specified voltage, under-voltage and over-voltage in the receiver coil clue to misalignment or other variation will resttit in shutdown of the battery charger circuit.

Effιeiency Enhancements through Coiℓ Voitage Clamping

[00167] **Figure 17** shows a figure of a circuit diagram 350 in accordance with an embodiment In accordance with one embodiment, **a** Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior to the regulator or battery charger circuit, as shown in **Figure** 17. Using a Zener aiiows more insensitivity to placement between the primary and receiver coil while maintaining the ability to charge or power the device. For example, the drive pattern on the primary can be set so that when the primary and receiver coii are aligned, the voltage on the receiver is above the nominal voltage for the battery charger startup. For example, for a 5 V startup, the voltage at center can be set for 8 or 7 volts. In this way, the Zener can be chosen to have an appropriate value (5 V) and clamp the voltage at this value at the input to the battery charger unit while the coils are centered or mis-aligned. Once the battery charger starts operation after detection of the appropriate voitage at the input, the battery charger circuitry will pull the voltage at this point to the pre-programmed voltage or voltage of the battery. in this way, the use of Zener diode enables less sensitivity to position and other operationai parameters in wireSβss chargers or power supplies and is extremely useful.

Efficiency Enhancements through Coil Stacking

[00168] **Figure 18** shows an illustration of a means of stacking coils, in accordance with an embodiment. In accordance with an embodiment, to achieve higher flux densities, a coil is constructed with two or more layers, for example by using two or more layers of printed circuit board. Multiple layer boards can be used to allow compact fabrication of high flux density coils. By altering the dimensions of the coil in each layer (including the thickness, width, and number of turns) and by stacking multiple layers, the resistance, inductance, fiux density, and coupling efficiency for the coils can be adjusted so as to be optimized for a particular application.

[00169] In accordance with an embodiment, a transformer comprising two PCB coiis separated by a distance has many parameters that are defined by the design of the coil, including:

R1 is the primary winding resistance,

RI is the secondary (in the receiver) winding resistance referred to the primary,

RL is the resistive load,

LIk1 is the primary leakage inductance,

L'ikZ is the secondary leakage inductance referred to the primary,
LMf is the primary mutual inductance,
Cf is the primary winding capacitance,
C2 is the capacitance In the secondary winding referred to the primary,
C12 is the capacitance between primary and secondary windings, and
n is the turns ratio.

[00170] In accordance with the embodiment shown in **Figure 18,** a multi-layer PCB coil 356 is created in separate PCB layers 357, which are then connected 358, and manufactured together via common techniques used in PCB fabrication, for example by use of a via or contacts. The resulting overall stack is a thin multi-layer PCB that contains many turns of the coil. In this way, wide coiis (low resistance) can be used, while the overail width of the coil is not increased. This technique can be particularly usefui for cases where smaS! x-y coil dimensions are desired, and can be used to create higher flux densities and more efficient power transfer.

Efficiency Enhancements through Coi‡ Shape and Materials

[00171] In accordance with an embodiment, the system can use a non-ferrite material for both the primary and the secondary (receiver) coils. For example, the coils can be made of copper materia! that is sputtered, deposited, or formed onto a printed circuit board (PCB), as described above. As also described above the coils can be formed in any number of different shapes, including, for example, flat or planar hexagonal shapes, or spirals. The coils can also be distributed in layers of coils, spirals, and other various shapes,

[001 72J One of the advantages of using a non-ferrite or non ferromagnetic material for the primary and secondary (receiver) is that the coils can be made much flatter and thinner than a ferrite coil. Additionally, non-ferrite coils can be made to have a lower inductance than a comparable coil made from a ferrite material (the inductance is on the order of 1 micro Henry, although the actual value wii! vary depending on the frequency of the voltage appiied to the coil). The non-ferrite nature effectively eliminates hysteresis in the coil, and allows the system to be switched on and off more rapidiy, and with less energy storage artifacts.

Variations in Coii Circuitry

[00173J In accordance with some embodiments, an inductance-capacitance (often referred to as an LC or "tank capacitor") circuit can be used to provide a range of power outputs to approximately suit the intended application. For example, the circuit can be optimized to suit either low-power applications, or high-power applications.

[00174] Depending on the particular intended application, the origina! capacitor (referred to herein as a "timing capacitor") in the circuit design can be removed and/or replaced with a different vaiue of capacitor to obtain a different overall level of power output. From a manufacturing perspective this is a relatively simple and inexpensive procedure. This technique can also be used to easily manufacture different charger or pad embodiments for different end-user applications, in that the majority of the pad components can be designed to be common to each pad design, with the primary difference being the vaiue for a single capacitor. This single capacitor can then be specified or changed during the manufacturing process. Although the timing capacitor can be used to adjust the system for, e.g. high-power or low-power applications, the final power output as it is received at the mobile device can be fine-tuned using additional techniques and features such as those described in further detail below.

CoH Waveform Generation

[00175] In accordance with an embodiment, a half-phase electrical waveform is used to charge the tank circuit, and to subsequently provide inductive power to the receiver coil in the mobile device. Unlike a full-phase waveform, the half-phase waveform can be used with a zero-crossing power supply. In accordance with this embodiment, when the transistor in the primary coil is first turned on, electrical current passes through the primary coil and the transistor to ground. When the transistor is turned off, the voltage level at the transistor swings high (anywhere from twice, to many times the value of the input voltage). This is the standard oscillation behavior of an inductor. When the current falls to zero the transistor is turned on again, and the process is repeated.

[00176] Many traditional transformer designs do not use half-phase waveforms, and instead use a non-zero-crossing design, since their ferrite core acts like a capacitor and stores energy during the off phase, which results in large losses in power efficiency if zero-crossing was used. However, in accordance with an embodiment, the use of non-ferrite coils, coupled with lower power (on the order of 2 Watts) allows for suitable efficiency with a half-phase and a zero-crossing circuit.

[00177] Furthermore, in accordance with some embodiments the half-phase waveform can be designed to have an exponential or curved shape, rather than an abrupt shape, so that higher frequency emissions are reduced. These higher frequency emissions might otherwise cause problems with portable and other devices, or conflict with federal communications regulations that prohibit high frequency emissions in consumer electrical devices.

