



(51) International Patent Classification:
H01Q 7/06 (2006.01)

(21) International Application Number:
PCT/US2016/047455

(22) International Filing Date:
18 August 2016 (18.08.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14/849,643 10 September 2015 (10.09.2015) US

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(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
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SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the
earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

(54) Title: MAGNETIC COILS HAVING CORES WITH HIGH MAGNETIC PERMEABILITY

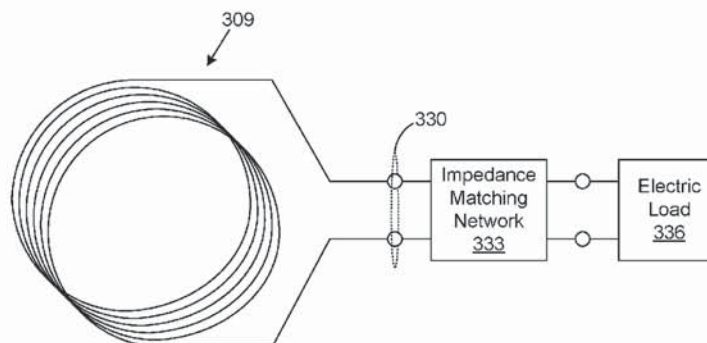


FIG. 19

(57) Abstract: Aspects of magnetic coils having cores with relatively high magnetic permeability are described. In some embodiments, a system includes a guided surface wave receive structure configured to obtain electrical energy from a guided surface wave traveling across a terrestrial medium. The guided surface wave receive structure includes a magnetic coil and a core disposed in the magnetic coil. The core in some embodiments has a relative magnetic permeability greater than about 10 and less than about 1,000,000. An electrical load is coupled to the guided surface wave receive structure, with the electrical load being experienced as a load at an excitation source coupled to a guided surface waveguide probe generating the guided surface wave.

ADVANCE E-MAIL

PCT

NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

D'AURELIO, Michael, J.
Thomas I Horstemeyer, L.L.P.
3200 Windy Hill Road, SE
Suite 1600E
Atlanta, GA 30339
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 25 January 2018 (25.01.2018)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference 170300-2280	
International application No. PCT/US2016/047455	International filing date (day/month/year) 18 August 2016 (18.08.2016)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address CPG TECHNOLOGIES, LLC. 202N I-35, Suite C Red Oak, TX 75154 United States of America	State of Nationality US	State of Residence US
	Telephone No.	
	Facsimile No.	
	E-mail address	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☐ the name ☒ the address ☐ the nationality ☐ the residence

Name and Address CPG TECHNOLOGIES, LLC. 1130 Dale Acres Road Italy, Texas 76651 United States of America	State of Nationality US	State of Residence US
	Telephone No.	
	Facsimile No.	
	E-mail address ☐ Notifications by e-mail authorized	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office ☒ the International Preliminary Examining Authority
☒ the International Searching Authority ☐ the designated Offices concerned
☐ the Authority(ies) specified for supplementary search ☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Bosset Fabienne e-mail pct.team7@wipo.int Telephone No. +41 22 338 74 07
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Facsimile No. +41 22 338 90 90

Form PCT/IB/306 (January 2009)

1/KXX7TJAZ5QPM20

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 170300-2280	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/US2016/047455	International filing date (<i>day/month/year</i>) 18.08.2016	Priority date (<i>day/month/year</i>) 10.09.2015
International Patent Classification (IPC) or national classification and IPC INV. H01Q7/06		
Applicant CPG Technologies, LLC		
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>8</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☒ (<i>sent to the applicant and to the International Bureau</i>) a total of <u>20</u> sheets, as follows: ☒ sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions). ☐ sheets containing rectifications, where the decision was made by this Authority not to take them into account because they were not authorized by or notified to this Authority at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4bis, 70.2(e), 70.16 and 91.2). ☐ superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)). b. ☐ (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing, in the form of an Annex C/ST.25 text file, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3ter of Annex C of the Administrative Instructions).		
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☐ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☐ Box No. VI Certain documents cited ☒ Box No. VII Certain defects in the international application ☒ Box No. VIII Certain observations on the international application		
Date of submission of the demand 07.07.2017	Date of completion of this report 15.12.2017	
Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016	Authorized officer Sipal, Vít Telephone No. +31 70 340-4607 	

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/US2016/047455

Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a) and (b))
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

2-6, 9-69 as originally filed

1, 7, 8, 70 filed in electronic form on

07-07-2017

Claims, Numbers

1-15 filed in electronic form on

04-12-2017

Drawings, Sheets

1/19-19/19 as originally filed

- ☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
5. ☐ This report has been established:
- ☐ taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).
 - ☐ without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91(Rules 66.4bis and 70.2(e)).

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/US2016/047455

6. ☒ With regard to top-up searches (Rules 66.1 *ter* and 70.2(f)):
- ☒ A top-up search was carried out by this Authority on 20.07.2017 (all discovered documents are listed in the Supplemental Box Relating to Top-up Search).
 - ☐ Additional relevant documents have been discovered during the top-up search.
 - ☐ No top-up search was carried out by this Authority because it would serve no useful purpose.
7. ☐ Supplementary international search report(s) from Authority(ies) has/have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).

