upper bounds for the complexity factor F_{21} can be selected from the list of

comprising: 1.05, 1.10, 1.15, 1.20, 1.25, 1.30, 1.35, 1.40, 1.45, 1.50, 1.55, 1.60, 1.65, 1.70, 1.75, and 1.80.

[00158] The complexity factors F_{21} and F_{32} have turned out to be relevant parameters that allow for an effective antenna design. Evaluation of those parameters give good hints on possible changes of antennas in order to obtain improved antennas.

[00159] In some cases the parameters F_{21} and F_{32} allow for easy identification of unsuitable antennas. Further those parameters may also be used in numerical optimization algorithms as target values or to define target intervals in order to speed up such algorithms.

[00160] In the following paragraphs some parameter ranges for F_{21} and F_{32} which have turned out to be particularly advantageous or useful are summarized.

[00161] It has been found that for MFWDs it is particularly useful to have a value of F_{21} larger than 1.43, 1.45, 1.47 or even preferably greater than 1.50. Such values in this complexity factor translate into a richer frequency response of the antenna which allows for more possible resonant frequencies and more frequency bands with better bandwidths or a combination of those effects.

[00162] Furthermore, for SMRT or MMT, design demands may be different since those devices are usually larger and a reduction of the antenna size is not of such utmost importance, but energy consumption may be important since those devices have to operate to provide many different functionalities. For those devices a complexity factor F_{21} of only more than 1.39, preferably 1.41 or most preferred more than 1.43 turns out to be advantageous.

[00163] For clamshell, twist or slider devices it has to be taken into account that those phones consist of at least two parts which may be moved relative to each other. As a result only a small amount of space is available for the phones and hence, a value of F_{21} of more than 1.43, 1.45, 1.47, or even more preferably greater than 1.50 is advantageous. The same applies to slim devices. For those devices, where there is the requirement of the antenna to be flat, a value of F_{21} greater than the above-mentioned limits provides sufficient possibilities for fringing electromagnetic fields to escape from the area below a patch such that the patch achieves a higher bandwidth and a higher gain. The antenna in case of clamshell, twist or slider devices does not necessarily have to become a patch or patch-like antenna.

[00164] For some MFWDs it is usually not possible to allocate a certain volume of space which is only available for the antenna. It may, for example, be necessary to fit an antenna around one, two or more openings in which a camera, a speaker, RF connectors, digital connectors, speaker connectors, power connectors, infrared ports and/or mechanical

elements such as screws, plastic insets, posts or clips have to be provided. The respective opening(s) can be achieved by a certain value F_{21} which is higher than 1.38, 1.40, or 1.42, or more preferably greater than 1.45 or 1.50. It turns out that with such values for F_{21} it is possible to provide sufficient opening in order to insert other components.

[00165] For those antennas which in their physical properties come quite close to patch antennas namely those with an overlap between the antenna and the ground-plane (patch-like antennas), a value of F_{21} being higher than 1.45, 1.47, 1.50, or 1.60 turns out to be a good measure for an antenna to provide an expected improved bandwidth or gain with respect to a patch antenna without any complexity in at least one of the frequency bands. This region for F_{21} further turns out to be useful for an MFWD with two or more RF transceivers. With a lower value it will be difficult to sufficiently isolate the two RF transceivers against each other. By the complexity factor F_{21} being more than 1.45, 1.47 or 1.50 the two RF transceivers can be electrically separated sufficiently, e.g. by connecting them to two antenna portions which are not in direct electrical contact.

[00166] The last mentioned range is also equally suitable for a MFWD with two, three or more antenna elements. Those elements may be convoluted into each other in order to occupy less space which translates into a high value of F_{21} .

[00167] A MFWD with an antenna with a complexity factor of F_{32} being larger than 1.55, 1.57 or 1.60 is advantageous. Such a high value of F_{32} provides an additional factor for tuning the frequency of high frequency bands without changing the gross geometry for low frequency bands. For this range of F_{32} it turns out that the parameter F_{21} being lower than 1.41, 1.39, 1.37, or 1.35 is advantageous since for a high value of F_{32} which provides some miniaturization, F_{21} may be low in particular to avoid an antenna with too many separate portions or antenna arms since such independent portions are difficult to physically secure with a device in order to achieve proper mechanical robustness.

[00168] For a SMRT or MMT device a value of F_{32} being larger than 1.50, 1.52, 1.55 or 1.60 is desirable. The phones which usually operate in high frequency bands such as UMTS and/or a wireless connectivity at a frequency of around 2.4 GHz a higher value of F_{32} can be used to appropriately adapt the antenna to a desired resonance frequency and/or bandwidth in those bands.

[00169] For slim devices (thickness less than 14mm, 13mm, 12mm, 11mm, 10 mm, 9mm or 8mm) it turns out that a parameter of F_{32} being larger than 1.60, 1.62 or 1.65 may be desired in order to achieve an edge rich structure that reduces the problems of certain antenna structures, such as flat patch antennas. A high value of F_{32} may lead to an increased

bandwidth which is useful in certain cases such as coverage of the UMTS band. For the same reasons, in some embodiments of MFWD and particularly in slim devices, it is preferred that the intersection of the projection of the antenna rectangle 110 onto the ground plane rectangle 202 is less than 90% of the area of said antenna rectangle. In particular, such a intersection should be in some cases below 80%, 70%, 50%, 30%, 20% or 10% of said area. Such values for the intersection may be given also for devices which are not considered slim.

[00170] For clamshell, twist or slider devices, even higher values of F_{32} such as higher than 1.63, 1.65, 1.68 or 1.70 may be necessary since in those MFWDs the antennas have to be even more flat.

[00171] MFWDs which have a camera or any other item such as a connector integrated in the antenna box it is desirable to have a value of F_{32} being larger than 1.56, 1.58, 1.60 or 1.63. For those devices it turns out that the mechanical fixing of the antenna may be difficult due to other items which are within the antenna box. With a high value of F_{32} being more than 1.55, or the other values mentioned above, the antenna usually has an edge or recess rich structure that facilitates fixing of the antenna at its border. Therefore, usually there is no problem in mechanically securing an antenna with a high value of F_{32} within a wireless device.

[00172] For antennas which are overlapping with the ground plane of a PCB of the MFWD with at least 50% or 100%, it is possible to achieve appropriate antenna performance even if the value of F_{21} is smaller than e.g. 1.42, 1.40 or 1.38 in cases that the complexity factor F_{32} is more than 1.55. Such edges, curves or steps in the border which lead to a high value of F_{32} , increase efficiency and gain since they lead to strong reorientations of current. This may compensate for lower values of F_{21} , in particular for antennas of patch-like geometry (i.e. those where the antenna overlaps 100% with the ground plane of a PCB of the MFWD).

[00173] Equally for MFWDs with two or more RF transceivers, efficient antennas are possible for values of F_{21} being lower than 1.40, 1.38 or 1.35 in cases that the complexity factor F_{32} is larger than 1.50, 1.52, 1.53, 1.57 or 1.60. Appropriate separation of the two RF transceivers is difficult with a low value of F_{21} . It may still be possible, however, with a high complexity value of F_{32} , which enables some kind of compensation for a low value of F_{21} .

[00174] In some embodiments, when a high level of complexity is sought it might be necessary to design an antenna system whose structure comprises 2, 3 or more antenna elements. Such complexity may be achieved at a coarser and/or finer level of detail. When a high level of complexity is sought in a coarser level of detail, a high value of F_{21} might be

required, namely more than 1.43, 1.45, 1.47, or 1.50. When a high level of complexity is sought in a finer level of detail, a high value of F_{32} might be required, namely more than 1.61, 1.63, 1.65 or 1.70.

[00175] Furthermore, it turns out that for some MFWDs with three or more antenna elements, a value of F_{21} lower than 1.36, 1.34, 1.32, 1.30, or even less than 1.25 is advantageous. In these cases the use of an additional antenna element pursues the enhancement of the radio electric performance of the antenna system in at least one of the frequency bands rather than introducing an additional frequency band disjoined from those already supported by the antenna system. For the above mentioned reason it may be advantageous to keep the value of F_{21} below a certain maximum. That can be achieved by reducing the separation of the third or additional antenna elements with respect to the antenna elements already present in the structure of the antenna system, so that the gaps between those antenna elements are not fully observed at a coarser level of detail. Therefore, for MFWDs with three or more antenna elements, lower values of F_{21} may be preferred in certain cases. Additionally, the separation of the antenna system into three or more antenna elements allows for easier adaptation of each antenna element to space requirements within the MFWD such that miniaturization is not such an issue. Therefore, it is possible to have antennas with larger dimensions which then provide for improved radiation efficiency, higher gain and also simply easier design and hence, less costly antennas.

[00176] With MFWDs, in general, it turns out to be particularly useful to have a value of F_{21} greater than 1.42, 1.44, 1.46, 1.48 or 1.50 while at the same time having a value of F_{32} being lower than 1.44, 1.42, 1.40 or 1.38. This is because for the portion of the antenna that resonates at low frequencies (which means long wavelengths, and hence, a long antenna portion), higher miniaturization is required. This miniaturization of large-scale portions translates into a high value of F_{21} and vice versa. For higher frequencies which have smaller wavelengths, there is not such a strong requirement for miniaturization but, rather an enhanced bandwidth is desired. Therefore lower values of F_{32} may be preferred. Low values of F_{32} further allow for maximum efficiency since those antennas do not need to be extremely miniaturized.