Automatic Voltage Setting

[00178] In accordance with some embodiments, the system can include additional circuits, components, features, and techniques, which perform specialized tasks, such as mobiie device identification, and automatic voitage or power-setting for different devices. As described above, aithough the timing capacitor can be repiaced to modify the circuit frequency and the resulting output voitage of the system, this is not a practice! solution for aiiowing a consumer to modify the voitage, or to modify the voltage to suit the particuiar requirements of individuai mobiie devices. in practice the timing capacitor can be used to provide a partteuiar range of output power (i.e. high power applications; or low power applications). Additional techniques are then used to adjust the power for a particular device. This is particuiarly important when the charger or the pad is designed to power or charge multiple different devices simultaneously, since each of those different devices may have different power and voltage requirements, in accordance with various embodiments, different features can be used b support this, including:

- Hardwiring the receiver coii to take the voitage requirements of its device into account, and to use the appropriate dimensions to receive the correct voitage for that device. However, whiie this approach works to adjust the voitage for that device, it is by its nature hard-wired and does not provide much flexibiiity to adjust the voltage for interoperability between different devices and different chargers or power supplies.
- Use of dynamic programming to obtain a different voitage. In accordance with this embodiment, if the timing capacitance is known, then the frequency of the circuit can be adjusted to produce the required output voltage.
- In a zero-switching circuit, cupping can be used to tune the voltage. This can inciude turning the circuit on, then aiiowing it to turn off but clipping the waveform earlier, and then turning it on again. The process is then repeated. The clipping may be iess efficient than undipped switching, but can be used to tune the voitage,

[00179] When used with the above capacitor-based techniques, the choice of timing capacitor can be used to determine the overall range of the charger, power supply, or pad (for example, whether if is best suited for low power, or for high power applications). The additional features can then be used to fine-tune the frequency and the output voltage. in accordance with some embodiments, additional features can be used to improve efficiency and to add functionaiity.

£00180] As described above, in accordance with one embodiment, the pad circuit 260 incorporates a micro control unit (MCU) 286 that can enable or disabie the FET driver 268, The MCU receives input from another sensor mechanism that wii! provide information that it

can then use to decide whether a device is nearby, what voltage the device requires, and/or to authenticate the device to be charged. The communicated feedback from the receiver to primary can be used by the primary to, for example, adjust the frequency, or to otherwise aiter the output voitage to that receiver, using the frequency/output characteristics described above. Some traditional transformer designs use a third coi! to provide a measure of feedback. However the use of an MCU as described herein eliminates the need for such extra coi! feedback devices,

[00181] Also as described above, in accordance with one embodiment, a Zener diode 352 is incorporated to damp the maximum voltage at the output of the receiver prior to the regulator or battery charger circuit. In each of the feedback designs described above, the actual communication between the receiver and the primary as to voitage requirements can be of open loop design, or of closed ioop design. In an open ioop design, the charging device, pad or power source provides the power to the primary, which is then inductively transferred to the receiver and the mobile device or battery other device to be charged. The primary itself determines how much power should be received at the receiver. In a closed loop design, such as in a switching mode power supply, the device/receiver communicates information back to the primary, and then the primary determines how much power should be sent to the receiver.

Device Identification and Verification

[00182] **Figure 19** shows a figure of a circuit diagram 400 for identification verification in accordance with an embodiment. In accordance with an embodiment, the circuit design can be used to ensure a device is valid, i.e. authorized to be used with the charger, power suppiy or pad. The information can also be used as part of an open-loop or closed-ioop design to set the voltage for the device. In operation, the primary circuit is first turned on. An initial signal is generated as the circuit induces power in the receiver. This information is quickly compared with a number or value stored in the MCU, and is used to determine whether the mobile device (or the receiver associated with that mobile device or battery) is valid for operation with the base unit, charger, power supply, or charging pad. In addition to validation the information can similarly be used to set the charging voitage for the receiver, battery, or mobile device.

[00183] Figure **20** shows a figure of a circuit diagram 420 for bidirectional communication in accordance with an embodiment. As shown in **Figure** 20, in accordance with an embodiment the charger or power supply or primary can include means for communication with the receiver, battery, or mobile device, including for example radio frequency (RF) or other means of communication.

[00184] **Figure 21** shows a figure of a circuit diagram 440 for output controller in accordance with an embodiment. As shown in **Fjgure** 21, in accordance with an embodiment the output controller in the receiver waits untii power is sufficient, and then turns the power on to the mobile device or battery.

[00185] **Figure 22** shows a figure of a circuit diagram 480 for receiver with regulator or charge management circuit in accordance with an embodiment. As shown in **Figure 22,** in accordance with an embodiment the receiver includes a reguiator for regulating the voltage.

[00186] **Figure 23** shows a figure of a circuit diagram 500 for MCU reguiation in accordance with an embodiment. As shown in **Figure** 23, in accordance with an embodiment the MCU can provide the voltage regulation.

[00187] Figure **24** shows a figure of a circuit diagram 540 for unidirectional communication and data transfer in accordance with an embodiment As shown in **Figure 24,** in accordance with an embodiment the receiver can include a means of transferring data to the mobile device to which it is coupied.

[00188] **Figure 25** shows a figure of a circuit diagram 580 for time-based regulation in accordance with an embodiment.

Zero Voltage Setting

[00189] In accordance with some embodiments, the system can use a technique such as Zero Voitage Switching (ZVS) to provide more efficient power transfer and power supply controi. These techniques can also be used to provide more efficient regulation for power transfer between coiis of small induction value, such as those created by spiral patterns in PCBs, stamped metal coils, and low number of turns wound wire coiis. in switching mode power supplies used today, the common geometries used are boost buck, flyback, boost, or a variation of these types. In most of these geometries, the input voltage is switched rapidiy by a transistor such as a FET and the energy is transferred across a transformer to a load. in accordance with an embodiment, by adjusting the duty cycSβ of the switching circuit, regulation of transferred power is achieved.

[00190] **Figure 26** shows a high ievel view of a flyback power supply geometry 580 in accordance with an embodiment. During the time that the FET is ciosed, the current through the primary coi! stores energy in this coi! and during the period that the FET is open, this energy is transferred to the secondary (receiver) coil and into the load. The energy stored in the coi! is directiy proportional to the inductance of the coii and values of severa! hundred Henry are typica! for 10's or 100's of Watts of power supply power.

[00191] In contrast. Printed Circuit Board Coiis (PCBCs) are typically spirai circular, rectangular, or other shape coils that are printed on rigid or flexible PCB materia! or stamped

out of sheets of copper or by other methods where the coil or transformer in a power supply is primarily flat and takes very little space. Two of these coils placed with a distance between them (such as on both sides of a PCB material) or with an air or material gap (such as in wireless power applications where a charger transmits power to a receiver in an electronic or electric device that can be separated or removed from the charger) can be used to form a transformer such as the one shown in Figure 26. Switching of these coiis at high frequency (-1 MHz depending on the coil geometry and size) can transfer power across an air or material gap and an efficient power supply with a very small transformer can be developed. Uses of such compact coils for wireless powering of mobile devices such as mobile phones and MP3 players have been demonstrated. However, many prior techniques used a laboratory power supply to provide a sinusoidal or similar voltage to the primary coil and study the transferred power, rather than a compact efficient circuit for a power supply.