* If item 4 applies, some or all of those sheets may be marked "superseded".

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-15</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	<u>1-15</u>
	No: Claims	
Industrial applicability (IA)	Yes: Claims	<u>1-15</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

1 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1.1 Reference is made to the following documents cited during the procedure:

D1 US 2014/252886 A1 (CORUM JAMES F [US] ET AL) 11 September 2014

D2 US 3 372 395 A (KLINE HALSEY W) 5 March 1968

D3 A Anonymous: "Permeability (electromagnetism)", 5 September 2015, pages 1-6, XP055314759, Retrieved from the Internet: URL:en.wikipedia.org/wiki/Permeability_(electromagnetism) [retrieved on 2016-10-28]

D4 Gary Peterson: "The application of electromagnetic surface waves to wireless energy transfer", 2015 IEEE Wireless Power Transfer Conference (WPTC), 1 May 2015, pages 1-4, XP055392851, DOI: 10.1109/WPT.2015.7139133 ISBN: 978-1-4673-7447-7

D5 CORUM K L ET AL: "RF coils, helical resonators and voltage magnification by coherent spatial modes", TELECOMMUNICATIONS IN MODERN SATELLITE, CABLE AND BROADCASTING SERVICE, 2001. TELSIS 2001. 5TH INTERNATIONAL CONFERENCE ON 19-21 SEPTEMBER 2001, PISCATAWAY, NJ, USA, IEEE, vol. 1, 19 September 2001, pages 339-348, XP010560949, ISBN: 978-0-7803-7228-3

1.2 D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses

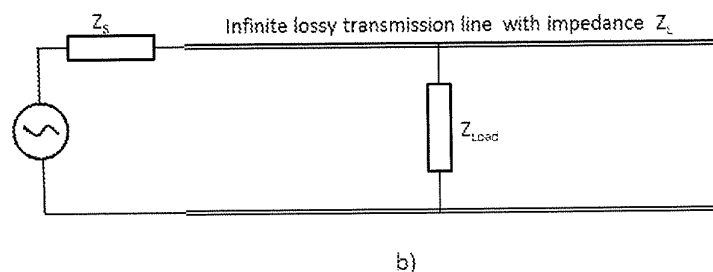
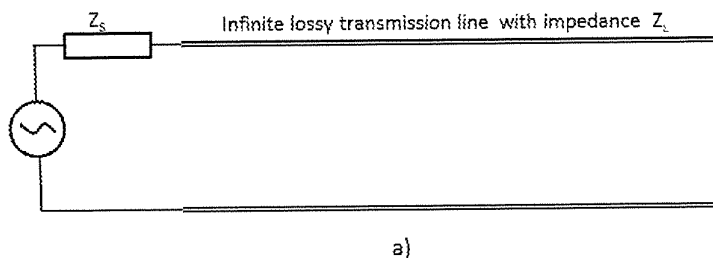
I. 1. A system, comprising: [D1: e.g. Fig. 3]

II. a guided surface waveguide probe with **a-single a plurality of** charge terminals configured to generate an electromagnetic field when excited by an excitation source, [D1: T1 and T2 in Fig. 3]

III. wherein the electromagnetic field synthesizes a wave front incident at a complex Brewster angle of incidence of a terrestrial medium to generate a guided surface wave that travels across the terrestrial medium; [D1: pars. 52-54, Figs. 3-6]

- IV. a feed network electrically coupled between the **single plurality of** charge terminals and the excitation source, the feed network providing a phase delay that matches a wave tilt angle associated with the complex Brewster angle of incidence [*D1: 209 in Fig. 3, pars. 52-54*]
 - V. a guided surface wave receive structure configured to obtain electrical energy from the guided surface wave, wherein the guided surface wave receive structure comprises a magnetic coil and a core disposed in the magnetic coil (309), ~~wherein the core has a relative magnetic permeability greater than about 10 and less than about 1,000,000; and~~ [*D1: 709 in Fig. 13, par. 180 explicitly discloses a core*]
 - VI. an electrical load coupled to the guided surface wave receive structure. [*D1: 736 in Fig. 13*]
- 1.3 The subject-matter of claim 1 therefore differs from this known system in that:
- I. the waveguide probe has only **a single** charge terminal
 - II. the core has a specifically defined permeability in the range 10-1,000,000
- and is therefore new (Article 33(2) PCT).
- 1.4 The problem to be solved by the present invention may be regarded as how to improve the efficiency of the power transfer.
- 1.5 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:
- 1.5.1 A waveguide probe with a single charge terminal as defined by point I. of section 1.3 is known e.g. from Fig. 1 of D4. Thus the skilled person would consider it obvious to replace the waveguide probe of D1 with its alternative disclosed by D4.
 - 1.5.2 The choice of permeability of point II. of section 1.3 would also be obvious for the skilled person who would regard ferrites as an obvious material for a core (see e.g. D3).
 - 1.5.3 Therefore, taken independently, the difference features of section 1.3 would be obvious to the skilled person.
However, since there are two difference features, it must be decided if there is a synergistic effect between them or not.

