(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

PCT

(43) International Publication Date
24 December 2008 (24.12.2008)

(10) International Publication Number
WO 2008/156489 A1

(51) International Patent Classification:
H04M 1/00 (2006.01) *H02J 7/00* (2006.01)

(21) International Application Number: PCT/US2007/074264

(22) International Filing Date: 24 July 2007 (24.07.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/945,572 21 June 2007 (21.06.2007) US
60/947,632 2 July 2007 (02.07.2007) US

(71) Applicants and
(72) Inventors: **SHIN, Roger, Sun** [US/US]; 465 S. Bridge View Drive, Anaheim Hills, CA 92808 (US). **NAM, Henry, S.** [US/US]; 465 S. Bridge View Drive, Anaheim Hills, CA 92808 (US).

(74) Agent: **LENKIN, Alan, M.**; Fulbright & Jaworski L.L.P., 555 South Flower Street, Forty-first Floor, Los Angeles, CA 90071 (US).

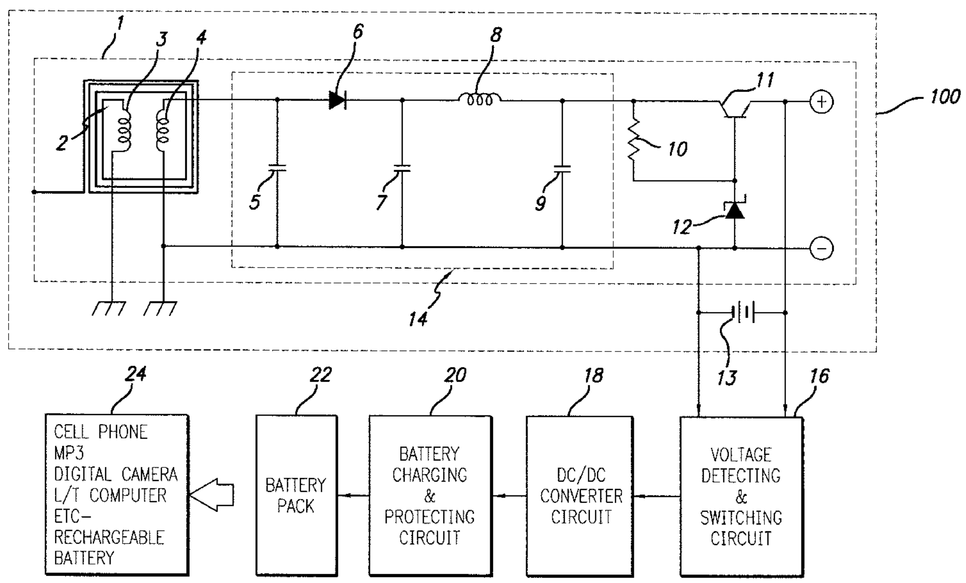
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Published:
— *with international search report*

(54) Title: WIRELESS ELECTRICAL CHARGING SYSTEM

FIG. 1



(57) Abstract: An apparatus wirelessly re-charges a rechargeable battery The apparatus includes a wireless receiver (1) that amplifies received radio waves, the wireless receiver (1) comprising a tourmaline and zeolite ceramic The re-charging apparatus also includes a patch antenna (2) that filters the received radio waves to usable RF signals The re-charging apparatus further includes circuits (14) that process the usable RF signals to create refined electric power for the rechargeable battery (13).

WO 2008/156489 A1

WIRELESS ELECTRICAL CHARGING SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Patent Application Number 60/945,572, entitled "Wireless Battery Charging From High Frequency Waves," filed on June 21, 2007, the disclosure of which is expressly incorporated herein by reference in its entirety.

[0002] This application also claims the benefit of U.S. Patent Application Number 60/947,632, entitled "Wireless Battery Charging From High Frequency Waves ," filed on July 2, 2007, the disclosure of which is expressly incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0003] The present invention relates to energy harvesting. More specifically, the present invention relates to attracting RF energy with special ceramics and converting the RF energy in DC power for applications, such as charging re-chargeable batteries.

BACKGROUND

[0004] Typically, consumer electronic devices require frequent charging by plugging an adapter into the wall. It would be desirable to eliminate the requirement for plugging a device into the wall for re-charging. Although systems exist for harvesting RF energy, prior art systems typically require multiple antennas and are generally inefficient.

SUMMARY

[0005] A primary object of the present invention is to efficiently harvest electricity from ambient RF energy.

[0006] An apparatus for wirelessly re-charging a rechargeable battery includes a wireless receiver that amplifies received radio waves. The wireless receiver is a tourmaline and zeolite composite. The apparatus also includes a patch antenna that filters the received radio

waves to usable RF signals; and a multiple circuits that process the usable RF signals to create refined electric power for the rechargeable battery.

[0007] A method for wirelessly re-charging a rechargeable battery includes creating a zeolite and tourmaline ceramic. The method also includes wirelessly receiving and amplifying radio waves with the tourmaline and zeolite ceramic, filtering the received radio waves to usable RF signals, and processing the usable RF signals to create refined electric power for the rechargeable battery.

[0008] Other objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawing figures, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated into and form a part of the specification, illustrate several embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating embodiments of the invention and are not to be construed as limiting the invention. In the drawings:

Figs. 1 is an electrical schematic, according to an aspect of the present invention;

Figs. 2A and 2B are cross section and end views of components, according to an aspect of the present invention;

Fig. 3 shows a comparison of RF absorption, according to an aspect of the present invention;

Fig. 4 is circuit schematic showing an exemplary battery charging and protecting board, according to an aspect of the present invention; and

Fig. 5 shows an exemplary system operation flow chart, according to an aspect of the present invention.

DETAILED DESCRIPTION

[0010] In order to increase efficiency to obtain sufficient DC voltage to charge a re-chargeable battery, tourmaline/zeolite ceramics are provided to improve RF absorption. Due to the increased efficiency, a single antenna can be used, as opposed to prior art systems that typically require multiple antennas. Moreover, no specific transmitting system is required.

[0011] Referring to Fig. 1, an embodiment of the present invention will now be described. An integrated circuit 100 is shown. The components of the integrated circuit 100 will now be described in detail.