[00192] In accordance with a ZVS geometry embodiment, a capacitor is added to the circuit so that in the switch OFF position, the capacitor and the coil inductor create a resonant circuit. During the switch ON time, current passes through the inductor while the voltage across the capacitor is zero. During the period where the switch is turned off, the voltage across the capacitor rises to a maximum value of twice the input voltage and then resonates back to zero. A characteristic of this geometry is that the switch is closed exactly when this voltage arrives back to zero (hence the name Zero Voltage Switching), thereby minimizing power usage and achieving high efficiencies. Some of the benefits of this geometry include: High efficiency and 'Loss-less' transitions; Reduced EMS/EMC due to soft switching and use of sinusoids rather than square waves; Peak current is not higher than square wave switching; and Relatively simple control and regulation. In addition, this geometry can work very efficiently with Sow inductance values and is therefore better suited for the PC8C applications. In accordance with various embodiments the geometry can be configured to operate in various topologies, for example buck, boost, buck-boost, and flyback.

[00193] Some embodiments provide more efficient power transfer and power supply control and regulation for power transfer between coils of small induction value such as created by spiral patterns in PCBs, stamped metal coils, low number of turns wound wire coils, etc, In addition, typically, magnetic cores are not used if the coils are driven at high frequency. For a spiral coil, the inductance of a coil is given by:

$$L = \frac{r^2 N^2}{(2r + 2.8d) \times W}$$

Where

L = inductance (H)

r = mean radius of coil (m)

N = number of turns

d = depth of coil (outer radius minus inner radius) (m)

[00194] For example, for a coil of 10 turns, an outer radius of 15 mm, and inner radius of zero, then L=1 H. While larger values can be obtained by increasing the number of turns or stacking a number of coiis vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor.

[0019S] Spiral coils printed on PCBs without use of any magnetic core can provide high power transmission efficiency if operated at high frequency. An analogous method to the above technique is one referred to as Zero Current Switching (ZCS). ZCS operates by simiSar principles; however switching is done during zero current passing through the switch thereby achieving iow switching losses. In the following discussion, ZVS switching is generally discussed; however, the ZCS geometry can equally be applied to the foilowing. in accordance with some embodiments, methods are described for achieving and optimizing high power transfer with such smali and/or thin coils with iow induction values and describe several techniques for control and regulation of this power in real world power applications. While this technology is generally described for any type of power supply using such inductors, in accordance with a particular embodiment the two coiis in the transformer are separated, with the primary being in an inductive charger and the receiver embedded in a device, battery, casing, skin, or other part of an electronic or electric device. In this case, a wireless charger or power suppiy can be created which is especially useful for charging or powering mobile electronic or electric devices or batteries.

[00196] The advantages of use of ZVS geometry in general, and in particular for coiis with small inductance and no magnetic cores, has been described above. However, another important aspect of power supply design is the Control and Regulation Circuitry that is impiemented. Regulation of the power to a load can be achieved by a linear or switching regulator at the output stage. However, if the regulation of the power is achieved in this way and constant power is supplied from the primary coil, under light load conditions (such as when a battery is fully charged or a device is on stand-by, then the power generated and transmitted by the primary is mostly wasted leading to a low efficiency power supply. A better solution is achieved by adjusting the power into the primary coil under different load conditions, to maintain high efficiency during different load conditions or battery charging stages.

[00197] In accordance with an embodiment, such control of output power in a ZVS power supply can be achieved by changing the frequency of the operation. In this embodiment, the output power is inversely proportional to the operating frequency and control can be achieved by an appropriate contra! circuit.

[00198] Figure 27 shows how the output voltage to the load is monitored and with changes in the load condition, a chip or a Micro Controiler Unit (MCU) varies the frequency or the duty cycle of the FET driver to achieve optimum operation and controlled output voltage with a changing load. As shown in Figure 27, a digital controi 600 for operation is shown. However, analog operation can also be achieved and may be simpler and faster in response time to load changes and preferable in some applications. In the implementation shown, the primary (Control Circuit, Clock, FET Driver, FET, primary coil etc.) and the receiver (secondary coil, rectifier, capacitor, other circuitry, etc.) arB able to communicate through a wired connection.

Switching Wlode Power Supply with Wireless Com munseat!on

[00199] In accordance with an embodiment that includes a charger or power supply wherein the charger or power supply and the receiver are separable from each other (wireless or inductive charging or supply of power to devices), the charger or power suppiy can contain the basic control and switching functions while the receiver contains the rectifier diode and capacitor for smoothing of the output voltage and additional circuitry. In this embodiment the two parts need to communicate with each other wirelessly.

[00200] Figure 28 shows an implementation of a more sophisticated charger or power supply. According to this embodiment, where the primary stage and the secondary (receiver) stage communicate wireiessly. In the geometry shown in Figure 28, a digital control scheme is implemented. The primary (charger or power supply) 620 is controlled by a Micro Controi Unit (MCU 1) that receives signals from a Current Sensor in series with the coil. The communication between the charger and the receiver 630 is achieved through the same coil as the power transfer. However, these functions can be separated.

[00201] In the geometry shown, the secondary (receiver) contains circuitry that enables this part to modulate the load as seen by the primary. In accordance with an embodiment this is achieved through modulation of switch Q2 by an MCU2 in the receiver. This can be a very small Programmable IC (PiC) and can easily fit into very small form factors. As the primary charger or power supply sends power to the secondary receiver, the circuit in the receiver turns on. The power received is rectified and filtered by rectifier D1 and Capacitor C2 respectively. Since MCU2 requires constant voltage input at all times, a small, low current regulator (Voltage Regulator) for powering MCU2 only is incorporated. This can

be a linear or switching regulator. Since the power usage of MCU2 is very small and the unit can also be put into hibernation between tasks, use of this reguiator does not affect the overall efficiency much. The output of the rectified stage is input to a device or Charge Management iC for the case of a battery charger configuration. This Charge Management sc is integrated into most Origina! Equipment Manufacturer (OEM) mobile devices that operate by rechargeable batteries or can be integrated into or on a rechargeable battery to directly charge the battery when the battery is in proximity to the charger. The Charge Management IC typically, for a fully drained battery, will pass on the maximum input current to the battery b enabie rapid charging when the battery is at Sow voltage. This presents a Sow impedance load to the power supply circuit and requires the power supply to sustain the voltage at the required value while supplying the current. The Charge Management IC is in communication with the MCU2 which also monitors the output voltage (Vout) and tries to maintain this Vouf within a pre-programmed range. This is achieved by MCU2 sending a digital signal to Q2 to modulate the switch. This modulation is prior to the rectifier stage and is at high frequency so the rectified and smoothed Vout is not affected. However, this modulation of the impedance of the secondary stage affects the current through the primary coil stage and can be βasϋy detected by the Current Sense circuit in the primary.

[00202] In accordance with an embodiment the Current Sense circuit can comprise a small resistor in parallel to a voltage amplifier, a Hal! sensor, etc. The output of the Current Sensor is connected to MCU 1 and the digital sequence is detected by an A/D converter. The firmware in MCU1 determines whether the output voltage is too high or too low and then executes the appropriate step to adjust accordingly by sending a signal to a clock to adjust the frequency of the FET drive to bring the output of the power supply to within acceptable range. Higher drive frequency corresponds to lower output power by shortening the time for integration of power in the resonant ZVS cycle and lower frequency corresponds to higher output power.