- 1.5.4 In a normal, wireless transmission using free space radiation, there would be no synergistic effect as the differences would merely sum up due to the linearity of Maxwell equations.
- 1.5.5 The system of claim 1 uses surface waves bound to the transition between the lossy ground and air. The conditions for the excitation of such a wave are defined by system features III. and IV. in section 1.2.
- 1.5.6 In such a scenario, there is a link between the excitation source and the load (see par. 36). This can be explained by the following two diagrams. Variant a) shows the situation when the system comprises a waveguide probe but no load. In such a case, the source "sees" only the infinitely long transmission line with impedance Z_L and only the power dissipated in the line is consumed. When a load Z_{Load} is connected the situation is as in case b) below.



- 1.5.7 It is essential to understand that one observes essentially a transmission line system, where basic power transfer rule applies. In other words, there is an optimum Z_{Load} for the best power transfer, like in a basic circuit the power transfer is optimum when the load correspond to the conjugate complex of the source impedance.

- 1.5.8 When replacing one probe with another as in point I. of section 1.3, we change the range for Z_S and a different range for Z_{Load} is necessary to achieve the optimum power transfer. The permeability of point II. of section 1.3 has an impact on Z_{Load} . Therefore, due to the presence of the guided surface wave defined by system features III. and IV. in section 1.2, it is not possible to claim that there is no synergy between the difference features of points I. and II. of section 1.3. Moreover, the new range of impedance for Z_S in fact enables a different range of impedance for Z_{Load} .
- 1.6 Consequently, the system of claim 1 complies with the requirements of Article 33(3) PCT because the skilled person would have to combine three pieces of prior art wherein the effects of the prior art would not be merely juxtaposed. Such a combination is an indicator of the presence of inventive step.
- 1.7 Considering the straightforward relationship between device claim 1 and method claim 11, the same reasoning as above applies also for method claim 11, *mutatis mutandis*.
- 1.8 Claims 2-10, and 12-15 are dependent on claims 1 and 11 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

2 **Re Item VII**

Certain defects in the international application

- 2.1 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1-D5 is not mentioned in the description, nor are these documents identified therein.
- 2.2 The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT. In particular, the description defines many different devices as "embodiments" even though the claims relate only to a specific phased array with specific antenna type. The word embodiment in the description should relate only to the claimed subject-matter. This objection applies also to pars. 208-228 and clauses 1-20 defined therein.

3 **Re Item VIII**

Certain observations on the international application

- 3.1 The application does not meet the requirements of Article 6 PCT, because claim 1 is not clear because it cannot be assessed if the excitation source 212 forms part of the claimed system or if the represents an external entity. Consequently, the scope of claim 1 is unclear (Article 6 PCT).

July 7, 2017

European Patent Office
Bob-van-Bentham-Platz 1
80469 Munich
Germany

Via EPOLINE

**Re: Guidance to Article 34 Amendment
Written Opinion Response Letter
International Patent Application No. PCT/US2016/047455
In the name of CPG Technologies, LLC
TH Ref: 170300-2280**

Dear Examiner Sipal:

In response to the Written Opinion accompanying the search report issued on 7 November 2016, we enclose new pages 1, 7, 8, and 70-74 to replace the pages 1, 7, 8, and 70-73 on file. To further assist the Examiner, we also enclose a courtesy copy of the original pages showing all amendments in marked-up form.

The claims have been amended as follows. Claims 1-6 amended; claim 7 unchanged; claim 8 amended; claim 9 unchanged; claims 10 and 11 amended; claim 12 unchanged; claims 13 and 14 amended; and claim 15 unchanged.

- a) Basis for amendments to Claim 1: The claim is amended to clarify that the “guided surface waveguide probe” is a “single phase guided surface waveguide probe,” that the single phase guided surface waveguide probe comprises a single charge terminal, to recite the excitation source experiences the electrical load as a load, and to add reference numbers.
- b) Basis for amendments to Claim 2: The claim is amended to recite an upper limitation of the relative magnetic permeability.
- c) Basis for amendments to Claim 3: The claim is amended to depend from claim 2.
- d) Basis for amendments to Claim 4: The claim is amended to recite an upper limitation of the relative magnetic permeability and to depend from claim 5.

- e) Basis for amendments to Claim 5: The claim is amended to recite an upper limitation of the relative magnetic permeability and to depend from claim 2.
- f) Basis for amendments to Claim 6: The claim is amended to depend from claim 2.
- g) Basis for amendments to Claim 8: The claim is amended to depend from claim 7.
- h) Basis for amendments to Claim 8: The claim is amended to depend from claim 7.
- i) Basis for amendments to Claim 10: The claim is amended to correct for antecedent basis and to depend from claim 9.
- j) Basis for amendments to Claim 11: The claim is amended to add a “single phase guided surface waveguide probe” that comprises a single charge terminal, to recite the excitation source experiences the electrical load as a load, and to add reference numbers.
- k) Basis for amendments to Claims 13 and 14: The claims are amended to correct for antecedent basis.