[0012] A tourmaline/zeolite ceramic 1 receives RF signals and significantly amplifies the signal. In one embodiment, the signal strength is increased by 5 times compared with a ceramic without the tourmaline/zeolite ceramic 1. The ceramic 1 absorbs RF signals across a wide range of frequencies and can include energy from a variety of sources such as fluorescent lights and cellular signals.

[0013] In an exemplary embodiment, the ceramic is a piezoelectric bender part number AB1560B manufactured by Projects Unlimited Inc. The ceramic is supplemented with approximately a 1 mm coating along the exposed tourmaline surface. The coating includes a mixture of about equal parts tourmaline, zeolite, and epoxy. The mixture is added to the ceramic from a dropper, and then heated to 120F to uniformly distribute the coating along the exposed surface, and also extend about 5% beyond the surface of the tourmaline surface. The ceramic 1 receives a very wide range of frequencies. Although a piezoelectric ceramic is described, any zeolite/tourmaline composite 1 on a substrate could perform the signal amplification.

[0014] A patch antenna 2, preferably plated with .5 micro millimeters of platinum is also shown. The patch antenna filters the received RF signals to between 50 Hz and 3.5 GHz. In one embodiment, the patch antenna is a square having rounded corners and 24 turns, as better seen in Fig. 2a. In a preferred embodiment, the patch antenna is 8 mm wide, and 8 mm long, with each coil spaced approximately .5 mm apart.

[0015] In one embodiment, the patch antenna 2 is designed in accordance with the equations below. The design width W of the microstrip patch antenna 1 is given by

(1)

$$W = \frac{1}{2 \cdot f_r \cdot \sqrt{\mu_0 \cdot \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \textbf{8mm}$$

where f_r is the frequency of operation of the antenna (or the resonant frequency);

μ_o and ε_o are fundamental physical constants, and,

ε_r is a dielectric constant of the substrate.

[0016] In the general case, the microstrip patch antenna 1 has a length L of half of a wavelength at its center frequency (e.g., 3.5GHz) which is given by

(2)

$$L = \frac{1}{2 \cdot f_r \cdot \sqrt{\varepsilon_{r,eff}} \cdot \sqrt{\mu_0 \cdot \varepsilon_0}} - 2 \cdot \Delta L = \textbf{8mm}$$

$$\text{where } \Delta L = 0.412 \cdot h \cdot \frac{(\varepsilon_{r,eff} + 0.3)\cdot\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{r,eff} - 0.258)\cdot\left(\frac{W}{h} + 0.8\right)} = \mathbf{0.5mm}$$

E_{reff} = effective side length; and

h = thickness = .01 mm

[0017] A transformer 3,4 is provided to convert the RF energy into voltage. A primary coil 3 receives the RF signal from the patch antenna 2 and outputs AC 0.7V/.05A. A secondary coil 4 increases the AC output to between approximately 2.0V/250 mA and 5.7 V/100 mA. In one embodiment, the transformer is part number 78253/35m, available from C&D Technologies, Inc.

[0018] An RF tuning circuit 5 is also provided. The tuning circuit 5 includes a spectrum analyzer (not shown) and a capacitor. The RF tuning circuit controls the radio frequency being received by the patch antenna 2. In one embodiment, the coil is tuned to receive a frequency zone of 50 Hz to 3.5 GHz. In one embodiment, the RF tuning circuit is implemented with a 2.9 pF capacitor, such as part # 06035J2R9BB, available from AVX Corporation. As is well known, the resonance frequency = $1/2\pi\sqrt{LC}$

[0019] A germanium diode 6 rectifies the signal received from the RF tuning circuit 5, converting AC to DC. An exemplary rectifier is IN45, 1N4148 – 1/8 watt, available from Fairchild Semiconductor Corporation.

[0020] After the signal is converted to DC, signal conditioning occurs. A low pass filter can be provided to filter the noise frequencies from the DC signal and can include capacitors 7, 9 and an inductor 8. An exemplary capacitor 7 is a .00029 μF capacitor, such as part number 06035JJ291BB available from AVX Corporation. An exemplary inductor 8 is a 68 μH inductor, such as part number HK0603-68NJ, available from Kemet Corporation. An exemplary capacitor 9 is a 1 μF 10V capacitor, such as part number GRM188F551A105ZA, available from Murata Manufacturing Co. Ltd.

[0021] In one embodiment, further signal conditioning prevents overcharging. An exemplary signal conditioning circuit includes a resistor 10, a transistor 11, and a Zener diode 12. The resistor 10 can be a 100 Ohm 1/8 watt resistor that operates the transistor 11. An exemplary resistor is part number 06035J102K, available from AVX Corporation. The transistor 11 regulates the voltage and can be a 30V/500mA NPN type transistor, such as part number NTE85, available from NTE Electronics, Inc. In one embodiment, the transistor 11 outputs 4.5V. The Zener diode 12 also regulates voltage. An exemplary Zener diode is part number FLZ4V7B, available from Fairchild Semiconductor Corporation. In one embodiment, the Zener diode 12 converts a 4.7 V signal into a 4.5 V output.

[0022] A primary rechargeable battery 13 can be a back up capacitor, such as an NEC-TOKIN FG series FG0h103ZF, available from NEC-TOKIN Corporation.

[0023] An isolator 14 is provided around components 5, 6, 7, 8, 9, preventing RF interference that would impair operation of the tuning circuit 5, rectifier 6, and low pass filter 7, 8, 9. In one embodiment, the isolator is implemented with copper foil 14 mm x 14 mm in a rounded rectangle shape.

[0024] Outside the integrated circuit, other components can be provided to facilitate battery charging. Such components include a voltage detecting and switching circuit 16, a DC/DC converter circuit 18, a battery charging and protecting circuit 20, a battery pack 22, and a rechargeable battery 24. In one embodiment, the voltage detecting and switching circuit 16 is part number S1111BA45 available from Seiko Instruments Inc., and the DC/DC converter circuit 18 is part number NKE0505, available from C&D Technologies, Inc. The battery charging and protecting circuit 20 is illustrated in more detail in Fig. 4, and can be part number AAT3681, available from Advanced Analogic Technologies, Inc.