[00203] In accordance with an embodiment, one method for implementing the variable frequency is to use a variable frequency source whose output frequency changes with change in the voltage to its input. Using a programmable resistor and changing this resistor value by varying a voltage signal from MCU 1, the frequency for driving FET 1 can be changed. Other methods for achieving this change are also possible.

[00204] As an example of the method for control, in a typical application, the operating frequency of the circuit can be 1-2 MHz and the data transmission for control is at 14.4 kbits/sec. If the full output power range is achieved by moving the frequency in the 1.2-1.4 MHz, this range is broken into 256 steps. In one implementation, the receiver sends a digital code corresponding to the output voltage and MCU 1 compares this to the earlier output

voltage value and makes a determination about which direction and by how many steps to move the frequency. The frequency is then changed accordingiy. In another implementation, MCU2 sends one of 2 values corresponding to a voltage high or low condition. If the voltage is within range, MCU2 does not communicate with the primary, When a voltage high signal is received, MCU1 , takes a pre-determined step towards higher frequency to lower the output power and the process is repeated until output voltage is within required range. A voltage low signal has the opposite effect. Many variations of these basic methods are possible to allow rapid, efficient locking of the output voltage. Proportional-integral- Derivative (PID) techniques, etc. can aiso be used. Depending on the geometry, the circuit may aiso use a switch Q3 in series with the load. This optional switch may be opened during communication to create a better signal to noise ratio. Since communication occurs in several msec, opening and closing Q3 rapidly does not have a large impact on charging time of a load battery that can be in many hours.

[00205] In accordance with an embodiment, as the battery charges and its terminal voltage rises, the Charge Management IC throttles the incoming current back, and switches to a mode where the voltage across the battery tβrminaS is maintained at or near its final value. The supply will sense a higher output impedance and MCU2 and MCU 1 work in concert to keep the output within range throughout the charging cycle. At the end of the charge cycle, the Charge Management sc can signa! end of charge cycle to MCLJ2 which sends a pre-determined code to MCU 1 to shut down the charger, move to hibernation mode or take some other pre-determined step.

[00206] It is important to note that, in the embodiment, the voltage regulator in the receiver does not regulate the output voltage to the ioad itseif. If the reguiator was performing this function, then the controi and regulation described here would not be necessary. However, the overall system efficiency is much lower and, with a constant power going into the receiver, some fraction of this power is wasted as the battery reached a full charge or as the ioad became lighter and less power was required. This wasted energy can heat up the receiver, the ioad, or the device battery depending on the geometry. All of these cases are undesirable. In the geometry described here, the primary can in these cases adjust to send less power to the receiver, thereby maintaining high efficiency regardless of load condition.

Verification and Data Transmission

[00207] In accordance with an embodiment, the digital transmission process described here is bi~directionai, and can be used for verification process at start of charge or power transfer to ensure that the right kind of device is present and about to be charged, or to

inform the charger or power supply about the voltage/power requirements of the device or battery to be charged or powered. In accordance with an embodiment, this bi-directional data transfer can also be used for actual data communication between a device and a charger or power suppiy. For example, the charger or power suppiy can be powered by the USB outlet of a laptop and simultaneously receive data from the laptop to be transferred to a mobile device. When a mobile device or battery is on the charger or power supply, it can be charged or powered, and its data can also be synchronized simultaneously through this channel.

Extension to Other Geometries

[00208] WNIe the above discussion has focused on one implementation of the control with a Zero Voltage Switching power supply, the basic concepts for the control, verification, and data transmission are applicable to other geometries and topologies, and can be implemented in a similar manner. in accordance with some embodiments, the Charge Management Circuit is optional and is only used when a battery is present at the load. For exampie, as shown in Figure 28, If Vout is used to directly operate a load, the Charge Management Circuit is not used and Vout is directly connected to the load.

Fully Regulated Switching Mode Supply with Wireless Communication

£00209] Figure 28, described above, shows the basic building blocks for a digitally controlled wireless control circuit for a Zero Voltage Switching (ZVS) circuit were described. The geometry shown in Figure 28 can regulate the output power through a wide range. However, as a battery charges or the load condition changes to require very low output powers, the accuracy required for control of the Vout may require many finer steps or not be possible with the geometry of Figure 28 alone.

[00210] Figure 29 shows an embodiment that includes an enhancement that can be used to address the ZVS issue.

[00211] In the fully regulated power suppiy shown in Figure 29, a voltage regulator (Voltage Regulator 1) that can switch the input voltage between 2 values or more is used. In normal operation, Q2 is closed and the Voltage Regulator 1 is shut down though its enable pin. Therefore, the input voltage is directly available for the Coil L1 and is regulated as described earlier. However, if the output requires extremely low powers (such as *end* of charge stage for batteries), and the charger determines that a switch to a different range is required, Q2 is opened, and Voltage Regulator 1 is switched on to change the input to Coil 1 to a lower voltage value. Regulation is maintained at this range by shifting to the appropriate

frequency to achieve required output power. For example, if Vin is 5 V, this lower voltage level may be 3 V. Multiple voltage levels are also possible.

[00212] Since for most cases, and in high power conditions, Q2 is open and Voltage Reguiator 1 is turned off, high overall system efficiency can be achieved. Only during the lowest current conditions, the input voltage is changed by switching this VoStage Regulator 1 on and regulating at this level. Depending on the type of regulator used, some efficiency loss can be expected in this regime. However, this occurs at very low output power levels only. Voltage Regulator 1 can be a high efficiency Switching DC-DC suppiy or a lower frequency, less complicated and less costiy itnβar reguiator depending on efficiency/cost trade-offs.

Regulated Switching Mode Power Supply with Opto-Coupfer Feedback

[00213] The geometries described above use a digital method for transmission of information between a primary and receiver circuit. However, in some cases, the load changes instantaneously. Examples are when in a iaptop computer, the screen or the hard drive start or shut down, etc. To handle these cases, the feedback loop has to be extremely fast to avoid having severe and rapid voitage overshoots and undershoots. This becomes especiaily important for high power appiications.

[00214] Figure 30 shows an embodiment in which instead of a digital feedback circuit, an analog circuit based on coupiing between an LED and a light detector can be used.

[00215] In this case, the output voltage, Vout is continuousiy compared to a reference voltage and the intensity of Sight from a diode changes rapidly in proportion to the voltage value. A detector in the charger stage provides a voitage value to a frequency controlier that controls the FET drive. An MCU in the charger, IvICU1 also monitors the process and can switch on an optional lower voitage input to the primary coil (through Q2 and Voltage Regulator} if necessary. It can also sense the end of charge or perform verification or other tasks.

[00216] In some embodiments a high power completely wireless inductive charger for a laptop requiring up to 90 W continuously can be implemented with this scheme. In accordance with an embodiment the transformer coiis are PCB spiral coils that have 4" or more diameters and comprise 7 turns with a total inductance of 1 micro Henry. The rapid response time of the analog circuit allows maintaining of the output voltage with rapid swings in the ioad. The charger or power supply comprises a pad where the charger or power supply circuitry and a flat spiral PCB coii are integrated into and the receiver comprises circuitry and a similar coii integrated into the bottom of a laptop. The optical components are mounted such that the Sight from the transmitter is detected by the receiver in the charger or power supply.