Any necessary amendments to the background and summary sections of the patent application will be made in due course, subject to their appropriateness in the relevant national jurisdictions.

Responses to Written Opinion Reasoned Statements in Item V

The following responses correspond to each reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability. The Applicant respectfully submits that these explanations clarify and identify support for the claims as required by Article 6 PCT.

Paragraph 2.1 - The WO alleges that claim 11 lacks novelty and inventive step. While Applicant disagrees, in an effort to move prosecution forward, claim 11 has been amended to recite that the “guided surface wave is generated by a single phase guided surface waveguide probe coupled to an excitation source,” that the “single phase guided surface waveguide probe comprises a single charge terminal,” and that the “excitation source experiences the electric load as a load,” which is neither known nor rendered

obvious in view of the cited prior art. For at least the foregoing reasons, claim 11 and its dependents are patentable over references D1-D3.

Paragraph 3.1 - The WO alleges that claim 1 lacks inventive step. While Applicant disagrees, in an effort to move prosecution forward, claim 1 has been amended to recite “the charge terminal is a single charge terminal,” which is neither known nor rendered obvious in view of the cited prior art. In contrast, D1 refers to poly-phase guided surface waveguide probes with two charge terminals. Specifically, D1 discusses “transmitting energy conveyed in the form of a guided surface-waveguide mode along the surface of a terrestrial medium by exciting a polyphase waveguide probe” (D1, Abstract), but is silent as to a single charge terminal. For at least the foregoing reasons, claim 1 and its dependents are patentable over references D1-D3.

Responses to Written Opinion Observations in Item VII

The following responses refer to the observations relating to the international application. The Applicant submits that the following responses satisfy observations in view of the requirements of Article 6 PCT.

Paragraph 5.1 - The WO alleges that the relevant prior art (D2 and D3) is not acknowledged in the description. Any amendments to the written description that are necessary to cite background art that is useful for the understanding of the claimed subject matter, will be made in due course at the conclusion of examination in a national office subject to national office requirements.

Paragraph 5.2 - Claims 1 and 11 are amended herein to include reference signs.

Paragraph 5.3 - The WO alleges that the independent claims are not cast in two part form. The Applicant respectfully submits that using the two-part claim format for the subject matter of this international application would be detrimental to the

clarity and conciseness of the claims. Amending the claims into two-part form will be held in abeyance unless and until national office examination dictates otherwise.

Paragraph 5.4 – The WO alleges that the expressions “incorporated by reference” in paragraphs [0001], [0002], [0038], and [0040] should be deleted. In addition, the WO alleges that paragraphs [0209] – [0230] should be deleted because they contain only unnecessary and irrelevant statements. Although Applicant respectfully disagrees, in order to expedite prosecution, the Specification is amended herein to delete the “incorporation by reference” expressions and delete paragraphs [0229] – [0230]. However, with respect to paragraphs [0209] – [0228], Applicant respectfully submits that the contents of paragraphs [0209] – [0228] are not unnecessary or irrelevant. As such, amending the Specification to remove paragraphs [0209] – [0228] will be held in abeyance unless and until national office examination dictates otherwise.

Paragraph 5.5 - Claims 3, 5, and 6 are amended herein to depend from claim 2 and claim 4 is amended to depend from claim 5, as recommended by the WO.

Paragraph 5.6 – Claims 2, 4, and 5 are amended herein to include an upper bound, as recommended by the WO.

Paragraph 5.7 – Claim 8 is amended herein to depend from claim 7, as recommended by the WO.

Paragraph 5.8 – Claim 10 is amended herein to depend from claim 9, as recommended by the WO.

Responses to Written Opinion Observations in Item VII

The following responses refer to the observations relating to the international application. The Applicant submits that the following responses satisfy observations in view of the requirements of Article 6 PCT.

Written Opinion Response Letter
PGT/US2016/047455
TH Ref: 170300-2280

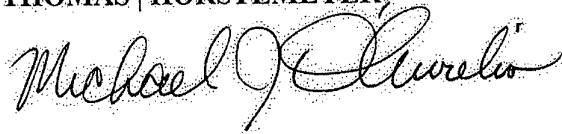
Paragraph 6.1 – Claim 1 is amended to clarify that the guided surface waveguide probe is “the single phase guided surface waveguide probe” and that the system comprises the excitation source, as recommended by the WO.

Conclusion

Applicant submits that this response and the accompanying amended pages address all objections raised in the Written Opinion and that a positive International Preliminary Report on Patentability (IPRP) can be issued. However, should the Examiner consider maintaining any of the objections or rejections in Item V paragraphs 2-4, Item VII paragraph 5, or Item VIII paragraph 6, notwithstanding the amendments made to the claims and the remarks above, we request the opportunity of a telephone interview with the Examiner to facilitate discussion of outstanding issues. In this regard, the Examiner is encouraged to contact the undersigned by telephone (US, Eastern Time) or by email to arrange for a mutually convenient conference time.