[0025] Referring now to Figs. 2 and 2a, more explanation will be provided of the integrated circuit 100. A substrate 30 is provided within an integrated circuit (IC) package 32. A printed circuit board 34 connects via lead wires 36 to the outside components 16, 18, 20, 22, 24 (not shown).

[0026] Exemplary substrate materials include brass and copper. On top of the substrate 30 is the ceramic 1. The patch antenna 2 connects the circuit board 34 to the ceramic 1. Isolator 14 is shown separating the substrate 30 and ceramic 1 from surface mounted devices 3 – 13, which are not shown in detail in Fig. 2.

[0027] Fig. 2a shows in detail the portion designated by “a” in Fig. 2, and exemplary dimensions. In one embodiment, the ceramic 1 has a diameter of 12 mm, the patch antenna 2 has a width of 8 mm, the substrate has a diameter of 15 mm, and the IC package 32 has a width of 17 mm.

[0028] As seen in Fig. 3, RF absorption with tourmaline/zeolite ceramics is much better than without tourmaline/zeolite ceramics.

[0029] Referring to Fig. 5, an exemplary system operation process flow will now be described. Initially, at step S10 the zeolite/tourmaline ceramic amplifies a wide range of received RF signals. At step S12 the patch antenna absorbs the appropriate RF signals. At step S14 the primary coil transforms the RF signal into voltage, and at step S16, the secondary coil amplifies the received RF signal. At step S18, the RF tuning circuit tunes the coil to receive signals having a frequency of less than 3.5 GHz. Next, at step S20, the alternating current is demodulated to direct current. At step S22 noise and low pass filtration occurs, and at step S24 the voltage is regulated for 4.5 volts.

[0030] It is then determined whether the voltage is 4.5 volts, at step S26. If not, the process returns to step S24. Otherwise, at step S28 voltage switching occurs, and at step S30 DC/DC converting for protection occurs. Next, it is determined whether the system is enabled at step S32. In one embodiment, the system is enabled when the voltage is greater than 4 volts. If enabled, at step S34 it is determined whether the power input voltage is greater than the under voltage lockout. If the input voltage is greater than the under voltage lockout, then at step S36 fault conditions are monitored to determine if the voltage is over voltage. If YES at step S36 or the system is not enabled (Step S32: NO), or the power input voltage is less or equal to the under voltage lockout (S34: NO), then the system shuts down at step S38.

[0031] If not over voltage, at step S40 a preconditioning test occurs, determining if a minimum voltage is greater than a battery voltage. If not, at step S42 a current phase test occurs at step S42. The current phase test compares a battery current with a charge termination threshold current. If the battery current is less than or equal to the charge termination threshold current, then a voltage phase test occurs at step S44 The voltage phase test determines whether an battery voltage for end of charge is greater than a battery voltage. If the battery end of charge voltage is greater, at step S46 the charge is completed.

[0032] After charge completion, at step S48 a recharge test repeats until a recharge voltage is greater than the battery voltage, at which time the process returns to step S42.

[0033] If the preconditioning test determines that minimum voltage is greater than the battery voltage, at step S50 preconditioning (i.e., trickle charging) occurs. Charge control then occurs at step S52 and the process returns to step S36.

[0034] If the current phase test indicates that the battery current is greater than the charge termination threshold current, at step S54 a constant charge mode is entered and the logic returns to step S52.

[0035] If the voltage phase test determines that the end of charge battery voltage is greater than the battery voltage, at step S56 a constant voltage charge mode is entered. Subsequently, the logic returns to step S52.

[0036] The illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The illustrations are not intended to serve as a complete description of all of the elements and features of apparatus and systems that utilize the structures or methods described herein. Many other embodiments may be apparent to those of skill in the art upon reviewing the disclosure. Other embodiments may be utilized and derived from the disclosure, such that structural and logical substitutions and changes may be made without departing from the scope of the disclosure. Additionally, the illustrations are merely representational and may not be drawn to scale. Certain proportions within the illustrations may be exaggerated, while other proportions may be minimized. Accordingly, the disclosure and the figures are to be regarded as illustrative rather than restrictive.

[0037] One or more embodiments of the disclosure may be referred to herein, individually and/or collectively, by the term “invention” merely for convenience and without intending to voluntarily limit the scope of this application to any particular invention or inventive concept. Moreover, although specific embodiments have been illustrated and described herein, it should be appreciated that any subsequent arrangement designed to achieve the same or similar purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all subsequent adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the description.

[0038] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b) and is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, various features may be grouped together or described in a single embodiment for the purpose of streamlining the disclosure. This disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter may be directed to less than all of the features of any of the disclosed embodiments. Thus, the following claims are incorporated into the Detailed Description, with each claim standing on its own as defining separately claimed subject matter.

[0039] The above disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other embodiments which fall within the true spirit and scope of the present invention. Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

[0040] Although the invention has been described with reference to several exemplary embodiments, it is understood that the words that have been used are words of description and illustration, rather than words of limitation. Changes may be made within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the invention in its aspects. Although the invention has been described with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed; rather, the invention extends to all functionally equivalent structures, methods, and uses such as are within the scope of the appended claims.

CLAIMS

What is claimed is:

1. An apparatus for wirelessly re-charging a rechargeable battery, comprising:

a wireless receiver that amplifies received radio waves, the wireless receiver comprising a tourmaline and zeolite composite,

a patch antenna that filters the received radio waves to usable RF signals; and

a plurality of circuits that process the usable RF signals to create refined electric power for the rechargeable battery.

2. The re-charging apparatus of claim 1, in which the plurality of circuits further comprise a primary coil that converts the usable RF signals into voltage.

3. The re-charging apparatus of claim 2, in which the plurality of circuits further comprise a secondary coil that amplifies the voltage.

4. The re-charging apparatus of claim 3, in which the plurality of circuits further comprise low pass and noise filtering circuits.

5. The re-charging apparatus of claim 4, in which the plurality of circuits further comprise a voltage regulating circuit.

6. The re-charging apparatus of claim 5, in which the voltage is regulated at 4.5 volts.

7. The re-charging apparatus of claim 5, in which the plurality of circuits further comprise an RF tuning circuit that tunes the patch antenna.