[00217] Digital communication through the optical parts is also possible to achieve this result, but requires a higher bandwidth and high speed processing.

[00218] It will be evident that these features, or any other geometry described here, can be combined to achieve the desired results. For example, white the control process for regulation may be through the opto-coupler feedback described here, a separate digital data link through the coil can be established for data transmission or verification of the charger, power supply, or vice versa.

Regulated Switching Mode Power Supply with Isolated Transformer Feedback

[00219] In accordance with an embodiment, another geometry for the regulation uses a similar analog feedback technique with the feedback information being transferred through a separate isoiated transformer.

[00220] **Figure 31** shows an embodiment in which the opfo-coupSer is replaced by a Voltage Controlled Oscillator (VCO) and FET and in the primary, the signal is sent to adjust a frequency controller to provide optimum output voltage. An optional voitage regulator and switch Q2 can also be used to provide precise control at low output powers. Similarly, this communication can be implemented digitally, and also requires a high bandwidth to allow for rapid response. Since the circuit in **Figure 31** is completely wireless and does not require optical components, it may be preferable in cases where an optically transmissive window in the charger or power supply or the receiver may not be possible.

Regulated Switching Mode Power Supply with RF Feedback Regulation

|00221J In accordance with another embodiment, the information between the charger and the receiver can be exchanged through a wireless link in the two parts. The advantage with this embodiment compared to the optical case is that the two parts do not need to be optically transmissive. In addition, compared to the earlier-described versions (optical and through a transformer), the relative alignment is not as important. However, in most practical application, the charger or power supply and the receiver coil will be aligned for power transfer, so an alignment of some degree will occur and with the right geometry, can enable transformer or optical feedback alignment and regulation to be implemented.

[00222] **Figure** 32 shows an embodiment in which the wireless link can be analog or digital (requires higher bandwidth and complexity) or can be integrated into the device to take advantage of existing wireless links in the device (Bluetooth, WIFi, Wireless USB. **WiMax,** etc.).

[00223] **Figure 33** shows a basic schematic for an inductive single coil charging system in accordance with an embodiment. As shown therein, the coil inductor in the

charger pad is switched by Switch T which is typicaily a FET transistor. A capacitor in paraiiel with the FET may be used to improve performance. The receiver in the right hand side comprises a similar coil, rectifying diode, and a capacitor to provide DC output to a load R_L.

[00224] Figure 34 shows the main components of a more advanced wireless power/charging system. Charge Management IC in the receiver aiso controls the charging of the battery to ensure appropriate charging. The MCU1 and current sense chips in the charger and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The optionai voltage regulator in the receiver is used to provide a constant low current voltage to MCU2 and is not reguiating the power into the battery. The Receiver is integrated into or on a mobile or eiectronic device or a rechargeabie battery. Points A, B and C are described later and can be used for placement of switching circuits. Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00225] An embodiment of the system incorporates a MicroControl Unit (MCU1) that can enable or disable the FET driver. This system also uses a Charge Management IC in the receiver which controls the charging of the battery to ensure appropriate charging profile is followed and the battery is not overcharged. Most mobile devices today aiready include a Charge Management IC in their power circuit between the input power jack and the rechargeable battery of the device to control charging of their internal battery. This chip can be incorporated into the receiver circuitry to enable a battery to directly receive power from an inductive source as shown in Figure 34.

[00226J Figure 34 also shows a Zβner diode (Z1) incorporated at the receiver. This Zener is used to ensure that the output voltage from the rectifier does not exceed a pre-determined value. In some instances this may be important, since the output of the receiver is fed into a Charge Management IC that may have a finite turn-on time. At the beginning of charging (when a device is placed on a pad first), the Charge Management IC may seem like a high impedance load. Without the Zener diode, such a load may cause the voltage the input to the Charge Management Circuit to increase to high values, potentially exceeding its safe operating conditions. A fast Zener diode can clamp the voltage under this or other unusual conditions and may be incorporated into the receiver. Depending on the architecture, other methods for avoiding such conditions may be incorporated. incorporating a Zener Diode is an effective, and inexpensive method for dealing with these potential issues.

[00227] In accordance with an embodiment, the receiver may aiso incorporate a voltage regulator just to provide a constant voitage (or voltage in the acceptable range for

operation) to MCU2. This voltage regulator just provides the iow power necessary for this and is not in the path of the main power going into the battery. Any power loss due to this regulator is small, because it is very Sow power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained.

[00228] The MCU 1 receives input from another sensor mechanism that provides information that it can use to decide whether a device or battery is nearby, what voitage the device or battery requires, and/or to authenticate the device or battery to be charged or powered. Several examples of the mechanisms for providing this information are:

[00229] The MCU1 periodically starts the FET driver. The current through the FET is monitored through a current sensing method. The inductance of L1 is highly dependent on the presence of objects nearby that affect its magnetic field. These objects Include metaliic objects or another nearby coil such as L2. Switching L1 at high frequency (100 kHz to several MHz) through a Field Effect Transistor (FET) such as Q1, the value of current being drawn is highly dependent on the L1 Value. This property can be used to sense the presence of nearby devices or batteries capable of drawing power and also to enable bi-directional communication if desired. Severa! methods for this are possible:

- A small resistor can be placed in series with the FET to ground contact. The voltage across this resistor can be measured by a current sensor chip such as Linear Technology Current Sense Amplifier part number LT1787.
- A Hall sensor such as Sentron CSA-1A that measures the current from a wire running under it can be piaced on top of the PCB Sine from the FET to the ground to measure the current without any electrical connection to the circuit. The advantage of this approach is that no extra resistor in series with this portion of the circuit is necessary reducing the impedance.
- Other techniques can be used to measure the current.
- By monitoring the current and comparing it to a baseline measurement taken at power *up,* and periodically with no devices nearby, MCU 1 can determine whether a device or battery is near the coil and drawing power. This provides a first level verification of an object capable of drawing power being nearby. However, there may be a possibility of false starts with metallic objects or wires in any electronic device or battery drawing power. A second level of verification may be desirable.

[00230] To enable a more secure verification, in accordance with an embodiment the MCU 1 can periodically start the FET driver. If current is being drawn, MCU 1 may activate the Q1 in a predetermined state (for example, this may be a iow power state). This can provide a first level indication that a receiver may be nearby. If there is a genuine receiver

nearby (versus, say, a metallic object, electronic device, or a non-approved receiver), the emitted power from L1 will power the receiver circuit. The charge control circuit in the figure or another chip in the Receiver circuit can be pre-programmed so that on power-up, it draws current in a pre-programmed manner. An example of this is the integration of the MCU2 and chip model number 10F220 Programmable IC by Microchip Inc. or another inexpensive microcontroller that upon power-up, executes a predetermined program that modulates the current being drawn in the receiver in a predetermined code (which can be encrypted). This receiver modulation can be detected as a current modulation in the current through the L1 by the charger or power supply current sensor in **Figure 34**.