Sincerely,

THOMAS | HORSTEMEYER



Michael J. D' Aurelio
mike.daurelio@thomashorstemeyer.com
+1 770 933-9500

Attachments:

1. Replacement pages 1, 7, 8, and 70-74
2. Complementary mark-up of original pages 1, 7, 8, and 70-73

Attorney Docket: 170300-2280

MAGNETIC COILS HAVING CORES WITH HIGH MAGNETIC PERMEABILITY**CROSS-REFERENCE TO RELATED APPLICATION**

[0001] This application claims priority to and the benefit of, U.S. Application No. 14/849,643, filed on 10 September 2015.

[0002] This application is related to co-pending U.S. Non-provisional Patent Application entitled "Excitation and Use of Guided Surface Wave Modes on Lossy Media," which was filed on March 7, 2013 and assigned Application Number 13/789,538, and was published on September 11, 2014 as Publication Number US2014/0252886 A1. This application is also related to co-pending U.S. Non-provisional Patent Application entitled "Excitation and Use of Guided Surface Wave Modes on Lossy Media," which was filed on March 7, 2013 and assigned Application Number 13/789,525, and was published on September 11, 2014 as Publication Number US2014/0252865 A1. This application is further related to co-pending U.S. Non-provisional Patent Application entitled "Excitation and Use of Guided Surface Wave Modes on Lossy Media," which was filed on September 10, 2014 and assigned Application Number 14/483,089. This application is further related to co-pending U.S. Non-provisional Patent Application entitled "Excitation and Use of Guided Surface Waves," which was filed on June 2, 2015 and assigned Application Number 14/728,507. This application is further related to co-pending U.S. Non-provisional Patent Application entitled "Excitation and Use of Guided Surface Waves," which was filed on June 2, 2015 and assigned Application Number 14/728,492.

SUMMARY

[0003] According to one embodiment, a system includes a guided surface waveguide probe that is configured to generate a guided surface wave that travels across a terrestrial medium. The system includes a guided surface wave receive structure configured that obtains electrical energy from the guided surface wave.

Attorney Docket: 170300-2280

strength curve 106 that shows the field strength of a radiated electromagnetic field as a function of distance.

[0038] Of interest are the shapes of the curves 103 and 106 for *guided wave* and for *radiation* propagation, respectively. The radiated field strength curve 106 falls off geometrically ($1/d$, where d is distance), which is depicted as a straight line on the log-log scale. The guided field strength curve 103, on the other hand, has a characteristic exponential decay of $e^{-\alpha d}/\sqrt{d}$ and exhibits a distinctive knee 109 on the log-log scale. The guided field strength curve 103 and the radiated field strength curve 106 intersect at point 112, which occurs at a crossing distance. At distances less than the crossing distance at intersection point 112, the field strength of a guided electromagnetic field is significantly greater at most locations than the field strength of a radiated electromagnetic field. At distances greater than the crossing distance, the opposite is true. Thus, the guided and radiated field strength curves 103 and 106 further illustrate the fundamental propagation difference between guided and radiated electromagnetic fields. For an informal discussion of the difference between guided and radiated electromagnetic fields, reference is made to Milligan, T., Modern Antenna Design, McGraw-Hill, 1st Edition, 1985, pp.8-9.

[0039] The distinction between radiated and guided electromagnetic waves, made above, is readily expressed formally and placed on a rigorous basis. That two such diverse solutions could emerge from one and the same linear partial differential equation, the wave equation, analytically follows from the boundary conditions imposed on the problem. The Green function for the wave equation, itself, contains the distinction between the nature of radiation and guided waves.

[0040] In empty space, the wave equation is a differential operator whose eigenfunctions possess a *continuous* spectrum of eigenvalues on the complex wave-number plane. This transverse electro-magnetic (TEM) field is called the radiation field, and those propagating fields are called "Hertzian waves." However, in the presence of a conducting boundary, the wave equation plus boundary conditions mathematically lead to a spectral representation of wave-numbers composed of a continuous spectrum *plus* a sum of *discrete* spectra. To this end, reference is made to Sommerfeld, A., "Über die Ausbreitung der Wellen in der Drahtlosen Telegraphie," *Annalen der Physik*, Vol. 28, 1909, pp. 665-736. Also see Sommerfeld, A., "Problems of Radio," published as Chapter 6 in Partial Differential Equations in

Attorney Docket: 170300-2280

Physics – Lectures on Theoretical Physics: Volume VI, Academic Press, 1949, pp. 236-289, 295-296; Collin, R. E., "Hertzian Dipole Radiating Over a Lossy Earth or Sea: Some Early and Late 20th Century Controversies," IEEE Antennas and Propagation Magazine, Vol. 46, No. 2, April 2004, pp. 64-79; and Reich, H. J., Ordnung, P.F, Krauss, H.L., and Skalnik, J.G., Microwave Theory and Techniques, Van Nostrand, 1953, pp. 291-293.