[00177] It is particularly useful to use a parameter range of F_{21} being more than 1.32, 1.34 or 1.36 and less than 1.54, 1.52 or 1.50 while at the same time F_{32} is less than 1.44, 1.42 or 1.40 and more than 1.22, 1.24 or 1.26. In this parameter range the values of F_{21} and F_{32} assume intermediate values which give the possibility of having different design parameters such as smallness, multi-band and broadband operation, as well as an appropriate antenna

gain and efficiency to be taken into account equally. This parameter range is particularly useful for MFWDs where there is no single or no two design parameters which are of outstanding importance.

[00178] Another useful parameter range is given by F_{21} being less than 1.32, 1.30 or 1.28 with a value of F_{32} being less than 1.54, 1.52 or 1.50 and at the same time being greater than 1.34, 1.36 or 1.38. This parameter range is useful for MFWDs where the robustness of the device is of outstanding importance since a low value of F_{21} leads to devices with a particularly simple geometry without having many highly diffracted portions which are difficult to mechanically secure individually within a device. In order to achieve some miniaturization, however, a value of F_{32} in the indicated range is preferred when taking into account the trade off between the disadvantages of too high values of F_{32} (in terms of too strong miniaturization which leads to a poor bandwidth) while on the other hand wanting to have at least some kind of miniaturization corresponding to F_{32} being above a lower limit.

[00179] For some MFWDs it may be desirable to have the value of F_{32} being less than 1.52, 1.50, 1.48, or 1.45. It was found that antenna elements with highly complex borders are often quite difficult to manufacture and assemble. For instance stamping tools require more resolution and wear out more easily in case of complex borders (which means high value of F_{32}) which translates into higher manufacturing costs (tooling manufacturing costs, tool maintenance cost, larger number of hits per piece of the stamping tool) and delivery lead times, particularly for large volume production.

[00180] This turns out to be important for large volume devices such as slim phones where mass production is common. High volume puts extreme pressure on manufacturing costs, time to market and production volumes.

[00181] Additionally, shapes with high factors of F_{32} are very complicated to model with appropriate CAD tools as the very complicated shapes turn out to consume a lot of computing time. This increases development costs which in turn increases total costs of such an antenna design.

[00182] Equally, for clamshell, twist or slider phones (which may have a major portion of the market share where mass manufacturing is carried out), it may be desirable to have a value of F_{32} being less than 1.30, 1.28 or 1.26.

[00183] For relatively low cost and robust antenna design, it is preferable to have the value of F_{21} being more than 1.15 or 1.17 and at the same time being less than 1.40, 1.38 or 1.36 while the value of F_{32} is less than 1.30, 1.28 and more than 1.15 or 1.17.

[00184] Additionally, it is advantageous to have a SMRT or a MMT device which is of the type twist, or clamshell.

[00185] For a MFWD which is slim (which here means it has a thickness of less than on the order of 14 mm) and is of the type clamshell, twist or slider the flatness requirement is very demanding because each of the parts forming the clamshell, twist or slider may only have a maximum thickness of 5, 6, 7, 8 or 9 mm. With the technology disclosed herein, it is possible to design flat antennas even for such MFWDs.

[00186] A MFWD incorporating 3.5G or 4G features (i.e. comprising 3G and other advanced services such as for instance HSDPA, WiBro, WiFi, WiMAX, UWB or other high-speed wireless standards, hereinafter 4G services) might require operation in additional frequency bands corresponding to said 4G standards (for instance, bands within the frequency region 2-11 GHz and some of its sub-regions such as for instance 2-11 GHz, 3-10 GHz, 2.4-2.5 GHz and 5-6 GHz or some other bands). In some cases, to achieve a maximum volume compactness it would be advantageous that the same antenna system is capable of supporting the radiation modes corresponding to the additional frequency bands. Nevertheless, this approach can be inconvenient as it will increase complexity to the RF circuitry of the MFWD 100, for example by filters to separate the frequency bands of the 4G services from the frequency bands of the rest of services. Therefore it may be advantageous to have a dedicated antenna for 4G services although inside the antenna box.

[00187] In other cases, achieving good isolation between the frequency bands of the 4G services and the frequency bands of the rest of services (3G and below) is preferred to compactness. In those cases the 4G antenna (i.e. the one or more additional antenna covering one or more of the 4G services) will preferably be separated as much as possible from the antenna box. Generally the longer side of the antenna rectangle is placed alongside a short edge of the ground plane rectangle. In some cases it would be advantageous to place the 4G antenna substantially close to the edge that is opposite to the shorter edge. In other cases it would be advantageous to place the 4G antenna substantially close to an edge that is adjacent to the shorter edge. Therefore since the MFWDs physical dimensions are usually predefined, the separation between antennas can be further increased by reducing the shorter side of the antenna rectangle and thus increasing its aspect ratio. As a consequence, for those devices, it may be desirable to have a value of F_{32} higher than 1.35, 1.50, 1.60, 1.65 or 1.75. When the complexity factor F_{21} is in the lower half of the typical range, for example when F_{21} is smaller than 1.40, it may be advantageous to have a value of F_{32} higher than 1.35. On the other hand when the complexity factor F_{21} is in the upper half of its typical range, for

example when F_{21} is larger than 1.45, it may be advantageous to have a value of F_{32} higher than a minimum value that can be selected from the list of values comprising: 1.10, 1.15, 1.20, 1.25, 1.30, 1.35, 1.40, 1.45, 1.50, 1.55, 1.60, 1.65, 1.70, 1.75, 1.80, 1.85, and 1.90.

[00188] Advantageously MFWD including 4G services may have two or more dedicated antennas for the 4G services forming an antenna diversity arrangement. In those cases not only is good isolation between the antenna system and the antennas for the 4G services required but also good isolation between the two or more antennas forming the antenna diversity arrangement.

[00189] One, two or more 4G antennas may be IFA-antennas and they may be located outside of the ground plane rectangle. They may be located next to the ground plane. One, two or more 4G antennas may be slot antennas, preferably within the ground plane.

[00190] Typically the number of contacts in an antenna system is proportional to the number of RF transceivers coupled to the antenna system and to the number of antenna elements comprised in the structure of the antenna system. Each RF transceiver drives an antenna element through typically one contact. Additionally each of the antenna elements may have a second contact for grounding purposes. Parasitic antenna elements typically comprise a contact terminal used for grounding purposes.

[00191] In some examples, the MFWD integrates an antenna system in such a way that the antenna rectangle of the antenna system is at least partially (such as for instance at least a 10%, 20%, 30%, 40%, 50% or even 60%) or completely on the projection of the ground plane rectangle of said MFWD. In some other examples, the antenna rectangle is completely outside of the projection of the ground plane rectangle of said MFWD.

[00192] In other examples in which the antenna rectangle of an antenna system is in the projection of the ground plane rectangle of a MFWD in an area of less than 10%, 20% or 30% of the antenna rectangle, the antenna contour of the antenna system preferably features a complexity factor F_{21} larger than 1.20, 1.30, 1.40 or 1.50. In still other examples in which the antenna rectangle of an antenna system is in the projection of the ground plane rectangle of a MFWD in an area larger than 80%, 90% or 95% of said antenna rectangle, the antenna contour of the antenna system preferably features a complexity factor F_{21} smaller 1.30, 1.35, 1.40 or 1.45.

[00193] Another aspect of the integration of an antenna system within a MFWD is the positioning of the antenna system with respect to the one or more bodies comprised in the MFWD.

[00194] An antenna system can be integrated either in the top part of the body of a MFWD (usually, above and/or behind a display), or in the bottom part of a body of the MFWD (usually, below and/or behind a keypad).

[00195] In some examples, an antenna system integrated within the bottom part of a body of a MFWD features advantageously an antenna contour with a complexity factor F_{21} smaller than 1.45 and a complexity factor F_{32} smaller than 1.50, since generally there is quite a bit more space available in such a part of the device. In some other examples, the antenna contour preferably features a factor F_{21} larger than 1.45 and/or a factor F_{32} larger than 1.75.

[00196] In some examples, an antenna system integrated on the top part of the body of a MFWD advantageously features an antenna contour with a complexity factor F_{21} smaller than 1.30, 1.25, or 1.20. In some other examples, the antenna contour preferably features a factor F_{21} larger than 1.45, 1.50 or 1.55.

[00197] In some cases, a two-body MFWD (such as for instance a clamshell or a flip-phone, a twist device, or a slider device) integrates the antenna system in the vicinity of the hinge that allows rotation of at least one of the two bodies. In such cases, the antenna contour of the antenna system preferably features a complexity factor F_{21} larger than 1.20 and/or a complexity factor F_{32} larger than or equal to 1.55.

[00198] Further of advantage for a general trade off between multiple parameters are values of a complexity factor of F_{21} being more than 1.52 and less than 1.65 and/or a complexity factor F_{32} being more than 1.55 and less than 1.70.