[00231] After the initial handshake and verification, the MCU1 and current sense chips in the charger or power supply and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The system can also regulate the power and voltage received at the Charge Control Circuit to insure overvoltage conditions do not occur. As shown in **Figure 34**, switch Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00232] If the handshake and verification between the charger or power supply and the receiver is not successful, the MCU1 will assume that the device drawing power is not an appropriate receiver and will terminate powering it. This process invalidates false starts due to objects being accidentally placed on the pad, and also provides protection against counterfeit or non approved receivers. An RFID, Near-Field Communication (NFC) or other wireless data transmission method reader that can detect an RFID, NFC, or other tag included with the receiver circuit and antenna (i.e. device or battery to be charged). The information on the tag can be detected to identify the voltage for the receiver required, and to authenticate the circuit to be genuine or under license.

[00233] The information on the tag can be encrypted to provide further security. Once a device containing the tag is near the charger or power supply pad, the tag reader is activated, the system reads the information on the tag memory, and compares it with a table to determine authenticity/voltage required or other info. In some embodiments, this information table can also reside on the MCU1 memory. Once the information is read and verified, the MCU1 can enable the FET driver to start driving the coil on the pad and to energize the receiver.

A Hall sensor or a Reed switch can sense a magnetic field. If a small magnet is placed inside the receiver unit of the system, a Hall sensor or Reed switch can be used to sense presence of the magnet and can be used as a signal to start the FET.

Other capacitance, optica!, magnetic, or weight, etc, sensors can be incorporated to sense the presence of a receiver and to begin the energy transfer process.

[00234] The methods for verification and communication between the charger or power supply and the receiver are provided above by way of example, and in accordance with various embodiments, in practice a combination or a variation on the above methods may be used. it will aiso be evident that different embodiments can use different verification techniques, in addition to or instead of those described above, and various combinations of such.

Efficiency Enhancements through Latera! Offset Between Coils

[00235] Figure **35** shows a typical experimental curve for power transferred and Power Transfer Efficiency through a pair of circular spirai coils as a function of iateral offset between the center of the coiis. The power transferred is shown at the receiver after rectification and other eiectronics, and is the DC power availabie for charging/powering a device. Power Transfer Efficiency is defined as the DC Power out from the receiver divided by DC power into the charger or power supply circuit; so it includes any power consumed by the FET driver, the FET, rectifier diode, and other electronics. This efficiency includes ail losses (electronics, coil to coil losses, rectifier, etc.) and is a more practical number for efficiency than the ratio of AC power out of a receiver coil to AC power into a charger or power suppiy coil commonly used. It can be seen that very efficient power transfer efficiency can be obtained with inductive methods. In accordance with the example shown, the coiis can be identical and 1.25" in diameter and comprise 10 turns.

[00236J As can be seen from **Figure 35,** for the coil geometries used here, at an offset between the center of coiis of half the radius, the power transferred can be 75% of the maximum value. Improvements in flatness of the curve may be possible with changing the design of the coii to overlap more of the field on the outer areas of the coii or by using hybrid coils.

[00237] However, it is important to note that while the transferred power decreases with offset between the coil centers due to reduced overlap of the coii areas, the power transfer efficiency (ratio of DC power out from receiver to DC power into charger or power supply) remains relatively constant in the range of offset < 3r/4. This is a more critical factor in design of an efficient system. If one assumes that a system can be designed such that the coil offset is never larger than r/2, then in a wireless charging or power transfer system, then, one can design the system such that the power transferred at this maximum possible offset is equai or greater than the maximum transferred power necessary.

[00238] For example, if Figure 35 represents the maximum power transfer possible given the particular coi! type, size, and geometry and the switching circuit (FET) and circuit design, then 3 W or more power can be transferred depending on the offset between the coils assuming that the coil offset is always sma‖er or equai to r/2. For a power suppSy application where regulated, constant power to a device is necessary, using regulation of the output power or a feedback to the charger or power supply to change the frequency or duty cycle, etc. to keep the power constant can insure that the received power to a device is independent of the offset between the cσiSs. For example in this case, using regulation, one can ensure that up to a maximum power of 3 W can *be* provided to a load independent of coi! offset (up to the maximum allowable offset - assumed to be r/2 here). in this case, the 3 W is sufficient for most mobile devices (mobile phones, cameras, Bluetooth headsets, etc.). Again, if is noted that the overall efficiency of the system remains high in all cases, since the offset (within the range of possible offset values) and regulation of the power (if it is performed at the charger or power supply by changing duty cycle, etc.) do not have a large impact on efficiency.

Position Independence using Layers

[00239] From the discussion above, one can achieve the goals of high efficiency and position independence if a method is found wherein the offset between the charger or power supply and receiver coils is always kept equal or iess than r/2. In the case of hexagonal spirals with side = r, the maximai diameter is 2r (similar to a circle with radius r). So for a given hexagon with side ≃ r, the same relation holds. As described herein, several methods of achieving this are proposed.

|00240] Figure 36 shows *&n* embodiment in which a coi! mosaic is used to cover the surface area of the pad. The circuitry can include means of sensing the presence of a receiver coi! to start the appropriate driver to provide power. The drive and sense circuits and other electronics are shown here as components in the perimeter of the coi! area but can be located anywhere. The approximate Effective Area is also shown. !f the center of a receiver coi! is placed anywhere within the effective area, the receiver will receive the specified power with only one appropriate coil in the charger or power supply activated.

[00241] in the geometry described here, each coil is driven by its own drive circuit. A sensing mechanism senses the presence of a receiver coi! on top or close to a charger or power supply coi! and starts the drive circuit to power the appropriate coi!. The sensing mechanism can be a current sense mechanism. Each coil drive circuit can periodically start driving the coi! at an appropriate frequency and a current sense circuit can monitor the drawn current to sense when a receiver is nearby thereby affecting the inductance of the charger or

power supply coil. Driving the charger or power supply coil circuit at an appropriate frequency determined by the inductances of the charger or power supply and receiver coiSs and the capacitance of the load, can provide very high sensitivity to this change in the inductance,

[00242] Additional verification can be obtained by exchanging a verification code through the coils or by exchange of information through a second wireless data communication link (such as RFSD, NFC, WiFi, etc) between the pad and the device(s) to be charged. The code exchange can also provide information to the charger or power supply coil regarding the necessary voltage, power, temperature, or other diagnostic information for achieving reliable charging.

[00243] The approximate Effective Area is shown in Figure 36. Any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within half a width or less of the center of at least one charger or power supply coil. If the system is designed such that moving the receiver coil within half the width of the center of any given activated coil provides at minimum the maximum output required (i.e. 3 W in the earlier example), the Effective Area has the property that a receiver coil with its center anywhere within this area can receive the necessary maximum output power or more with only one appropriate charger or power supply coil activated.