[0041] The terms "*ground wave*" and "*surface wave*" identify two distinctly different physical propagation phenomena. A surface wave arises analytically from a distinct *pole* yielding a *discrete* component in the plane wave spectrum. See, e.g., "The Excitation of Plane Surface Waves" by Cullen, A.L., (Proceedings of the IEE (British), Vol. 101, Part IV, August 1954, pp. 225-235). In this context, a *surface wave* is considered to be a guided *surface wave*. The *surface wave* (in the Zenneck-Sommerfeld guided wave sense) is, physically and mathematically, not the same as the *ground wave* (in the Weyl-Norton-FCC sense) that is now so familiar from radio broadcasting. These two propagation mechanisms arise from the excitation of different types of eigenvalue spectra (continuum or discrete) on the complex plane. The field strength of the guided *surface wave* decays exponentially with distance as illustrated by curve 103 of FIG. 1 (much like propagation in a lossy waveguide) and resembles propagation in a radial transmission line, as opposed to the classical Hertzian radiation of the *ground wave*, which propagates spherically, possesses a *continuum* of eigenvalues, falls off geometrically as illustrated by curve 106 of FIG. 1, and results from branch-cut integrals. As experimentally demonstrated by C.R. Burrows in "The Surface Wave in Radio Propagation over Plane Earth" (Proceedings of the IRE, Vol. 25, No. 2, February, 1937, pp. 219-229) and "The Surface Wave in Radio Transmission" (Bell Laboratories Record, Vol. 15, June 1937, pp. 321-324), vertical antennas radiate *ground waves* but do not launch guided *surface waves*.

[0042] To summarize the above, first, the *continuous* part of the wave-number eigenvalue spectrum, corresponding to *branch-cut integrals*, produces the radiation field, and second, the *discrete* spectra, and corresponding *residue sum* arising from the poles enclosed by the contour of integration, result in non-TEM traveling surface waves that are exponentially damped in the direction transverse to the propagation. Such surface waves are guided transmission line modes. For further explanation,

Attorney Docket: 170300-2280

[0227] Clause 19. The system of any of clauses 14-18, wherein the core comprises a nickel-iron magnetic alloy.

[0228] Clause 20. The system of any of clauses 14-18, wherein the core comprises an alloy comprising nickel, iron, and molybdenum.

September 29, 2017

European Patent Office
Bob-van-Bentheim-Platz 1
80469 Munich
Germany

Via EPOLINE

**Re: Guidance to Article 34 Amendment
Written Opinion Response Letter
International Patent Application No. PCT/US2016/047455
In the name of CPG Technologies, LLC
TH Ref: 170300-2280**

Dear Examiner Sipal:

In response to the Written Opinion accompanying the search report issued on 2 August 2017, we enclose new pages 71-73 to replace the pages 71-73 on file. To further assist the Examiner, we also enclose a courtesy copy of the original pages showing all amendments in marked-up form.

The claims have been amended as follows. Claim 1 amended; claims 2 and 3 unchanged; claims 4 and 5 amended; claims 6-9 unchanged; claim 10 and 11 amended; claim 12 unchanged; claims 13 and 14 amended; and claim 15 unchanged.

- a) Basis for amendments to Claim 1: The claim is amended to remove the term “single phase” from the claim and add further detail to the generation of the guided surface wave.
- b) Basis for amendments to Claims 4 and 5: The claims are amended to change the order of the claims.
- c) Basis for amendments to Claim 10: The claim is amended to remove the term “single phase” from the claim.
- d) Basis for amendments to Claim 11: The claim is amended to remove the term “single phase” from the claim and add an element related to generating the guided surface wave.

Written Opinion Response Letter
PCT/US2016/047455
TH Ref: 170300-2280

- e) Basis for amendments to Claims 13 and 14: The claims are amended to remove the term “single phase” from the claim.

Any necessary amendments to the background and summary sections of the patent application will be made in due course, subject to their appropriateness in the relevant national jurisdictions.

Responses to Written Opinion Reasoned Statements in Item V

The following responses correspond to each reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability. The Applicant respectfully submits that these explanations clarify and identify support for the claims as required by Article 6 PCT.

Paragraph 1 - The WO alleges that claims 1 and 11 lack inventive step alleging that “it would seem that the single phase implies not only to the fact that: ‘the guided surface waveguide probe comprises a single charge terminal;’ but that the ‘single phase property’ has an implication on the type of the surface wave excited.” Applicant respectfully disagrees. The amended claims sets forth that a single charge terminal generates an electromagnetic field that “synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of a terrestrial medium (203) to generate a guided surface wave that travels across the terrestrial medium (203).” D1 relates to generating an electromagnetic field using two separate charge terminals. However, D1 lacks the technical solutions with respect to how an electromagnetic field can be generated to intersect the lossy conducting medium at a complex Brewster angle using only a single charge terminal. The present disclosure includes elements used for generating an electromagnetic field using a single charge terminal that synthesizes a wave front incident at a complex Brewster angle using only a single charge terminal.

For at least the foregoing reasons, claims 1 and 11, and their dependents, are patentable over references D1-D3.

Written Opinion Response Letter
PCT/US2016/047455
TH Ref: 170300-2280

Responses to Written Opinion Observations in Item VII

The following responses refer to the observations relating to the international application. The Applicant submits that the following responses satisfy observations in view of the requirements of Article 6 PCT.