Illustration Examples

[00199] Referring now to Figure 1B, there is shown a perspective view of a MFWD 100 comprising, in this particular example, only one body. A volume of space 101 within the MFWD 100 is made available for the integration of an antenna system. The MFWD 100 also comprises a multilayer PCB that includes feeding means and/or grounding means. A layer 102 of the PCB serves as a ground plane of the antenna system.

[00200] An antenna box 103 is obtained as a minimum-sized parallelepiped that completely encloses the volume 101. In this example, the antenna box 103 has rectangular faces 104–109. According to the present invention as described above, the structure of the antenna system comes into contact with each of the six (6) faces of the antenna box 104–109 in at least one point of each face. Moreover, the antenna system of MFWD 100 has no portion that extends outside the antenna box 103.

[00201] An antenna rectangle 110 is obtained as the orthogonal projection of the antenna box 103 along the normal to the face with largest area, which in this case is the direction normal to faces 104 and 105.

[00202] Referring now to Figure 2A, there is shown a top plan view of the MFWD 100. For the sake of clarity, the volume of space 101 has been omitted in figure 2A. A ground plane rectangle 200 is adjusted around the layer 102 that serves as a ground plane to the antenna system of the MFWD 100. The ground plane rectangle 200 is the minimum-sized rectangle in which each of its edges is tangent to at least one point of the perimeter of layer 102.

[00203] Figure 2B depicts the relative position of the ground plane rectangle 200 and the antenna rectangle 110 for the MFWD 100 of Figure 1A. The antenna rectangle 110 has a long side 203 and a short side 204. The ground plane rectangle 110 has a long edge 202 and a short edge 201.

[00204] In this particular example, the antenna rectangle 110 and the ground plane rectangle 200 lie substantially on a same plane (i.e., the antenna rectangle 110 and the ground plane rectangle 200 are substantially coplanar). Furthermore, a long side 203 of the antenna rectangle 110 is substantially parallel to a short edge 201 of the ground plane rectangle 200, while in some other embodiments it will be substantially parallel to a long edge 202 of the ground plane rectangle 200.

[00205] In this example, the antenna rectangle 110 is partially overlapping the ground plane rectangle 200. Although in other cases, they can be completely overlapping or completely non-overlapping. Moreover, in this example the placement of the antenna rectangle 110 is not symmetrical with respect to an axis of symmetry that is parallel to the long edge 202 of the ground plane rectangle 200 and that passes by the middle point of the short edge 201 of said ground plane rectangle 200. In other words, the antenna rectangle 110 is shifted slightly to the left as seen in this view.

[00206] Figure 3 shows an example of a structure of an antenna system contained within an antenna box 301. In this particular example, the structure comprises only one antenna element 300. The antenna element 300 has been shaped to be able to support different radiation modes, in order that the resulting antenna system can operate in multiple frequency bands. In particular, two apertures 302 and 303 with closed perimeters have been created in the antenna element 300. Additionally, the antenna element 300 also features an opening 304 that increases the number of segments that form the perimeter of the antenna element 300. The antenna element 300 also includes two parts 305 and 306 that are bent 90°

with respect to the rest of the antenna element 300, but are fully contained in the antenna box 301.

[00207] The bottom part of Figure 3 shows an antenna rectangle 351 associated with the antenna box 301. The antenna rectangle 351 contains the antenna contour 350 associated with the antenna element 300.

[00208] The antenna contour 350 comprises three disjointed subsets of segments: (a) a first subset is formed by the segments of the perimeter 357 (which includes both external segments of the antenna element 300 and those segments added to said antenna element by the opening 304) and the group of segments 356 corresponding to the orthogonal projection of part 306 of the antenna element 300; (b) a second subset is formed by the segments 352 associated to the perimeter of aperture 302; and (c) a third subset is formed by the segments 353 associated to the perimeter of aperture 303.

[00209] Note that in this example, part 305 of the antenna element 300 has an orthogonal projection that completely matches a segment of the perimeter 357, and therefore does not increase the number of segments of the antenna contour 350.

[00210] Referring now to Figure 4 there is shown how the structure of an antenna system such as the one presented in Figure 3 can be obtained by appropriately shaping a rectangular conducting plate 400. The structure in Figure 4 can be seen to have been formed in three steps (top to down) in a manufacturing process of antenna system by means of, for instance, a stamping process.

[00211] The top part of Figure 4 shows the plate 400 occupying (and extending beyond) the antenna rectangle 351 (represented as a dash-dot line). The cut out lines that delimit those parts of the conducting plate 400 that will be removed are depicted as dashed lines. A peripheral part of the plate 400 will be removed, as indicated by the outline 401. Additionally, two closed apertures will be created as defined by outline 402 and outline 403.

[00212] The middle part of Figure 4 shows a planar structure 430 resulting after eliminating the parts of plate 400 that will not be used to create the antenna system. In the planar structure 430, two closed apertures 302 and 303, and an opening 304 can be identified.

[00213] The planar structure 430 has a first part 405, and a second part 406, that extend beyond the antenna rectangle 351. The first and second parts 405 and 406 are bent or folded so that their orthogonal projection does not extend outside the antenna rectangle 351.

[00214] The bottom part of Figure 4 shows the antenna element 300 obtained from the planar structure 430. The antenna element 300 is a three-dimensional structure that fits within the antenna box 301 (also depicted as a dash-dot line). The first part of the planar

structure 405 is bent 90 degrees downwards (in the direction indicated by arrow 431) to become part 305 of the antenna element 300. The second part of the planar structure 406 is folded twice to become part 306 of said antenna element 300. The second part 406 is rotated a first time 90 degrees downwards (as indicated by the arrow 432), and then at another point along the second part 406 rotated a second time 90 degrees leftwards (as indicated by the arrow 433).

[00215] Referring now to Figure 5A-B there is shown a MFWD 500 consisting of a single body being typically held by a right-handed user to originate a phone call while facing a display 501 of the MFWD 500. The MFWD 500 comprises an antenna system and a PCB that includes a layer that serves as a ground plane of the antenna system 502 (depicted in dashed line). The antenna system is arranged inside an antenna box, whose antenna rectangle 503, 504 is depicted also in dashed line. The antenna rectangle 503, 504 is in the projection of the ground plane layer 502. In the case of Figure 5A, the antenna rectangle 503 is placed substantially in the top part of the body of the MFWD 500 (i.e., above and/or behind a display 501), while in Figure 5B the antenna rectangle 504 is placed substantially in the bottom part of the body of the MFWD 500 (i.e., below and/or behind a keypad).

[00216] For reasons of ergonomics, it is advantageous in the examples of Figure 5 to select a corner of the antenna rectangle close to the left edge of the MFWD 500. The upper left corner of the antenna rectangle 505 is selected as the feeding point corner in the case of Figure 5A, while the lower left corner of the antenna rectangle 506 is selected as the feeding point corner in the case of Figure 5B. In these two examples the corners designated as feeding point corners 505, 506 are also substantially close to a short edge of a ground plane rectangle (not depicted in Figure 5) that encloses the ground plane layer 502.

[00217] Figure 5C illustrates an alternate embodiment of a MFWD 500 having a clamshell-type configuration. The MFWD 500 includes a lower circuit board 522, an upper circuit board 524, and an antenna system. The antenna system is arranged inside an antenna box, whose antenna rectangle 523 is depicted also in dashed line. The antenna rectangle 523 is secured to a mounting structure 526. Figure 5C further illustrates an upper housing 528, a lower housing 530 that join to enclose the circuit boards 522, 524 and the antenna rectangle 523. The lower circuit board includes a ground plane 532, a feeding point 534, and communications circuitry 536. The antenna rectangle 523 is secured to a mounting structure 526 and coupled to the lower circuit board 522. The lower circuit board 522 is then connected to the upper circuit board 524 with a hinge 538, enabling the lower circuit board 522 and the upper circuit board 524 to be folded together in a manner typical for clamshell-

type phones. In some embodiments, the hinge 538 may be adapted to provide rotation of the upper circuit board 524 with respect to the lower circuit board 522 around two or more, preferably non-parallel, axes of rotation, resulting in a MFWD 500 having a twist-type configuration. In order to reduce electromagnetic interference from the circuit boards 522, 524, the antenna rectangle 523 is preferably mounted on the lower circuit board 522 adjacent to the hinge 538.

[00218] Figure 6A-6C represents, respectively examples of a first grid 601, a second grid 602 and a third grid 603 used for the computation of the complexity factors F_{21} and F_{32} of an antenna contour that fits in an antenna rectangle 600. The antenna rectangle 600 has a long side 603 and a short side 604.

[00219] In Figure 6B, the second grid 602 has been adjusted to the size of the antenna rectangle 600. The long side of the antenna rectangle 603 is fitted with nine (9) columns of cells of the second grid 602. As far as the number of rows is concerned, the aspect ratio of the antenna rectangle 600 in this particular example is such that a cell aspect ratio closest to one is obtained when the short side of the antenna rectangle 604 is fitted with five (5) rows of cells of the second grid. Therefore, the antenna rectangle 600 is perfectly tessellated with 9 by 5 cells of the second grid 602.