[00244] For the geometry shown in Figure 36 comprising 75 hexagonal coils with side = r in 3 layers, the effective area is approximately 12 r wide and 6 mr high where mr is the minimal radius of the hexagon = √3 r. The total area is approximately 62r. In accordance with an embodiment, the Coverage Efficiency (CE) is defined as the Effective Area in units of coil radius (for circular coils) or length of side (for Hexagonal coils) divided by the number of Coils used. CE ~ 0.83 in this example.

[0024S] To consider an example, one can take the maximum offset between the receiver and charger or power supply coil to achieve sufficient output power to be half the width of a coil (assuming symmetrical coils). Using coils with different width or radii (in the case of circular coils) or other geometries would change this value, it can be shown that a hybrid coil with a PCB coil and a wound wire coil are placed on top of each other is shown to have a more flat power transfer efficiency curve as a function of offset between the charger or power supply and receiver coil offsets. The general results and the operating principles for the embodiments discussed herein are valid regardless of what type of coil, geometry, or regulation is used to allow larger (or smaller) insensitivity to charger or power supply/receiver coil offset.

[00246] For the remaining portions of this document, embodiments are generally described which use half the width of the charger or power supply coil as the maximum

allowable offset between the charger or power supply and receiver coil before the transferred power becomes Sower than the desired maximum transferred power value.

[00247] The sense and control mechanism in the Configuration shown In Figure 38 may be shared between a number of dnve circuits to reduce parts count or may be integrated with each drive section. A number of other sense mechanism such as magnetic, optical, or capacitance sensors may also be used.

[00248] Figure 3? shows an alternative embodiment in which the number of drive (and sensing) circuits may be reduced by using 1XN electrical or electronic switches. In this embodiment, a number (N) of coils are connected to a 1XN switch that is on the other side connected to a coil drive and sense circuitry. The switch periodically switches each of the coils in rotation to the coil drive and sense circuitry. Once an appropriate receiver coil in the vicinity of a charger or power supply coil is detected, that coil may be interrogated further to verify a chargeable device is nearby and then charging or powering of the device begins.

[00249] One drawback of this scheme is that since each drive electronics module can at most only be connected to 1 coil out of N coils in each segment, 2 devices placed on 2 different coils in that segment may not be powered or charged simultaneously. In practice, since each device to be charged will cover a certain amount of area on the surface, by appropriately segmenting the pad and choosing the size of charger or power supply and receiver coils, one can minimize the impact of this effect.

[00250] For an extreme case that N= NC (i.e. the number of coils in the pad), one can use a single drive and sense electronics module to monitor and power any coil in the pad thus greatly simplifying the architecture and potentially the cost of the charger or power supply. However, only one receiver coil, and hence only one device may be powered up or charged at any given time. The desirable characteristics of the 1XN switch are:

- Low ON resistance: This would reduce wasted power in the form of heat at the switch.
- High current capability: For power charging applications, depending on application and device to be charged, 0.5 A and higher, up to several Amps of current may be carried in ON state.
- High reliability: Failure of a switch would render the related segment dysfunctional.

Fortunately, the switching speed of the 1 X N switch is not critical for this application. For example, if it is desired for the pad to have a 1 second response time (time it takes for the pad to sense a device and begin charging), the switch must be able to disconnect and establish a new connection in under 1/N seconds (ignoring the time it takes for the sense and control circuitry to work which can be extremely fast). As an example, for N=10, this switch

disconnect and connect time is under 100 msec, which is quite achievable. Even lower switching speeds are acceptable for longer response times.

[00251] In accordance with an embodiment, the 1 X N switches may be implemented by eiectronics circuits or SPOT or DPDT iC switches, relays, MOSFETs, or ivlicro-Electro-Mechanical Systems (MEMS) switches. Other methods for switching may also be employed.

[00252] As an example of a an IC switch for this application, a series of Single Pole Double Throw (SPDT) switches with relativeiy low R_{ds} of 80 mΩ that can be used in this application. An example of the SPDT is available in a Quad (four switches) pack and is capable of carrying 500 mA which is sufficient for most low power applications. If larger current carrying capability is desired, two or more of the switches may be used in parallel. This particular IC also incorporates over current, short circuit, and temperature sense circuitry which provides additional safety features for a system. A 1XN switch can be created by connecting several of such switches.

£00253] In accordance with one embodiment, the surface of a charging pad is divided into segments where within each segment, a significant Effective Area wherein the center of a receiving coil can be placed to receive power is created.

[00204] Figure **38** shows a case where a three-coil layer PCB is arranged to provide a cluster for uniform power in an area using only one coil powered at any given time. In this case, layer 1 comprises six coils arranged around a central coil for a totai of seven coils. The second and third layers comprise six coils totai. in total, nineteen coils exist in the three layers of the PCB.

[0020S] Figure 39 shows the coils are arranged such that by powering only one of the coils in the cluster, any receiver coil (for the receiver) placed with a center within any location in the effective area receive the specified power if the appropriate charger or power supply coil is activated. When the three layers are stacked together, seen from above, the structure is as shown in Figure 39. As described above, any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within haif a width of the center of at least one charger or power supply ∞ is. Therefore, it can receive the necessary minimum power or more with only one appropriate charger or power supply coil activated.

[00256] For the case shown in Figure 38 with nineteen distinct coils, five of the quad SPDT chips mentioned above can provide the necessary Switching capability to allow a single drive and sense circuit to sense the presence or absence of a receiver coil near each coil. In accordance with an embodiment, the sequence can be:.

- The switches are set so that the coil 1 in Layer 1 shown as (1,1) in Figure 38 is connected to a switching and sense circuitry similar to the left side of Figure 34 (i.e. the charger or power supply in Figure 34).
- MCU 1 gives a command to the FET driver to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- If a receiver coil is nearby, it begins drawing power from the charger or power supply coil. This can be sensed as a higher than normal current draw in the current sense circuit of the charger or power supply.
- AdditionaSly, the charger or power suppSy and receiver coii can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified,
- At this point, the amount of current through the sense circuit is digitized by MCU 1 and saved in its memory,
- Alternateiy, the receiver circuit can note the amount of voltage or power being received and report back to the charger or power supply. This information can be encoded by modulating the input impedance of the receiver circuit by MCU2. This information is then sensed by the charger or power supply sense circuitry, digitized by MCU1 and saved.
- The FET driver and therefore the FET are disabled.
- The switches are configured to connect the drive and sense circuitry to the next coil (Coil (1,2) in this example).
- Commands 2 through 8 are executed untii ail coils have been activated and tested.
- MCU 1 compares the values received for sense currents and determines which coil has the highest sense current when turned on. This is the closest charger or power supply coil to the receiver coil. If additionai circuitry for confirmation of valid receiver through exchange of code is implemented, the closest coil has to aiso pass this test
- The appropriate coii is turned on and charging starts. An additional verification can be performed prior to start of charge.
- The charging continues in open or closed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00257] Depending on the characteristics desired and cost/performance tradeoffs, it may be decided that for each cluster, 2 or more drive and sense circuits and a smaller number of switches are used.