Paragraph 7.1 - The WO states that “[c]laim 4 is drafted as dependent on claim 5, and consequently, claims 4 and 5 should be reordered.” Claims 4 and 5 have been reordered as requested by the WO.

Paragraph 7.2 - The WO alleges that the relevant prior art (D2 and D3) is not acknowledged in the description. Any amendments to the written description that are necessary to cite background art that is useful for the understanding of the claimed subject matter, will be made in due course at the conclusion of examination in a national office subject to national office requirements.

Responses to Written Opinion Observations in Item VIII

The following responses refer to the observations relating to the international application. The Applicant submits that the following responses satisfy observations in view of the requirements of Article 6 PCT.

Paragraph 8.1 – Claim 1 is amended to remove “wherein the excitation source experienced the electrical load.” Accordingly, Applicant respectfully submits that claim 1 is clear.

Written Opinion Response Letter
PCT/US2016/047455
TH Ref: 170300-2280

Conclusion

Applicant submits that this response and the accompanying amended pages address all objections raised in the Written Opinion and that a positive International Preliminary Report on Patentability (IPRP) can be issued. However, should the Examiner consider maintaining any of the objections or rejections in Item V paragraphs 2-6, Item VII paragraph 7, or Item VIII paragraph 7, notwithstanding the amendments made to the claims and the remarks above, we request the opportunity of a telephone interview with the Examiner to facilitate discussion of outstanding issues. In this regard, the Examiner is encouraged to contact the undersigned by telephone (US, Eastern Time) or by email to arrange for a mutually convenient conference time.

Sincerely,

THOMAS | HORSTEMEYER



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Attachments:

1. Replacement pages 71-73
2. Complementary mark-up of original pages 71-73

December 4, 2017

European Patent Office
Bob-van-Bentheim-Platz 1
80469 Munich
Germany

Via EPOLINE

**Re: Guidance to Article 34 Amendment
Amendments in Response to Communications
International Patent Application No. PCT/US2016/047455
In the name of CPG Technologies, LLC
TH Ref: 170300-2280**

Dear Examiner Sipal:

In response to our communications on November 27, 2017 and the Note on an informal communication by telephone with the Applicant issued on November 27, 2017 (the "Minutes"), we enclose new pages 71-73 to replace the pages 71-73 on file. To further assist the Examiner, we also enclose a courtesy copy of the original pages showing all amendments in marked-up form.

The claims have been amended as follows. Claim 1 amended; claims 2-10 unchanged; claim 11 amended; and claims 12-15 unchanged.

- a) Basis for amendments to Claim 1: The claim is amended to remove 200d from the list of numerals for the guided surface waveguide probe and to change "comprising a single charge terminal" to "with a single charge terminal," as requested by the Examiner.
- b) Basis for amendments to Claim 11: The claim is amended to remove 200d from the list of numerals for the guided surface waveguide probe.

Any necessary amendments to the background and summary sections of the patent application will be made in due course, subject to their appropriateness in the relevant national jurisdictions.

Responses to Minutes in Item II

The Minutes (p. 3) state that “it was pointed out that due to the nature of surface waves, the system is to be regarded as a waveguide system where the transmit probe connects as a source to a lossy waveguide with the receiver also being connected to said waveguide.” Applicant agrees that the guided surface waveguide probe couples energy into the lossy conductive medium in the form of a guided surface wave and that the guided surface wave receive structure obtains electrical energy the guided surface wave traveling in the lossy conductive medium. To this end, the guided surface wave is a transmission line mode. The Minutes further allege that “Consequently, using a different probe with a different impedance essentially opens up a different range of impedances for the receiver.” Applicant wishes to point out that given that the guided surface wave transmission is a transmission line mode, the electric load at the receiver acts as a load on the excitation source coupled to the guided surface waveguide probe so a change in the core of the magnetic coil (309) alters the load felt at the excitation source (212) as a greater amount of magnetic flux will pass through a coil of the receiver. Further, the feed network provides a phase delay (Φ) that matches a wave tilt angle (Ψ) associated with the complex Brewster angle of incidence. It should be noted that the receive structure is not necessarily impedance matched to the probe. Rather, the guided surface waveguide probe is matched to the terrestrial medium and the impedance of the load is matched to the receiver structure.

Comments Regarding D4

Applicant would further point out that D4 does not provide any detail as to how to enable one skilled in the art to cause a probe with a single charge terminal to operate. Rather, D4 makes several general assertions that somehow a Zenneck Surface Wave could be launched, but simply does not provide the needed technical information in order to operate a guided surface waveguide probe. Although D4 provides schematics that show probe circuits, there is no discussion that provides specific direction as to how such structures are to be operated. For example, there is no discussion of how the fields around the probes create the complex angle of incidence needed to couple energy into the

Written Opinion Response Letter
PCT/US2016/047455
TH Ref: 170300-2280

waveguide medium which is the ground as is described in the present application.