[00220] Figure 6A shows a possible first grid 601 obtained from grouping 2-by-2 cells of the second grid 602. In this example, the upper left corner of the antenna rectangle 600 is selected as the feeding point corner 605. A first cell of the first grid 601 is placed such that the cell 606 has a corner designated as the feeding point corner 605 and is completely inside the antenna box 600. In the example of Figure 6A, the antenna rectangle 600 spans five (5) columns and three (3) rows of cells of the first grid 601.

[00221] Since the antenna rectangle 600 is tessellated with an odd number of columns and rows of cells of the second grid. An additional column 608 and an additional row 609 of cells of the second grid 602 are necessary to have enough cells of the first grid 601 to completely cover the antenna rectangle 600. The additional column 608 and additional row 609 meet at the lower right corner of the antenna rectangle 607 (i.e., the corner opposite to the feeding point corner 605).

[00222] Figure 6C shows the third grid 603 obtained from dividing each cell of the second grid 602 into four (4) cells. Each cell of the third grid 603 has a cell width and cell height equal a half of the cell width and cell height of a cell of the second grid 602. Thus, in this example the antenna rectangle 600 is perfectly tessellated with eighteen (18) columns and ten (10) rows of cells of the third grid 603.

[00223] Referring now to Figure 7 there is shown a graphical representation of the two-dimensional space 700 defined by the complexity factors F_{21} and F_{32} for an illustrative antenna (not shown). The antenna contour of the illustrative antenna system of a MFW is represented as a bullet 701 of coordinates (F_{21} , F_{32}) in the two-dimensional space 700.

[00224] Figures 8A-8C provide examples to illustrate the complexity factors that feature two radically different antennas: (1) A solid planar rectangular antenna that occupies the entire area of an antenna rectangle 800 for a MFW (not specifically shown); and (2) an antenna whose contour is inspired in a Hilbert curve 810 that fills the available space within the antenna rectangle 800 (the antenna structure shown in the rectangle 800 of each of Figures 8A-8C). These two antenna examples, although not advantageous to provide the multiple frequency band behavior required for the antenna system of a MFW, help to show the relevance and characteristics of the two complexity factors F_{21} and F_{32} .

[00225] Figures 8A-8C show antenna 810 inside the antenna rectangle 800 under a first grid 801, a second grid 802, and a third grid 803. In this example, the antenna rectangle 800 is perfectly tessellated with nine (9) columns and five (5) rows of cells of said second grid 802 (Figure 8b). The antenna 810 has a feeding point 811, located substantially close to the lower left corner of the antenna rectangle 805 (being thus the feeding point corner).

[00226] In Figure 8A, there are fifteen (15) cells of the first grid 801 at least partially inside the antenna rectangle 800 and that include at least a point of the antenna contour of antenna 810 (i.e., $N_1=15$). In Figure 8B, there are forty-five (45) cells of the second grid 802 completely inside the antenna rectangle 800 and that include at least a point of the antenna contour of the antenna 810 (i.e., $N_2=45$). Finally in Figure 8C, there are one hundred eighty (180) cells of the third grid 803 completely inside the antenna rectangle 800 and that include at least a point of the antenna contour of the antenna 810 (i.e., $N_3=180$). Therefore, in the present example, an antenna whose contour is inspired in the Hilbert curve 810 shown within the antenna space 800 of Figures 8A-8C features $F_{21}=1.58$ (i.e., smaller than 2.00) and $F_{32}=2.00$.

[00227] On the other hand if the process of counting the cells in each of the three grids is repeated for a planar rectangular antenna whose contour fills the entire rectangular space of the antenna rectangle 800 (not actually shown) then $N_1=12$, $N_2=24$ and $N_3=52$, which results in $F_{21}=1.00$ and $F_{32}=1.12$ (i.e., larger than 1.00).

[00228] These results illustrate that complexity factor F_{21} is geared more towards discerning if the antenna contour of a particular antenna system distinguishes sufficiently from a simple planar rectangular antenna rather than capturing the complete intricacy of said

antenna contour, while complexity factor F_{32} is predominantly directed towards capturing whether the degree of complexity of the antenna contour approaches to that of a highly-convoluted curve such as a Hilbert curve.

[00229] Figures 9A-9C and 10A-10C provide two examples illustrating the complexity factors that characterize a quasi-rectangular antenna 910 having a highly convoluted perimeter and a triple branch antenna 1010, respectively. These two exemplary antennas help to show the relevance of the two complexity factors.

[00230] Figures 9A-9C show, respectively, the antenna 910 inside an antenna rectangle 900 under a first grid 901, a second grid 902, and a third grid 903. In this example, the antenna rectangle 900 is perfectly tessellated with nine (9) columns and five (5) rows of cells of said second grid 902 (Figure 9b). The antenna 910 has a feeding point 911, located substantially close to the upper left corner of the antenna rectangle 905 (being thus the feeding point corner).

[00231] In Figure 9A, there are twelve (12) cells of the first grid 901 at least partially inside the antenna rectangle 900 and that include at least a point of the antenna contour of antenna 910 (i.e., $N_1=12$). In Figure 9B, there are twenty-four (24) cells of the second grid 902 completely inside the antenna rectangle 900 and that include at least a point of the antenna contour of the antenna 910 (i.e., $N_2=24$). Finally in Figure 9C, there are ninety-six (96) cells of the third grid 903 completely inside the antenna rectangle 900 and that include at least a point of the antenna contour of the antenna 910 (i.e., $N_3=96$). Therefore, in the present example, a quasi-rectangular antenna 910 having a highly convoluted perimeter features $F_{21}=1.00$ and $F_{32}=2.00$. This antenna example appears on a coarse scale (as probed e.g. by a long wavelength resonance) quite similar to a simple planar rectangular antenna which is also shown by F_{21} being very low. On the other hand the edge is highly convoluted which will have influence on small wavelength resonances. This feature is characterized by a high value of F_{32} .

[00232] Figures 10A-C show, respectively, antenna 1010 inside the antenna rectangle 1000 under a first grid 1001, a second grid 1002, and a third grid 1003. In this example, the antenna rectangle 1000 is perfectly tessellated with nine (9) columns and five (5) rows of cells of said second grid 1002 (Figure 10b). The antenna 1010 has a feeding point 1011, located substantially close to the bottom left corner of the antenna rectangle 1005 (being thus the feeding point corner).

[00233] As for the antenna 1010 as shown in Figure 10A, there are ten (10) cells of the first grid 1001 at least partially inside the antenna rectangle 1000 and that include at least a

point of the antenna contour of antenna 1010 (i.e., $N_1=10$). In Figure 10B, there are thirty-four (34) cells of the second grid 1002 completely inside the antenna rectangle 1000 and that include at least a point of the antenna contour of the antenna 1010 (i.e., $N_2=34$). Finally in Figure 10C, there are seventy (70) cells of the third grid 1003 completely inside the antenna rectangle 1000 and that include at least a point of the antenna contour of the antenna 1010 (i.e., $N_3=70$). Therefore, in the present example, a triple branch antenna, similar to an asymmetric fork, features $F_{21}=1.77$ and $F_{32}=1.04$. In this fork example the antenna is not miniaturized since the three branches are essentially straight. This configuration corresponds to a low value of F_{32} . The fork, however is substantially different from a rectangle in that the three branches can be identified clearly and performance of the calculations in accordance with the principles of the invention yields a high value of F_{21} .

[00234] Figure 11 is a graphical presentation that maps the values of the complexity factors F_{21} and F_{32} of the exemplary antennas of figures 6, 8, 9, and 10. In Figure 11 the horizontal axis represents increasing values of F_{21} while the vertical axis represents increasing values of F_{32} . The exemplary simple planar, rectangular antenna discussed above in connection with Figure 6, occupies the entire area of an antenna rectangle 800 and is characterized by a pair of complexity factors $F_{21}=1.00$ and $F_{32}=1.12$ that are mapped as bullet 1102 in Figure 11. The complexity factors for the antenna whose contour is discussed above in connection with Figure 8, and that is inspired in a Hilbert curve 810 are $F_{21}=1.58$ and $F_{32}=2.00$ and is mapped onto Figure 11 as bullet 1101. The quasi-rectangular antenna, discussed above in connection with Figure 9, and having a highly convoluted perimeter of 910 is characterized by complexity factors $F_{21}=1.00$ and $F_{32}=2.00$ and is mapped onto Figure 11 as bullet 1103. Bullet 1104 represents the pair of complexity factors $F_{21}=1.77$ and $F_{32}=1.04$ for the exemplary triple branch antenna 1010 discussed above in connection with Figure 10. These antenna examples help to show the value and antenna characteristics represented by the two complexity factors, F_{21} and F_{32} . Further, Figure 11 and the bullets 1001-1004 illustrate how a two dimensional graphical space 700 might be used for antenna system design.