8. The re-charging apparatus of claim 7, in which the patch antenna is tuned to receive usable RF signals having a frequency of between 50 Hz and 3.5 GHz.

9. The re-charging apparatus of claim 7, in which the plurality of circuits further comprise a rectifier that converts alternating current, received from the secondary coil, into direct current.

10. The re-charging apparatus of claim 9, further comprising an isolator that prevents RF interference with the RF tuning circuit, low pass and noise filtering circuits, and the rectifier.

11. The re-charging apparatus of claim 10, in which the plurality of circuits, the patch antenna, and the wireless receiver are in an integrated circuit.

12. A method for wirelessly re-charging a rechargeable battery, comprising:

creating a zeolite and tourmaline ceramic;

wirelessly receiving and amplifying radio waves with the tourmaline and zeolite ceramic,

filtering the received radio waves to usable RF signals; and

processing the usable RF signals to create refined electric power for the rechargeable battery.

13. The re-charging method of claim 12, in which the processing further comprises converting the received RF signals into voltage and amplifying the voltage.

14. The re-charging method of claim 13, in which the processing further comprises low pass and noise filtering of the voltage.

15. The re-charging method of claim 14, in which the processing further comprises regulating the voltage.

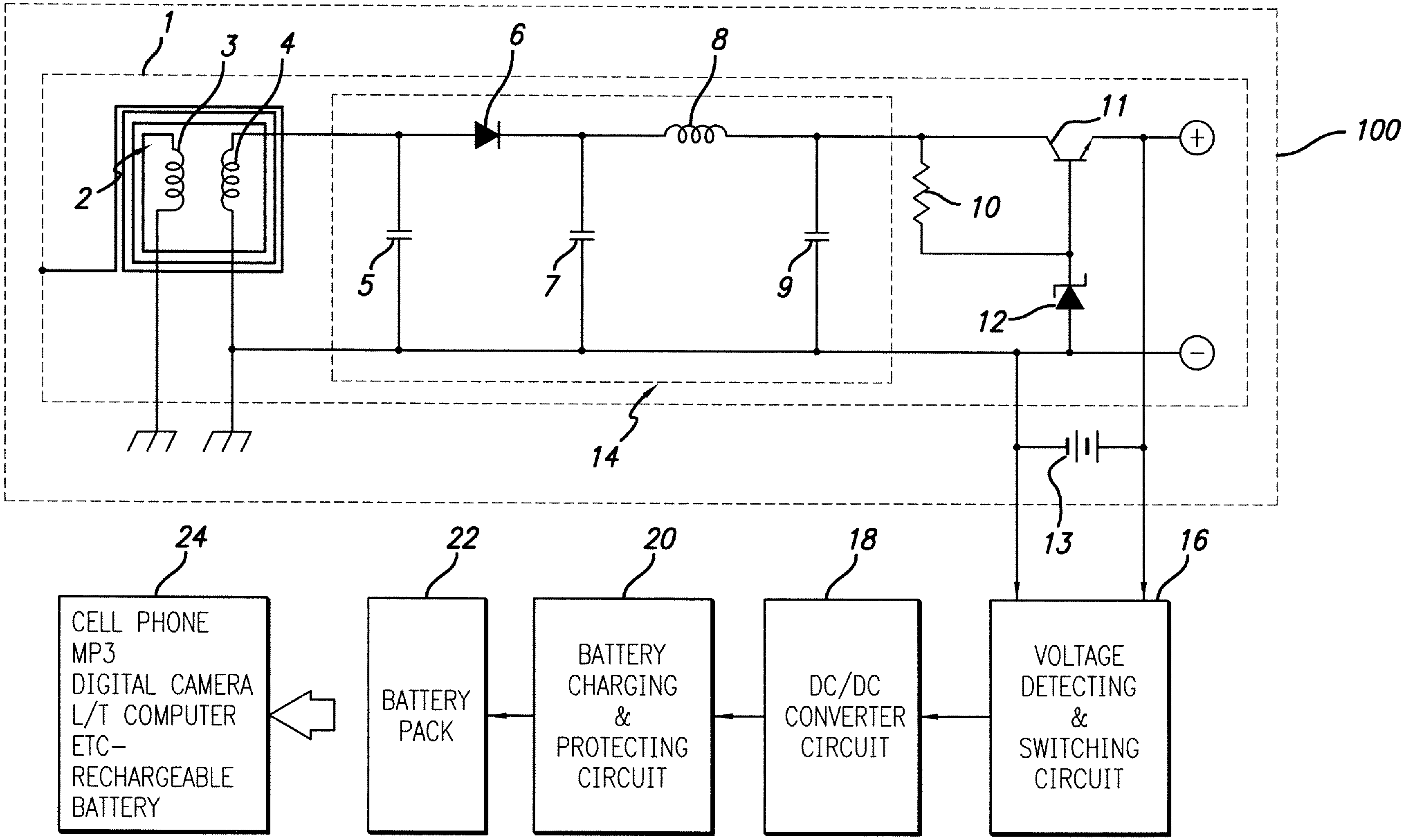
16. The re-charging method of claim 15, in which the voltage regulating is for 4.5 volts.

17. The re-charging method of claim 15, in which the processing further comprises tuning the patch antenna to receive signals having a frequency of less than 3.5 GHz.

18. The re-charging method of claim 17, in which the processing further comprises converting alternating current into direct current.

19. The re-charging method of claim 12, in which creating the ceramic comprises applying approximately equal parts tourmaline, zeolite and resin to a substrate having tourmaline thereon.