Further, there is no discussion of the wave tilt angle associated with the terrestrial waveguide or how the phase delay of the probe matches such wave tilt angle in order to launch a guided surface wave. Further, it is not clear whether the experimental structure pictured in D4 is merely producing radiation. For example, if the phase delay of the probe does not substantially match the wave tilt angle associated with the terrestrial medium, then no guided surface wave will be launched with a single phase probe.

By way of contrast, the present application provides significant discussion and depth as to how a guided surface waveguide probe operates using a single charge terminal including a detailed discussion of the concepts of the wave tilt angle, the phase delay, the phase shift, and other parameters. For example, see the discussion with respect to FIGS. 7-9B which correlates to paragraphs [0078] through [0100].

Accordingly, Applicant asserts that one skilled in the art would require inventive skill to implement the single charge probe of D4 while being aware of D1. Therefore, for this additional reason, Applicant asserts that the claims of the present application are both novel and set forth an inventive step.

Written Opinion Response Letter
PCT/US2016/047455
TH Ref: 170300-2280

Conclusion

As agreed during communications with the Examiner, Applicant submits that this response and the accompanying amended pages address all objections raised in the Written Opinion and that a positive International Preliminary Report on Patentability (IPRP) can be issued. However, should the Examiner consider maintaining any of the objections or rejections, notwithstanding the amendments made to the claims and the remarks above, we request the opportunity of a telephone interview with the Examiner to facilitate discussion of outstanding issues. In this regard, the Examiner is encouraged to contact the undersigned by telephone (US, Eastern Time) or by email to arrange for a mutually convenient conference time.

Sincerely,

THOMAS | HORSTEMEYER



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Attachments:

1. Replacement pages 71-73
2. Complementary mark-up of original pages 71-73

CLAIMS

Therefore, the following is claimed:

1. A system, comprising:
 - a guided surface waveguide probe (200a, 200b) with a single charge terminal (T_1) configured to generate an electromagnetic field when excited by an excitation source (212), wherein the electromagnetic field synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of a terrestrial medium (203) to generate a guided surface wave that travels across the terrestrial medium (203);
 - a feed network (209) electrically coupled between the single charge terminal (T_1) and the excitation source (212), the feed network (209) providing a phase delay (Φ) that matches a wave tilt angle (Ψ) associated with the complex Brewster angle of incidence ($\theta_{i,B}$);
 - a guided surface wave receive structure configured to obtain electrical energy from the guided surface wave, wherein the guided surface wave receive structure comprises a magnetic coil (309) and a core disposed in the magnetic coil (309), wherein the core has a relative magnetic permeability greater than about 10 and less than about 1,000,000; and
 - an electrical load (327) coupled to the guided surface wave receive structure.
2. The system of claim 1, wherein the relative magnetic permeability is greater than about 100 and less than about 1,000,000.
3. The system of claim 2, wherein the relative magnetic permeability is greater than about 1,000 and less than about 10,000.
4. The system of claim 2, wherein the relative magnetic permeability is greater than about 10,000 and less than about 1,000,000.
5. The system of claim 4, wherein the relative magnetic permeability is greater than about 100,000 and less than about 1,000,000.

6. The system of claim 2, wherein the relative magnetic permeability of the core is greater than about 5,000 and less than about 60,000.

7. The system of any of claims 1-6, wherein the core comprises a nickel-iron magnetic alloy.

8. The system of claim 7, wherein the core comprises an alloy comprising nickel, iron, and molybdenum.

9. The system of any of claims 1-8, wherein the magnetic coil is attached to a support structure that is configured to adjust a position of the magnetic coil.

10. The system of claim 9, wherein the magnetic coil is attached to the support structure that is configured to adjust the position of the magnetic coil relative to the guided surface waveguide probe.

11. A method, comprising:

generating, by exciting a single charge terminal (T_1) of a guided surface waveguide probe (200a, 200b) via an excitation source (212), an electromagnetic field that synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of a terrestrial medium (203) to generate a guided surface wave that travels across the terrestrial medium (203), wherein a feed network (209) is electrically coupled between the single charge terminal (T_1) and the excitation source (212), the feed network (209) providing a phase delay (Φ) that matches a wave tilt angle (Ψ) associated with the complex Brewster angle of incidence ($\theta_{i,B}$);

receiving electrical energy in the form of the guided surface wave using a guided surface wave receive structure, wherein the guided surface wave receive structure comprises a magnetic coil (309) and a core disposed in the magnetic coil (309), wherein the core has a relative magnetic permeability greater than about 10 and less than about 1,000,000; and

supplying the electrical energy to an electrical load (327) coupled to the guided surface wave receive structure.

12. The method of claim 11, further comprising positioning the magnetic coil so that a magnetic flux of the guided surface wave passes through the magnetic coil.

13. The method of claim 11 or 12, further comprising adjusting a position of the magnetic coil in response to a change in an orientation of the magnetic coil relative to the guided surface waveguide probe.

14. The method of claim 13, further comprising detecting a change in the orientation of the magnetic coil relative to the guided surface waveguide probe.

15. The method of claim 13 or 14, wherein adjusting the position of the magnetic coil causes an angle between a horizon and a longitudinal axis of the core to change.

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