[00235] Referring to Figure 11 and the bullet 1102 in connection with the configuration and performance characteristics of the sample planar rectangular antenna of Figure 6 it can be seen that such an antenna has a relatively low level of complexity on both a gross as well as a finer level of detail. Thus, while the antenna is relatively large and resonant at a relatively low frequency, it is less likely to provide multiple frequencies of resonance for multiband performance. As one moves up along the vertical axis toward bullet

1103 in connection with the configuration and performance characteristics of the generally rectangular antenna with a convoluted space-filling perimeter of Figure 9, it can be seen that while the complexity of the antenna remains low at a gross level of detail, the complexity increases at a finer level of detail. This, in turn, enhances the miniaturization of the antenna to some degree and causes the antenna to resonate at lower harmonic frequencies and behave as a larger antenna than it actually is even though this may not be enough of a change to render the antenna suitable for successful use.

[00236] If one now moves from the origin of the graph of Figure 11 along the horizontal axis toward bullet 1104 in connection with the configuration and performance characteristics of the forked antenna of Figure 10 we see that the antenna has a relatively high level of complexity on a gross level of detail but a low level of complexity at a finer level of detail. These characteristics tend to enrich the frequency of resonance and, thus, its, multiband capabilities as well as, in some respects, its miniaturization. Finally, in moving toward bullet 1101 of Figure 11 in connection with the configuration and performance characteristics of the antenna discussed above in connection with Figure 8, we see that the antenna is highly complex on both gross and fine levels of detail. This produces an antenna with a high degree of miniaturization which tends to penalize the bandwidth of the antenna and render it less than ideal for antenna performance.

[00237] An antenna designer can see that the complexity factors F_{21} and F_{32} , as represented and characterized by the antennas on Figure 6, 8, 9 and 10 and the illustrated graph of Figure 11 are very useful tools for modern antenna design for MFWD and similar devices. Use of these tools in accordance with the invention yields antenna designs, as well as MFWD devices having antennas, with enhanced performance characteristics.

[00238] Figure 12A shows a top-plan view of one illustrated embodiment of the structure 1200 of an antenna system for a MFWD according to the present invention. The antenna rectangle 1210 is depicted as a dashed line. The structure 1200 has been shaped to attain the desired multiple frequency band operation as well as desired RF performance. In particular, peripheral parts of a substantially flat conducting plate have been removed, and slots 1230–1233 have been created within the structure 1200. Slot 1232 divides the structure 1200 into two antenna elements 1201 and 1202. Antenna element 1201 and antenna element 1202 are not in direct contact, although the two antenna elements 1201 and 1202 are in contact through the ground plane of the MFWD.

[00239] The resulting structure 1200 supports different radiation modes so as to operate in accordance with two mobile communication standards: GSM and UMTS. More

specifically it operates in accordance with the GSM standard in the 900MHz band (completely within the 810MHz – 960MHz region of the spectrum), in the 1800MHz band (completely within the 1710MHz – 1990MHz region of the spectrum), and in the 1900MHz band (also completely within the 1710MHz – 1990MHz region of the spectrum). The UMTS standard makes use of a band completely within the 1900MHz – 2170MHz region of the radio spectrum. Therefore, the antenna system operates in four (4) separate frequency bands within three (3) separate regions of the electromagnetic spectrum.

[00240] In the example of Figure 12A, the MFWD comprises four (4) contact terminals to couple the structure of said antenna system 1200 with feeding means and grounding means included on a PCB of said MFWD. In Figure 12A, the antenna element 1201 includes a feeding point 1204 and a grounding point 1203, while the antenna element 1202 includes another feeding point 1205 and a grounding point 1206.

[00241] The feeding point 1204 is responsible for the operation of the antenna system in its lowest frequency band (i.e., in accordance with the 900MHz band of the GSM standard). Therefore, the lower left corner of the antenna rectangle 1211 is chosen to be the feeding point corner.

[00242] Figure 12B shows the position of the antenna rectangle relative to the PCB that includes the layer 1220 that serves as a ground plane of the antenna system. The layer 1220 is confined in a minimum-sized rectangle 1221 (depicted in dash-dot line), defining the ground plane rectangle for the MFWD. In this example, the antenna rectangle 1210 is placed substantially in the bottom part of the PCB of said MFWD. Moreover, the antenna rectangle 1210 is substantially parallel to the ground plane rectangle 1221. The antenna rectangle 1210 in this example is completely located in the projection of the ground plane rectangle 1221; however, the antenna rectangle 1210 is not completely on the projection of the ground plane layer 1220 that serves as a ground plane.

[00243] A long side of the antenna rectangle 1210 is substantially parallel to a short edge of the ground plane rectangle. The feeding corner 1211 is near a corner of the ground plane rectangle, providing advantageously a longer path to the electric and/or equivalent magnetic currents flowing on the ground plane layer 1220 to potentially enhance the RF performance of the antenna system or the RF performance of the MFWD in at least a lowest frequency band.

[00244] The antenna contour of the structure of antenna system 1200 of the example in Figure 12A is formed by the combination of two disjoint subsets of segments. A first subset is given by the perimeter of the antenna element 1201 and comprises forty-eight (48)

segments. A second subset is given by the perimeter of the antenna element 1202 and comprises twenty-six (26) segments. Additionally, all these segments are shorter than at least one tenth of a free-space wavelength corresponding to the lowest frequency band of operation of said antenna system.

[00245] Moreover, the length of the antenna contour of the structure 1200 is more than six (6) times larger than the length of a diagonal of the antenna rectangle 1210 in which said antenna contour is confined.

[00246] In Figures 13A-13B, the antenna contour of the structure of the antenna system 1200 is placed under a first grid 1301, a second grid 1302, and a third grid 1303 for the computation of the complexity factors of said structure 1200.

[00247] The antenna rectangle 1210 has been fitted with nine (9) columns and five (5) rows of cells of said second grid 1302 (in Figure 13B), as the aspect ratio of the antenna rectangle 1210 is such that fitting five (5) rows of cells in the short side of the antenna rectangle 1210 produces a cell of the second grid 1302 with an aspect ratio closest to one.

[00248] In Figure 13A, there are thirteen (13) cells of the first grid 1301 that, while being at least partially inside the antenna rectangle 1210 and including at least a point of the antenna contour of the structure 1200 (i.e., $N_1=13$).

[00249] In Figure 13B, there are thirty-eight (38) cells of the second grid 1302 completely inside the antenna rectangle 1210 and that include at least a point of the antenna contour of the structure 1200 (i.e., $N_2=38$).

[00250] Finally in Figure 13C, there are one hundred and fourteen (114) cells of the third grid 1303 completely inside the antenna rectangle 1210 and that include at least a point of the antenna contour of the structure 1200 (i.e., $N_3=114$).

[00251] The complexity factor F_{21} for the antenna shown in Figures 12A, 13A and 13B is computed as

$$F_{21} = -\frac{\log(38) - \log(13)}{\log(\frac{1}{2})} = 1.55$$

while the complexity factor F_{32} is obtained as

$$F_{32} = -\frac{\log(114) - \log(38)}{\log(\frac{1}{2})} = 1.58$$

[00252] Therefore, the exemplary structure of antenna system for a MFWD 1200 shown in 12A, 13A and 13B is characterized advantageously by complexity factors $F_{21}=1.55$ and $F_{32}=1.58$.

[00253] Figures 14A-14C show, respectively, another exemplary antenna 1410 inside the antenna rectangle 1400 under a first grid 1401, a second grid 1402, and a third grid 1403 for the computation of the complexity factors of the antenna 1410. In this example, the antenna rectangle 1400 may be tessellated with nine (9) columns and five (5) rows of cells of the second grid 1402 (Figure 14B) as well as with nine (9) columns and seven (7) rows of cells of said second grid (not depicted) since in both cases the aspect ratio is at its closest to one. A second grid 1402 with nine (9) columns and five (5) rows of cells has been selected since the aspect ratio for grid 1402 is bigger than 1. The antenna 1410 has a feeding point 1411, located substantially close to the bottom left corner of the antenna rectangle 1405 (being thus the feeding point corner).

[00254] In Figure 14A, there are fifteen (15) cells of the first grid 1401 that, while being at least partially inside the antenna rectangle 1400 and that include at least a point of the antenna contour 1410 (i.e., $N_1=15$). It should be noted that the cells have been shaded forming the group of cells 1412 to add clarity to the discussion contained herein.

[00255] In Figure 14B, there are forty-two (42) cells of the second grid 1402 completely inside the antenna rectangle 1400 and that include at least a point of the antenna contour 1410 (i.e., $N_2=42$). These cells are shaded forming the group of cells 1413 for clarity as set forth above.

[00256] Finally in Figure 14C, there are one hundred and forty-two (142) cells of the third grid 1403 completely inside the antenna rectangle 1400 and that include at least a point of the antenna contour of the structure 1410 (i.e., $N_3=142$). These cells are shaded forming the group of cells 1414 for clarity as set forth above.

[00257] The complexity factor F_{21} is for the antenna shown in Figures 14A-14C computed as

$$F_{21} = -\frac{\log(42) - \log(15)}{\log(\frac{1}{2})} = 1.49$$

while the complexity factor F_{32} is obtained as

$$F_{32} = -\frac{\log(142) - \log(42)}{\log(\frac{1}{2})} = 1.76$$

[00258] Therefore, the example antenna 1410 for a MFWD features advantageously complexity factors $F_{21}=1.49$ and $F_{32}=1.76$.