FIG. 1


1
2
3
4
5
6
7
8
9
10
11
12
13
14
16
18
20
22
24
100
CELL PHONE
MP3
DIGITAL CAMERA
L/T COMPUTER
ETC–
RECHARGEABLE
BATTERY
BATTERY PACK
BATTERY CHARGING & PROTECTING CIRCUIT
DC/DC CONVERTER CIRCUIT
VOLTAGE DETECTING & SWITCHING CIRCUIT

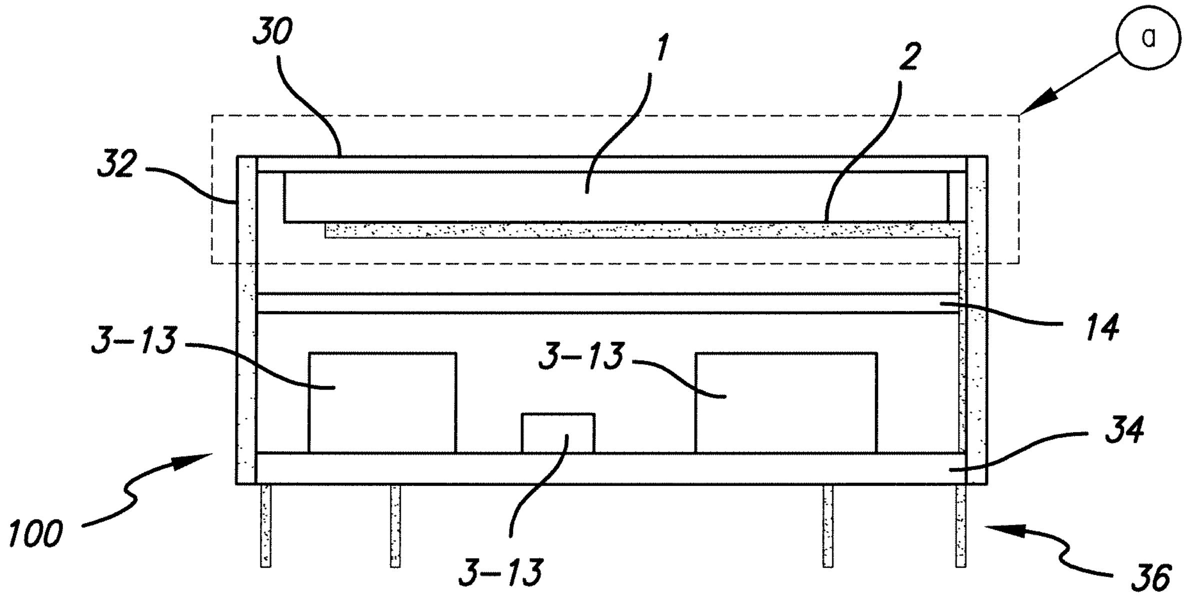


FIG. 2A

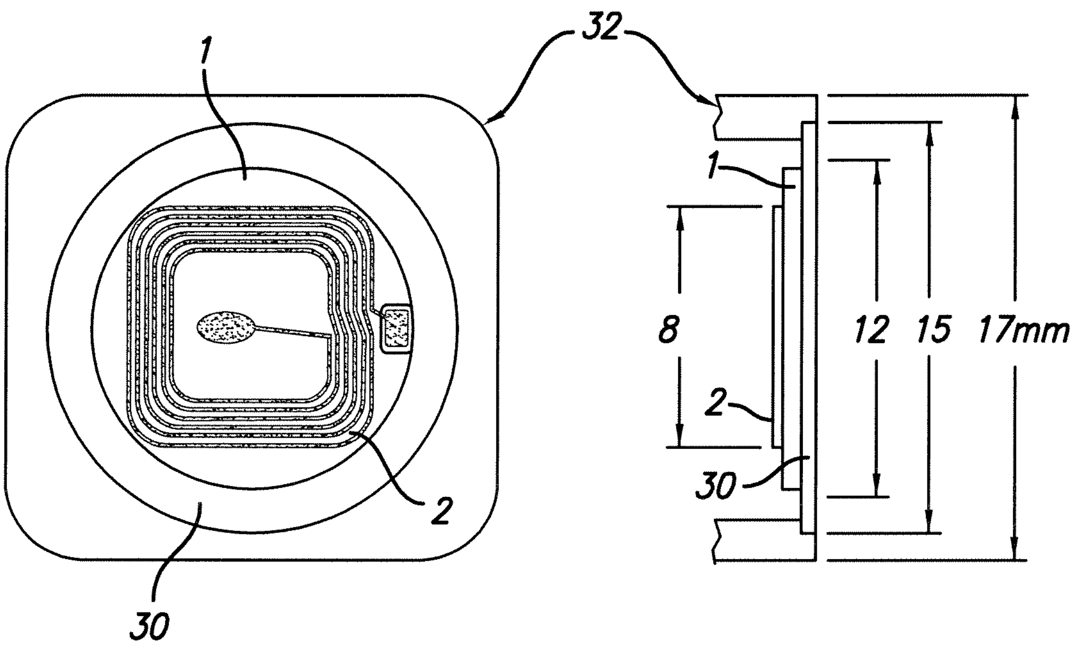


FIG. 2B

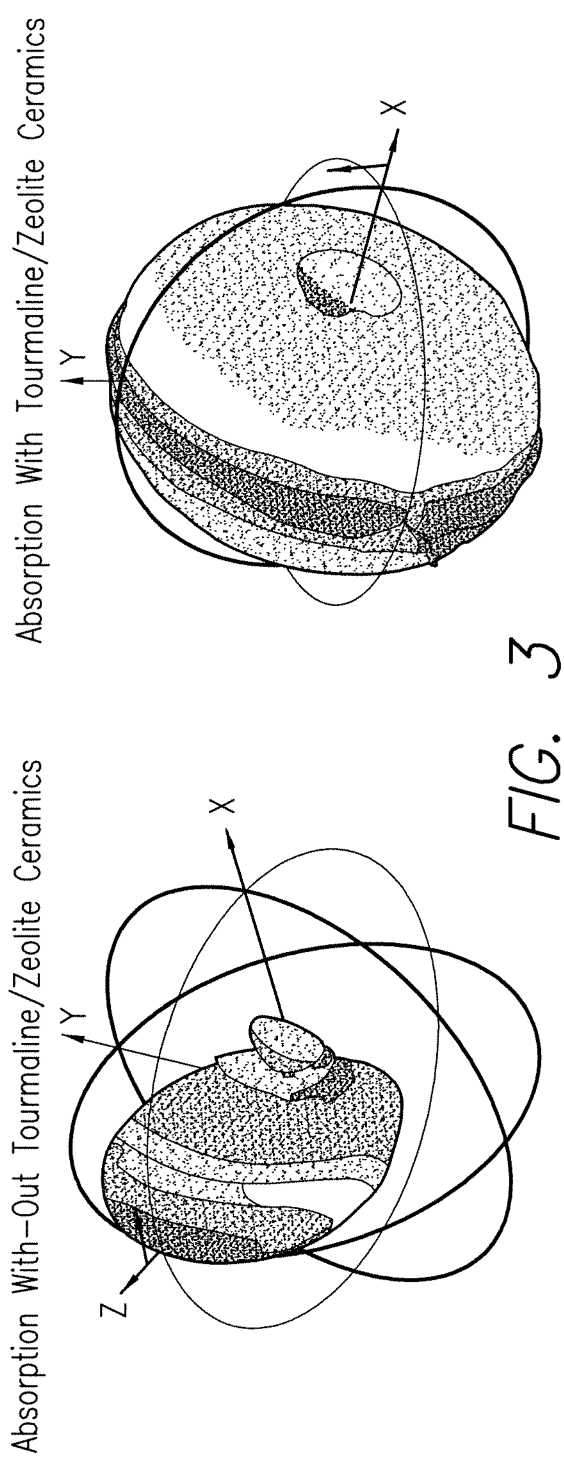
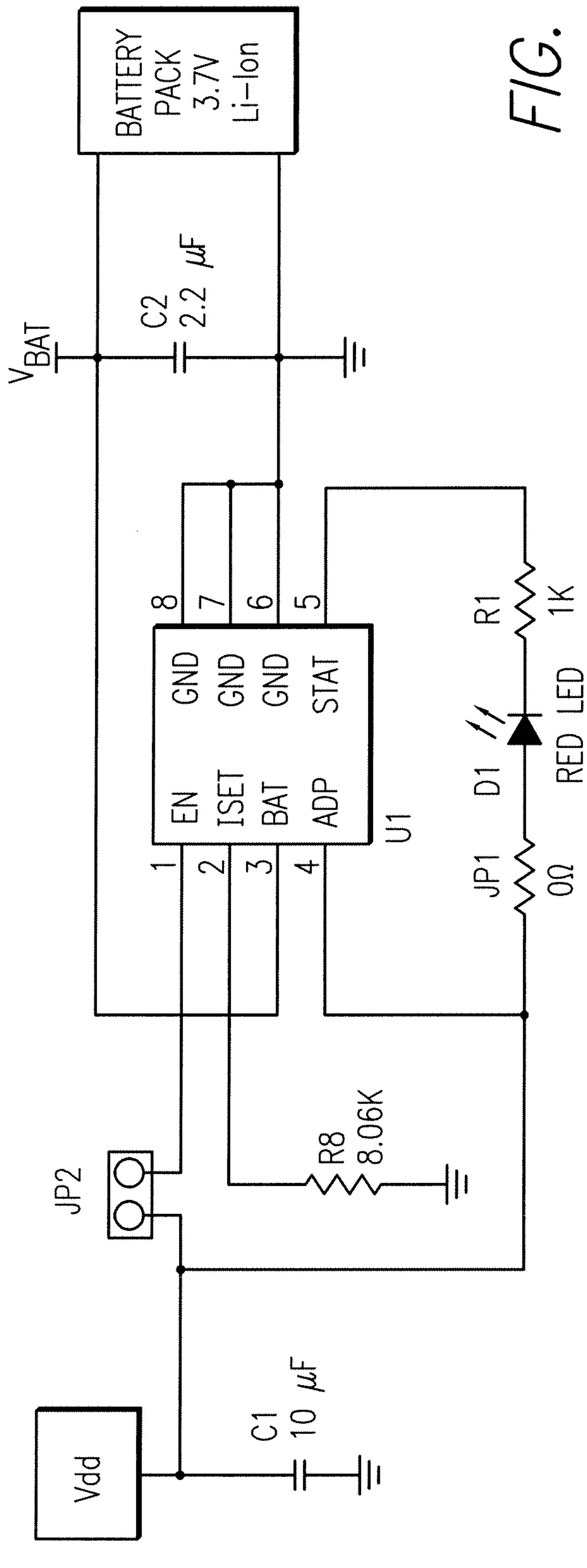