[00259] The antenna complexity contour of the antenna structure 1200, Figures 12A, 13A and 13B is mapped in the graphical representation of Figure 15 as a bullet 1501 with coordinates ($F_{21}=1.55$ or $F_{32}=1.58$). The antenna 1410 of Figures 14A-14C is mapped on the graph of Figure 15 as a bullet 1502 with coordinates ($F_{21}=1.49$ or $F_{32}=1.76$). Those two examples show cases where intermediate values of F_{21} and F_{32} are used. For intermediate values the value of F_{21} of the structure 1200 is relatively high and in case of the structure 1400 the value of F_{32} is relatively high.

[00260] Referring now to Figures 16 – 19, there is shown one example of optimizing the geometry of an antenna system to obtain a superior performance for MFWDs. In that sense, complexity factors F_{21} and F_{32} , as described above, are useful in guiding the optimization process of the structure of an antenna system to reach a target region of the (F_{21} , F_{32}) plane, as it is depicted in the flowchart 1600 in Figure 16.

[00261] In one embodiment, the process to design an antenna system starts with a set of specifications 1601. A set of specifications includes a list of heterogeneous requirements that relate to mechanical and/or functional aspects of said antenna system. A typical set of specifications may comprise:

- Dimensional information of the MFWD, and more particularly of the space available within the MFWD for the integration of an antenna system (data necessary to define the antenna box and the antenna rectangle) and of the ground-plane of the MFWD (data necessary to define the ground plane rectangle).
- Communication standards operated by the MFWD, and some requirements on RF performance of the antenna system (such as for example, and without limitation, input impedance level, impedance bandwidth, gain, efficiency, and/or radiation pattern) and/or RF performance of the MFWD (such as for example, and without limitation, radiated power, received power and/or sensitivity).
- Information on the functionality envisioned for a given MFWD (i.e., MMT, SMRT, or both), number of bodies the MFWD comprises (for instance whether the MFWD features a bar, clamshell, flip, slider or twist structure), and presence of other electronic modules and/or subsystems in the vicinity of the antenna box, or even (at least partially) within the antenna box.

[00262] As described above, an aspect of the present invention is the relation between functional properties of an antenna system of a MFWD and the geometry of the structure of the antenna system. According to the present invention, a set of specifications for an antenna system can be translated into a certain level of geometrical complexity of the antenna contour

associated to the structure of said antenna system, which is advantageously parameterized by means of factors F_{21} and F_{32} described above.

[00263] Therefore, once a set of specifications has been compiled, one embodiment of the design method of the present invention translates the set of specifications into a target region of the (F_{21}, F_{32}) plane 1602. In some examples, the target region is defined by a minimum and/or a maximum value of factor F_{21} (denoted by $F_{21}^{\min}$ and $F_{21}^{\max}$ in Figure 16), and/or a minimum and/or a maximum value of factor F_{32} (denoted by $F_{32}^{\min}$ and $F_{32}^{\max}$ in Figure 16).

[00264] It will then be advantageous in order to benefit from a superior RF performance of the antenna system and/or a superior RF performance of the MFW to shape the structure of the antenna system so that its antenna contour features complexity factors within the target region of the (F_{21}, F_{32}) plane.

[00265] Starting from an initial structure of an antenna system 1603, whose antenna contour features complexity factors F_{21}^0 and F_{32}^0 , most likely outside the target region of the (F_{21}, F_{32}) plane, an antenna system designer may need to gradually modify the structure of antenna system 1605 (such as, for instance, creating slots, apertures and/or openings within said structure; or bending and/or folding said structure) to adjust the complexity factors of its antenna contour. This process can be performed in an iterative way, verifying after each step whether factors F_{21}^1 and F_{32}^1 are within the target region of the (F_{21}, F_{32}) plane 1604. Depending on the current values of the complexity factors after step "i" of this iterative process, an antenna system designer can apply changes to the structure of the antenna system at step "i+1" to correct the value of one, or both, complexity factors in a particular direction of the (F_{21}, F_{32}) plane.

[00266] The design process ends 1606 when a structure of the antenna system has an antenna contour featuring complexity factors within the target region of the (F_{21}, F_{32}) plane (denoted by F_{21}^* and F_{32}^* in Figure 16).

[00267] In further illustration of the above, an example of designing an antenna system of a MFW can be illustrated by reference to one process to obtain the antenna system of Figure 12a.

[00268] In this particular example, the MFW is intended to provide advanced functionality typical of a MMT device and/or a SMRT device. The MFW must operate two mobile communication standards: GSM and UMTS. More specifically it operates the GSM standard in the 900MHz band (completely within the 810MHz – 960MHz region of the spectrum), in the 1800MHz band (completely within the 1710MHz 1990MHz region of the

spectrum), and in the 1900MHz band (also completely within the 1710MHz – 1990MHz region of the spectrum). The UMTS standard makes use of a band completely within the 1900MHz – 2170MHz region of the spectrum. The MFWD comprises one RF transceiver to operate each mobile communication standard (i.e., two RF transceivers).

[00269] The MFWD has a bar-type form factor, comprising a single PCB. The PCB includes a ground plane layer 1220, whose shape is depicted in Figure 12B. The antenna system is to be integrated in the bottom part of the PCB, such integration being complicated by the presence of a bus connector and a microphone module.

[00270] In this example the ground plane rectangle 1221 is approximately 100mm x 43mm. The antenna rectangle 1210 has a long side approximately equal to the short side of the ground plane rectangle 1221, and a short side approximately equal to one fourth of the long side of the ground plane rectangle 1221. Also in this example, the space provided within the MFWD for the integration of said antenna system allows placing parts of the structure of the antenna system at a maximum distance of approximately 6mm above the ground plane layer 1220.

[00271] Furthermore, there are additional functional requirements in terms of impedance, VSWR and efficiency levels in each frequency band, and requirements on the mechanical structure of the antenna system and materials to be used. These requirements are listed in Table 1 below.

Parameter	Condition	TARGET			Unit
		Minimum	Typical	Maximum	
Impedance			50		Ohm
Frequency Bands	GSM900	800		960	MHz
	GSM1800	1710		1880	
	GSM1900	1850		1990	
	UMTS	1920		2170	
VSWR	GSM900			3.5:1	
	GSM1800			3.0:1	
	GSM1900			3.0:1	
	UMTS			2.5:1	
Efficiency	GSM900	20			%
	GSM1800	30			
	GSM1900	30			
	UMTS	30			
Antenna System Structure	Type	Patch, PIFA, Monopole, IFA...			
				3	
			2		
				3	
Antenna System Materials	Radiator	Bronze, brass, stainless steel, nickel-silver... (Thickness: 0.1, 0.15, 0.2, 0.3, 0.4, or 0.5mm)			
	Plating	Nickel, gold... (Thickness: between 0.1 and 10microns)			
	Carrier	ABS, PC-ABS, POM, LCP			
	Assembly	Clips, screws, adhesive, heat-stakes...			

Table 1

[00272] The PCB area required by other electronic modules carried by the MFWD makes it difficult to remove any additional portions of the ground plane layer 1220 underneath the antenna system. Since substantial overlapping of the antenna rectangle 1210 and the ground plane rectangle 1221 occurs, a patch antenna solution is preferred for the MFWD of this example.

[00273] In order to take full advantage of the dimensions of the ground plane layer 1220 to potentially enhance the RF performance of the antenna system or the RF performance of the MFWD in at least a lowest frequency band, a feeding point of the antenna system will be placed substantially close to the bottom left corner of the ground plane layer 1220, so that a longer path is offered to the electric and/or equivalent magnetic currents flowing on said ground plane layer 1220. Therefore, the bottom left corner of the antenna rectangle 1211 is selected to be the feeding corner.

[00274] The antenna rectangle 1210 is then fitted with nine (9) columns and five (5) rows of cells of a second grid 1302 (in Figure 13B), as the aspect ratio of the antenna rectangle 1210 is such that fitting five (5) rows of cells in the short side of the antenna rectangle 1210 produces a cell of the second grid 1302 with an aspect ratio closest to one.

[00275] Once a set of mechanical and/or functional specifications has been compiled, they are translated into a level of geometrical complexity that the antenna contour associated to the structure of an antenna system needs to attain.

[00276] For those antennas in which their physical properties come quite close to patch antennas, a value of F_{21} being higher than 1.45, 1.47, 1.50, or 1.60 turns out to be a good measure for an expected improved bandwidth or gain with respect to a patch antenna without any complexity in at least one of the frequency bands. In the example of Figure 12, a value of F_{21} higher than 1.50 is preferred.

[00277] For a SMRT or MMT device a value of F_{32} being larger than 1.50, 1.52, 1.55 or 1.60 is desirable. The phones which usually operate in high frequency bands such as UMTS and/or a wireless connectivity of around 2.4 GHz a higher value of F_{32} can be used to appropriately adapt the antenna to a desired resonance frequency and/or bandwidth in those bands. In the example of Figure 12, a value of F_{32} higher than 1.55 is preferred.