FIG. 3



Battery Charging & Protecting Board Schematic Diagram

FIG. 4

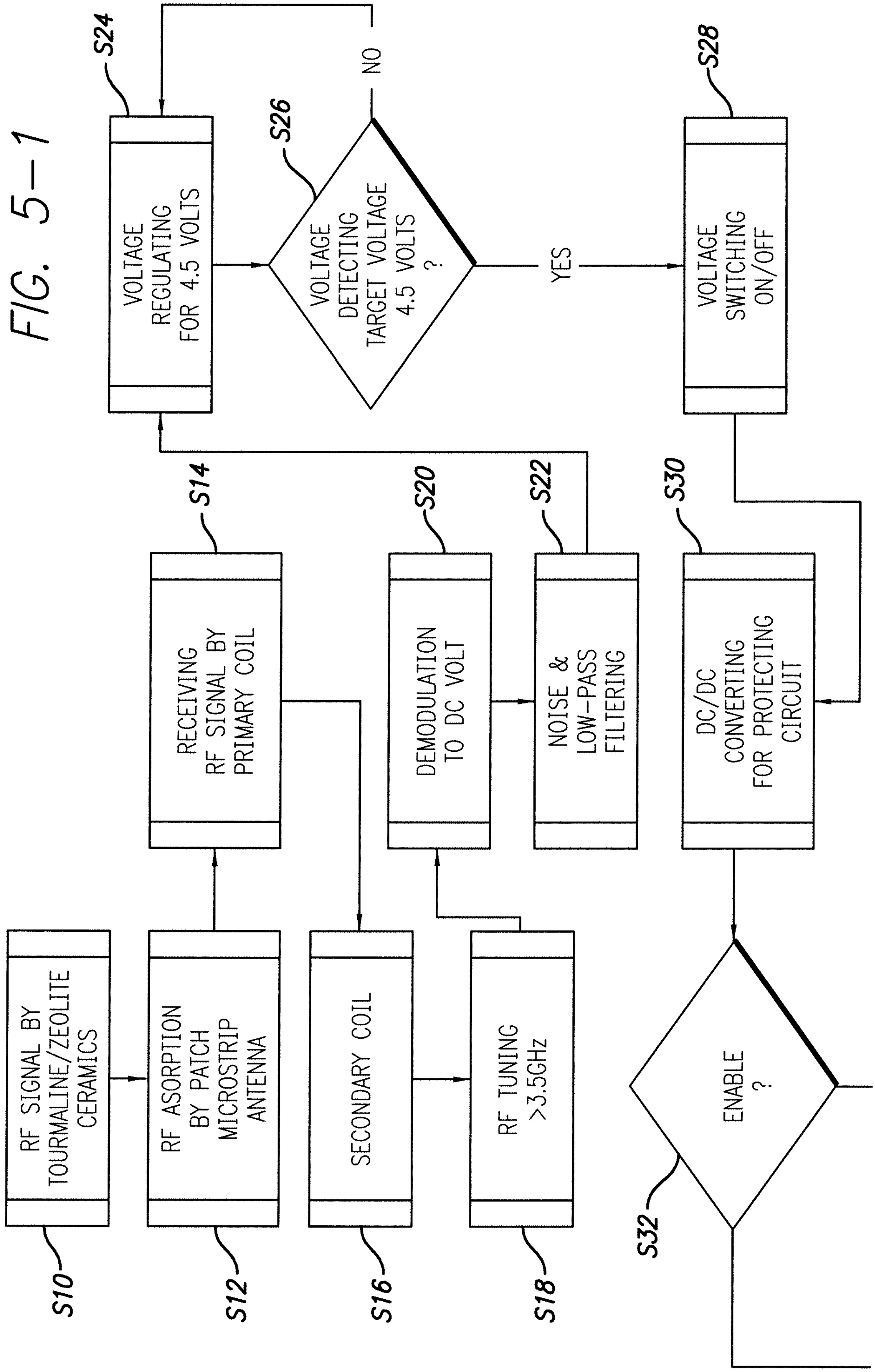


FIG. 5-1
RF SIGNAL BY TOURMALINE/ZEOLITE CERAMICS
S10
RF ASORPTION BY PATCH MICROSTRIP ANTENNA
S12
RECEIVING RF SIGNAL BY PRIMARY COIL
S14
SECONDARY COIL
S16
RF TUNING >3.5GHz
S18
DEMODULATION TO DC VOLT
S20
NOISE & LOW-PASS FILTERING
S22
VOLTAGE REGULATING FOR 4.5 VOLTS
S24
VOLTAGE DETECTING TARGET VOLTAGE 4.5 VOLTS ?
S26
NO
YES
VOLTAGE SWITCHING ON/OFF
S28
DC/DC CONVERTING FOR PROTECTING CIRCUIT
S30
ENABLE ?
S32

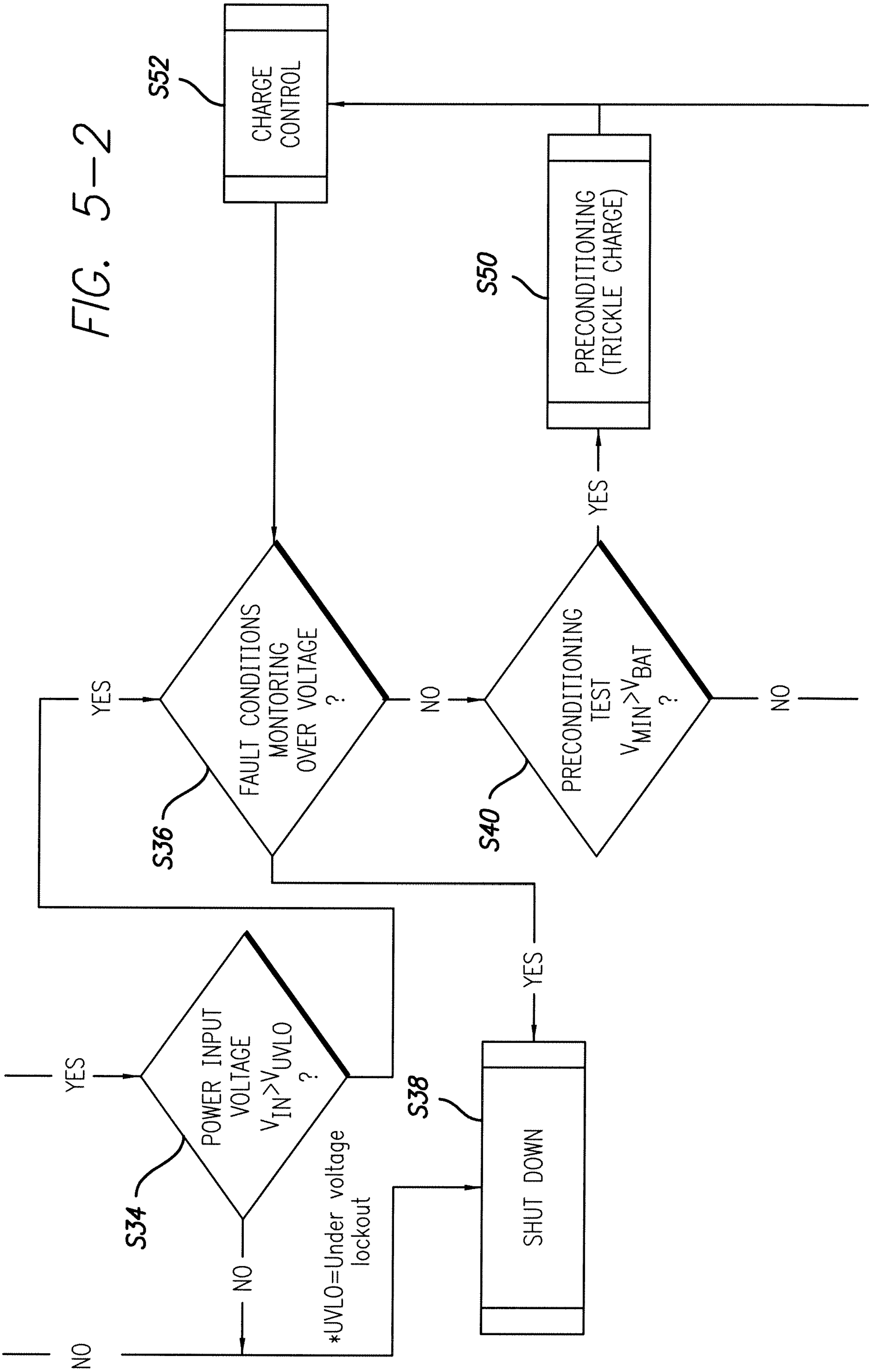

S52
CHARGE CONTROL
S50
PRECONDITIONING (TRICKLE CHARGE)
YES
S36
FAULT CONDITIONS MONTORING OVER VOLTAGE ?
YES
NO
S40
PRECONDITIONING TEST $V_{MIN}>V_{BAT}$?
NO
YES
S34
POWER INPUT VOLTAGE $V_{IN}>V_{UVLO}$?
YES
NO
*UVLO=Under voltage lockout
S38
SHUT DOWN
NO