[00278] Moreover, for MFWDs which have e.g. a camera or any other item such as a connector integrated in the antenna box, it is desirable to have a value of F_{32} being larger than 1.56, 1.58, 1.60 or 1.63. Therefore, since in the example of Figure 12 a connector and a microphone module are to be integrated in the antenna box alongside the antenna system, it is preferred to further increase the value of F_{32} to make it higher than 1.56.

[00279] In conclusion, it will be advantageous to shape the structure of the antenna system in such a way that its antenna contour features complexity factor F_{21} higher than 1.50 and F_{32} higher than 1.56, thus defining a target region 1800 in the upper right part of the (F_{21} , F_{32}) plane in Figure 18.

[00280] Referring now to Figure 17, there is shown the progressive modification of the antenna contour as the structure of the antenna system through the different steps of the optimization process. As indicated by the designer of the MFWD, a feeding point to couple the RF transceiver that operates the GSM communication standard should be preferably located at point 1722, while a feeding point to couple the RF transceiver that operates the UMTS communication standard should be preferably located at point 1724. Furthermore, grounding points should be preferably located at points 1721 and 1723.

[00281] Table 2 lists for each step the number of cells of the first, second and third grids considered for the computation of the complexity factors of the antenna contour, 15 and the values of said complexity factors F_{21} , F_{32} .

Step	Cells Counted in First Grid (N_1)	Cells Counted in Second Grid (N_2)	Cells counted in Third Grid (N_3)	Complexity Factor F_{21}	Complexity Factor F_{32}
0	12	24	52	1.00	1.12
1	15	31	82	1.05	1.40
2	13	31	82	1.25	1.40
3	13	37	103	1.51	1.48
4	13	38	113	1.55	1.57
5	13	36	103	1.47	1.52
6	13	38	110	1.55	1.53
7	13	38	114	1.55	1.58

Table 2

[00282] As a starting point (step 0), the structure of the antenna system is simply a rectangular plate 1701 occupying the entire antenna rectangle 1210 and placed at the maximum distance allowed above the ground plane layer 1220 (see Figure 17a). In this case the antenna contour is equal to the antenna rectangle 1210, and features complexity factors $F_{21}=1.00$ and $F_{32}=1.12$ (represented as point 1801 in Figure 18), obviously outside the target region 1800.

[00283] In the first iteration (step 1), a slot 1702 is practiced in the rectangular plate 1701, dividing said plate 1701 into two separate geometric elements: a larger antenna element 1711 and a smaller antenna element 1712, as shown in Figure 17b. The larger antenna element 1711 will be coupled to the RF transceiver that operates the GSM communication standard, while the smaller antenna element 1712 will be coupled to the RF transceiver that operates the UMTS communication standard.

[00284] The slot 1702 increases the geometrical complexity of the antenna contour, mainly along the F_{32} axis, mapping as point 1802 with coordinates $F_{21}=1.05$ and $F_{32}=1.40$ on the (F_{21} , F_{32}) plane.

[00285] In order to offer a longer path to the electrical currents flowing on the antenna element 1711, particularly those currents responsible for a radiation mode associated to the lowest frequency band of said antenna system, the next iteration step (step 2) is initiated. An upper right portion of the antenna element 1711 is removed creating an opening 1703 (Figure 17C). As it can be seen in Table 2, the effect sought when creating opening 1703 in the structure of the antenna system is directed towards enhancing the coarse complexity of the antenna contour (F_{21} increases from 1.05 to 1.25), while leaving its finer complexity unchanged. This modification accounts in Figure 18 for the jump from point 1802 to 1803, still far from the target region 1800. A fringe benefit of creating the opening 1703 in the

structure of the antenna system is that additional space within the MFWD, and in particular within the antenna box, is made available for the integration of other functional modules.

[00286] In the next iteration (step 3) a second slot is introduced in the structure of the antenna system (Figure 17D). Slot 1704 is practiced in antenna element 1711 with the main purpose of creating different paths for the currents flowing on said antenna element, so that it can support several radiation modes. The slot 1704 intersects the perimeter of the antenna element 1711 and has two closed ends: a first end 1730 near the left side of the antenna rectangle, and a second end 1731. As a result, the antenna element 1711 comprises a first arm 1732, a second arm 1733, and a third arm 1734.

[00287] From Table 2 it can be seen that the complexity factor F_{21} has been augmented to 1.51 in recognition of the improvement in the multiple frequency band and/or multiple radiation mode behavior of the structure shown in Figure 17D. The convoluted shape of slot 1704 contributes also to an increase of complexity factor F_{32} , reaching the value of 1.48.

[00288] After step 3, the antenna contour corresponds to point 1804 on the (F_{21}, F_{32}) plane of Figure 18. It can be noticed that while F_{21} is already above the minimum value of 1.50, F_{32} has not reached the minimum value of 1.56 yet.

[00289] In order to increase the value of F_{32} (step 4), three small slots 1705, 1706, 1707, are created in the structure of the antenna system, in particular in the antenna element 1711 (see Figure 17E). Slots 1706 and 1707 are connected to slot 1702, introduced in the structure to separate the larger antenna element 1711 from the 15 smaller antenna element 1712. The slots 1705, 1706, 1707 are effective in providing a more winding path for the electrical currents flowing on the arms of antenna element 1711, hence increasing the degree of miniaturization of the resulting antenna system.

[00290] At this stage the antenna contour features complexity factors $F_{21}=1.55$ and $F_{32}=1.57$ and maps into point 1805 on the (F_{21}, F_{32}) plane of Figure 18, clearly within the target region 1800.

[00291] However, the design in Figure 17E is to be modified for mechanical reasons (step 5). A portion in the lower left corner of antenna element 1711 is to be removed (creating the opening 1708) in order for the antenna system to fit in its housing in the body of the MFVVD. Moreover in order to accommodate a connector and a microphone module, portion 1740 on the right side of the antenna element 1712 needs to be shortened and then bent 90 degrees downwards (i.e. towards the ground plane layer 1220) forming a capacitive load. Such a modification results in opening 1709.

[00292] Unfortunately, the changes introduced in step 5 lead to an antenna system whose antenna contour is no longer within the target region of the (F_{21} , F_{32}) plane 1800: F_{21} has dropped to 1.47 (i.e., below 1.50) and F_{32} to 1.52 (i.e., below 1.56), which corresponds to point 1806.

[00293] The detuning of the antenna system in its upper frequency band due mostly to the reduction in size of antenna element 1712 can be readily corrected by creating a slot 1760 in said antenna element 1712 (step 6), to increase the electrical length of said antenna element. With this modification, the antenna contour of Figure 17G has fully restored the value of F_{21} to 1.55, and partially that of F_{32} (point 1807 in Figure 18).

[00294] A final fine-tuning of the structure of the antenna system is performed at step 7 (Figure 17H) aimed at restoring the level of F_{32} to be within the target region 1800, in which small indentations 1770, 1771, 1772, 1773, 1774 are created in the proximity of the feeding points 1722, 1724 and grounding points 1721, 1723 of the antenna system. The final design of the antenna system has a structure whose antenna contour features $F_{21}=1.55$ and $F_{32}=1.58$ (represented as point 1808 in Figure 18), well within the target region of the (F_{21} , F_{32}) plane 1800.

[00295] The typical performance of the antenna system of Figure 12a (or Figure 17h) is presented in Figure 19.

[00296] Referring specifically to Figure 19A, there is shown the VSWR of the antenna system referred to an impedance of 50 Ohms as a function of the frequency. Solid curve 1901 represents the VSWR of antenna element 1711 (i.e., the antenna element coupled to the RF transceiver that operates the GSM communication standard), while dashed curve 1902 represents the VSWR of antenna element 1712 (i.e., the antenna element coupled to the RF transceiver that operates the UMTS communication standard). The shaded regions 1903 and 1904 correspond to the mask of maximum VSWR allowed constructed from the functional specifications provided in Table 1. As it can be observed in Figure 19A, the VSWR curves 1901, 1902 are below the mask 1903, 1904 for all frequencies within the frequency bands of operation of the antenna system.

[00297] Figure 19B shows the efficiency of the antenna system as a function of the frequency. Curve 1951 represents the efficiency of antenna element 1711 in the 900MHz band of the GSM standard; curve 1952 represents the efficiency of antenna element 1711 in the 1800MHz and 1900MHz bands of the GSM standard; and curve 1953 represents the efficiency of antenna, element 1712 in the frequency band of the UMTS standard. The dashed regions 1954 and 1955 correspond to the mask of minimum efficiency required

constructed from the functional specifications provided in Table 1. As it can be observed in Figure 19b, the efficiency curves 1951, 1952, 1953 are above the mask 1954, 1955 for all frequencies within the frequency bands of operation of the antenna system.

[00298] Figures 20A-20F illustrate cross-sectional views of exemplary MFWDs comprising three bodies in which at least one body is rotated with respect to another body around two parallel axes.

[00299] Figures 20A-B illustrate a MFWD 2000 comprising a first body 2001, a second body 2002, and a third body 2003. A first connecting means 2004, such as, for example, a hinge, connects the first body 2001 to the third body 2003 and provides rotation of the first body 2001 around a first axis. A second connecting means 2005 connects the second body 2002 to the third body 2003 and provides rotation of the second body 2002 around a second axis. The first and second axes of rotation are parallel to each other and each of the axes is perpendicular to the cross-sectional plane of the figure. In this particular example, the third body 2003 is substantially smaller in size than the first and second bodies 2001, 2002 of the MFWD 2000.