FIG. 5-2

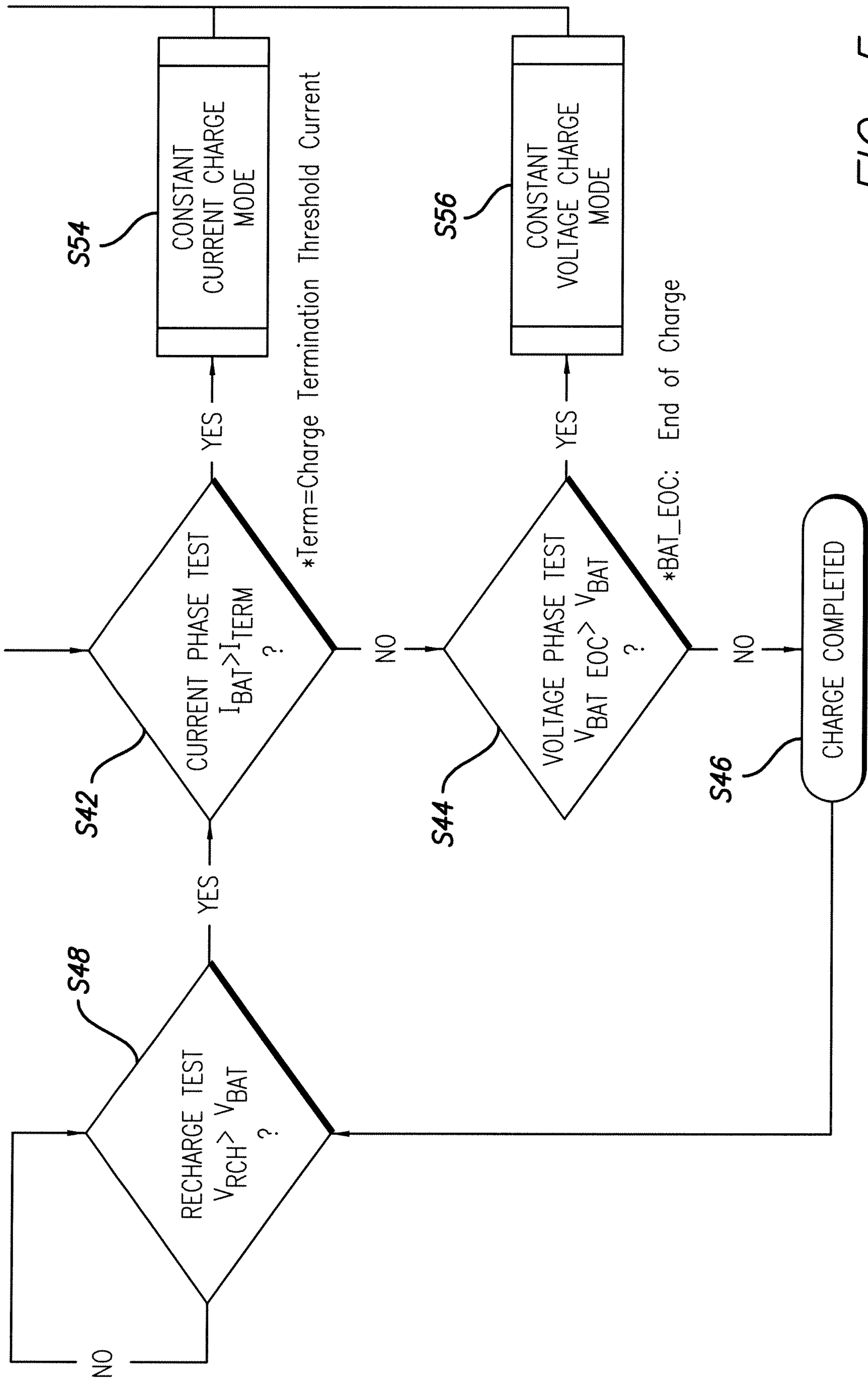

CONSTANT CURRENT CHARGE MODE
S54
CONSTANT VOLTAGE CHARGE MODE
S56
*Term=Charge Termination Threshold Current
*BAT_EOC: End of Charge
RECHARGE TEST V_{RCH}> V_{BAT} ?
S48
YES
NO
CURRENT PHASE TEST I_{BAT}>I_{TERM} ?
S42
YES
NO
VOLTAGE PHASE TEST $V_{BAT\ EOC}$> V_{BAT} ?
S44
YES
NO
CHARGE COMPLETED
S46

FIG. 5–3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US07/74264

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **H04M 1/00**(2006.01);**H02J 7/00**(2006.01)

USPC: 320/106,107;455/575.2,573
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 320/106,107;455/575.2,573

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/0032274 A1 (LEE et al) 8 February 2007 (8.07.2007), paragraph 38 and 47, figure 6 and 12.	1-19
y	US (7,058,362) B1 (KHORRAMI et al.) 6 June 2006 (06.06.2006), column 5, lines 5-20 and 45-67, figure 2.	1-19
y	US 2005/0017673 A1 (TSUKAMOTO et al.) 27 January 2005 (27.01.2005), figure 1.	1
y	US 2006/0063568 (MICKLE et al.) 23 March 2006 (23.03.2006), figure 1.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 June 2008 (02.06.2008)	10 JUN 2008

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US
Commissioner of Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (571) 273-3201

Authorized officer
Ullah Akm *Lydia Dale For*
Telephone No. 571-272-2361