[00300] Figure 20A illustrates the three bodies 2001, 2002, 2003 of the MFWD 2000 in a closed (or folded) state. The dashed lines indicate the position occupied by the centers of the first body 2001 and that of the second body 2002 when they are in the closed state.

[00301] Figure 20B illustrates the MFWD 2000 in a partially extended state. The first body 2001 and the second body 2002 are displaced with respect to a position they occupy in the closed state. The possible directions of rotation of the first body 2001 and the second body 2002 are indicated by the arrows.

[00302] Figures 20C-20D illustrate a MFWD 2030 comprising a first body 2031, a second body 2032, and a third body 2033. The MFWD 2030 further comprises a first connecting means 2034 connecting the first body 2031 to the third body 2033 and provides rotation of the first body 2031 around a first axis. The MFWD 2030 further comprises a second connecting means 2035 connecting the second body 2032 to the third body 2033 and provides rotation of the second body 2032 around a second axis. As shown in Figures 20A-20B, the first and second axes of rotation are parallel to each other.

[00303] In this particular example, the third body 2033 is substantially larger than the first and second bodies 2031, 2032 of the MFWD 2030, allowing the first body 2031 and the second body 2032 to be folded on top of the third body 2033 (and more generally on a same side of the third body 2033) when the MFWD 2030 is in its closed state, as illustrated in Figure 20C. In some cases, the first body 2031 and the second body 2032 will be substantially equal in size,

while in other cases, the first body 2031 and the second body 2032 will have substantially different dimensions.

[00304] Figure 20D illustrates the MFWF 2030 in a partially extended state. In the partially extended state, the first body 2031 is rotated around the first rotation axis provided by the first connecting means 2034, while the second body 2032 is rotated around the second rotation axis provided by the second connecting means 2035.

[00305] A third example of a MFWD is presented in Figure 20E-F, in which the MFWD 2060 comprises a first body 2061, a second body 2062, and a third body 2063. According to this example, the first, second, and third bodies 2061, 2062, 2063 can be selectively folded and unfolded by means of a first connecting means 2064 and a second connecting means 2065.

[00306] Figure 20E illustrates the MFWD 2060 in a closed state. In this example, the first body 2061 is located on top of the third body 2063 while the second body 2062 is located below the third body 2063 (and more generally on an opposite side of the third body 2063).

[00307] The MFWD 2060 can be extended to its maximum size state by rotating the first body 2061 around a first rotation axis provided by the first connecting means 2064 and rotating the second body 2062 around a first rotation axis provided by the second connecting means 2065. Figure 20F represents the MFWD 2060 in a partially extended state. The directions of rotation of the first body 2061 and the second body 2062 are indicated by means of the arrows shown in figure 20F.

[00308] As can be seen from the various examples and explanations above the use of the complexity factor F_{21} and F_{32} in accordance with the principles of the present invention are very useful in the design of MFWD devices and, in particular, multiband antennas for such devices. The choice of certain complexity factor ranges to optimize both the miniaturization of the antenna as well as the multiband and RF performance characteristics, all in accordance with the principles of the invention, should be clear to one of ordinary skill in the art from the above explanations.

[00309] The previous Detailed Description is of embodiment(s) of the invention. The scope of the invention should not necessarily be limited by this Description. The scope of the invention is instead defined by the following claims and the equivalents thereof.

WHAT IS CLAIMED IS:

1. A multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the multifunction wireless device comprising:

an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner; and

an antenna system disposed within at least one of the upper body and the lower body and having a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.

2. The multifunction wireless device of claim 1, wherein the multifunction wireless device has multimedia functionality.

3. The multifunction wireless device of claim 1, wherein the multifunction wireless device has smartphone functionality.

4. The multifunction wireless device of claim 1, further comprising:
a microprocessor;
at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
an input device comprising at least one of a keyboard comprising at least 26 keys and a touch screen; and
wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{32} has a value greater than 1.50.

5. The multifunction wireless device of claim 1, further comprising:
 - a receiver of at least one of analog and digital sound signals;
 - an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;
 - data storage of at least 1 GB in capacity; and
 - wherein the complexity factor F_{21} has a value greater than 1.39 and the complexity factor F_{32} has a value greater than 1.50.
6. The multifunction wireless device of claim 1, wherein the first body and the second body comprise a clamshell configuration.
7. The multifunction wireless device of claim 6, comprising:
 - an image-recording system;
 - a display comprising at least 75,000 pixels and capable of displaying at least 65,000 color levels;
 - a keyboard; and
 - wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor F_{21} having a value greater than 1.45 and the complexity factor F_{32} having a value greater than 1.75.
8. The multifunction wireless device of claim 6, comprising:
 - a keyboard comprising at least 40 keys; and
 - wherein the antenna system is mounted on the lower body below the keyboard, the complexity factor F_{21} having a value less than 1.45 and the complexity factor F_{32} having a value less than 1.50.
9. The multifunction wireless device of claim 6, further comprising:
 - a hinge connecting the upper body to the lower body; and
 - wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor F_{21} having a value greater than 1.20 and the complexity F_{32} having a value of at least 1.55.

10. The multifunction wireless device of claim 1, wherein the upper body and the lower body each have a thickness value of at least 5mm and not greater than 9mm and the complexity factor F_{21} has a value greater than 1.43 and the complexity factor F_{32} has a value greater than 1.63.

11. The multifunction wireless device of claim 1, wherein the upper body and the lower body are adapted to move relative to each other in a manner selected from the group consisting of a twist manner and a slide manner.

12. The multifunction wireless device of claim 11, further comprising:
a receiver of at least one of analog and digital sound signals;
a microprocessor interoperably coupled to the receiver;
a keyboard;
wherein the antenna system is mounted on the lower body below the keyboard; and
wherein the complexity factor F_{21} has a value greater than 1.45 and the complexity factor F_{32} has a value greater than 1.75.

13. The multifunction wireless device of claim 11, comprising:
a microphone system adapted to record sound and convert the recorded sound to a digital format;
a keyboard;
wherein the antenna system is mounted on the lower body below the keyboard; and
wherein the complexity factor F_{21} has a value less than 1.45 and the complexity factor F_{32} has a value less than 1.50.

14. The multifunction wireless device of claim 11, comprising:
a hinge connecting the upper body to the lower body; and
wherein the antenna system is mounted on the lower body adjacent to the hinge, the complexity factor F_{21} having a value greater than 1.20 and the complexity factor F_{32} having a value of at least 1.55.

15. The multifunction wireless device of claim 1, further comprising:
a geolocalization system;
wherein the upper body and the lower body each have a thickness value of at least 5mm and not greater than 9mm; and
wherein the complexity factor F_{21} has a value greater than 1.43 and the complexity factor F_{32} has a value greater than 1.63.

16. A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:
a microprocessor and operating system adapted to permit running of word-processing, spreadsheet, and slide software applications;
at least one memory interoperably coupled to the microprocessor, the at least one memory having a total capacity of at least 1 GB;
an antenna system; and
wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least 1.05 and not greater than 1.80 and by complexity factor F_{32} having a value of at least 1.10 and not greater than 1.90.

17. The multifunction wireless device of claim 16, further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner.

18. A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:
a receiver of at least one of analog and digital sound signals;
an image recording system comprising at least one of an at least two-Megapixel image sensor, a flashlight, an optical zoom, and a digital zoom;
data storage means having a capacity of at least 1 GB;
an antenna system; and
wherein the antenna system has a shape with a level of complexity of an antenna contour defined by complexity factor F_{21} having a value of at least 1.05 and not greater than 1.80 and by complexity factor F_{32} having a value of at least 1.10 and not greater than 1.90.

19. The multifunction wireless device of claim 18, further comprising an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner

20. A multifunction wireless device having at least one of multimedia and smartphone functionality, the multifunction wireless device comprising:

an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner;

a display;

a processing module;

a memory module;

a communication module; and

a power management module;

wherein the display, the processing module, the memory module, the communications module and the power management module are disposed within at least one of the upper body and the lower body;

wherein the communication module operates at a first frequency band fully contained within 810MHz–960MHz region of the electromagnetic spectrum, at a second frequency band fully contained within 1710MHz–1990MHz region of the electromagnetic spectrum, and at a third band fully contained within 1900MHz–2170MHz region of the electromagnetic spectrum, said first, second and third frequency bands being used by at least one communication standard; and

wherein the communication module comprises an antenna system having a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.

ABSTRACT

[00310] A multifunction wireless device having at least one of multimedia functionality and smartphone functionality, the multifunction wireless device including an upper body and a lower body, the upper body and the lower body being adapted to move relative to each other in at least one of a clamshell, a slide, and a twist manner. The multifunction wireless device further includes an antenna system disposed within at least one of the upper body and the lower body and having a shape with a level of complexity of an antenna contour defined by complexity factors F_{21} having a value of at least 1.05 and not greater than 1.80 and F_{32} having a value of at least 1.10 and not greater than 1.90.