[00258] Figure 40 shows one configuration wherein the number of switches required is reduced to three to switch to any of the 20 coils in Figure 39. The first switch connects the Vc to one of the ports (outside or inside contact point of the spiral coil) on every coil in one of

the three layers. The other ports of groups of three of coils from different layers are connected together and input into the switches 2 & 3 as shown in the figure. The outputs of Switch 2 & 3 *ar&* connected together, and connect to the FET for switching. The center coil (1,7) is connected to the poles of the switches by itself. This coil is often the most iikeSy coil for the receiver coil to be adjacent to since it is central. Comparing **Figure** 40 with **Figure** 34 shows that using this scheme,, any one of the coils in the system can be connected by the switches to be driven by the FET.

[00259] Depending on cost/performance trade-offs involved, it may be advantageous to cut the number of switches by schemes such as shown in Figure 40. Such a scheme can aiso be used to cut down the number of switches in a Sarger array. For example, the array in Figure 36 comprising 75 coiis would require 19 Quad SPDT ICs to implement However, by using one Switch to choose one of the 3 iayers and 7 switches to choose one of the 25 coiis in each layer, one can achieve the same results with 8 totai switches.

[00260] With further cascading of switching layers, it is possible to further reduce this number. However, it must be noted that cascading of switching iayers increases the Series Resistance along the current path of the charger or power suppiy coil which is undesirable.

[00261] In the exampies given above, the switching is shown for Point A in Figure 34 prior to the coils. However, Point B can also be used for this purpose.

[00262] The associated electronics are shown on the perimeter of the coiis but can be piaced in other iocations too.

[00263] Figure 41 shows a multi-charger or power suppiy pad that incorporates four of the dusters shown in Figure 39. A device to be charged or powered wouid have to be piaced such that the center of the receiver coii is within one of the effective areas in one of the clusters or segments. As an example, if the duster is made of hexagons with side lengths r, a hexagonai Effective Area in the center of the cluster with a maximal diameter of 5 r is created. The Effective Area ~ 19r achieved with 19 coils giving a Coverage Efficiency = Effective Area (in coil radius or side length Units)/Number of Coils = 1.

[00264] For a typical coil of r =0.625" side, this leads to a maxima! diameter of 3.125". Such an almost circuiar Effective Area with a diameter of over 3" can be marked on the surface of the charger or power suppiy pad and aSlows the user b easiiy place the receiver coil inside (or on) a mobile device such as camera, mobiie phone, batteries, game piayers, etc. in the right iocation for charging without much alignment and effort. Each of the dusters in the configuration shown in Figure 41 can have their own coil drive and sense circuits or may share this circuitry through muStipiexing with switches.

[00265] In this way, a practical system for providing a large Effective Area in each charging area (i.e. segment) while maintaining high power transfer efficiency is developed. A significant advantage is also that simuitaneous charging of multiple devices can be achieved.

[00266] It should be noted that the charger or power supply coils can be designed to be larger than the receiver coils. By doing so, one can obtain an even larger effective area and insensitivity to placement of the receiver coil. The Effective Area has a maxima! diameter of 3r. Other combination of coiS patterns to achieve Socai position independence with a number of coils can be constructed.

[00267] Figure 42 shows a cluster of 2 layers of 3 coils and a central coil (total 7 coils) that can create an effective area of 3r. In practice, such an area may be sufficient for many applications. It will be noted that while Hexagonal coils are shown in many of these figures, a combination of Hexagons and/or circles, or other shapes can be combined to provide the best efficiency/position independence performance. Similarly, the size and shape of the receiver can be non-Hexagonal.

[00268] For example, in Figure 42, the central and the receiver coil can instead be circular (spiral coil) and the central charger or power supply coil is the most likely charger or power supply coil for the receiver coil to be on top of. If the receiver coil is placed on any other position, a hexagonal coil is the closest coil and be powered. In accordance with other embodiments, the centra! coil in Figure 16 can be larger than the receiver coil and cover most of the likely central area. The remainder of the coils would only be used if the receiver is placed in extreme outside locations.

[00269] It must be noted that the foregoing description describes the situation wherein the transmitted power drops to acceptable levels when the coil centers are offset by half the radius. In practice, this value can be different and by using a combination of coil patterns and sizes and regulation of the transmitted power, uniform power transmission across an area can be maintained.

[00270] While the use of IC switching elements has been discussed above, other switching mechanisms such as IVIEIVIS, relays, etc. can be used to achieve the results. In accordance with other embodiments, the switching may be implemented by creating a deformabie layer under the coii layers to act as the switch. Each spiral coil discussed here has 2 ports with one at the outside diameter wherein the coil starts and one at the center wherein the coil terminates.

[00271] Figure 43 shows a mosaic of hexagonal coils with the central port to each coil shown as circles. In accordance with an embodiment, one of the ports of all of the coils in the 3 layers (in this case, the outside port) is connected to a common point, called here P1. The other port of each coii (shown as the centra! one here) in the mosaic pattern of Figure 42

is brought down through vias to a common layer at the bottom of the multi-layer PCB and connected to a copper pad with a certain surface area. Such a pattern seen from above (the same side as Figure 43} is shown in Figure 44.

[00272] Figure **44** shows the fop view seen from the same side. The side view of the pad has integrated MEMS switch for contacting individual coil contact pads,

[00273] In an earlier US patent application 11/869,113, the use of attracting magnets placed at the centers of an inductive charger or power supply's PC8 coil and the center of the receive coil to align and center the 2 parts conveniently has been described. Such techniques were used in the charger or power supply for mobile device or battery alignment.

[00274] In accordance with a present embodiment, a planar conductive layer or conductive traces patterned with conductive pads similar to the coil port pattern shown in Top part of Figure 44 and al! connected to a common point (called P2 here) is created on a flexible materia! film. Examples of the material for the flexible film are mylar, polyimide, fiexibie PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a small magnet or ferromagnetic material is attached to the other side of the fiim. Alternatively, a layer of ferromagnetic materia! is deposited and patterned to have a pattern similar to Figure 45 top so that only material with a pattern similar to the PCB port pad remains. The flexible film is attached to the bottom of the PCB such that a smaS! gap between the top iayer of the film and the bottom of the PCB is created by a spacer. The side view of the MEMS charger or power supply pad is shown in Figure 44.

[00275] The entire package shown in the bottom of Figure 44 has 2 electricai connection points. One from the PCB, called P1 that is connected to one of the ports of all of the coils in the 3 layers of the PCB (in this case the edge port). The other connection is to the common pads on the flexible film. This is called P2. Looking at Figure 34, the entire package can be treated as 11, and connect P1 to point A in this circuit and P2 to point C.

[00276] Ordinarily, none of the coii center ports are connected to the contact pads on the flexible film and therefore the circuit is not completed. If a receiver coil with a magnet attached to the back of its PCS coil and the magnet oriented with correct polarity is brought close to the pad, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest charger or power supply coii and at the bottom of the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the center port of the appropriate coil and close the circuit. In this way, current can flow only through the appropriate coil and then activate it.

[00277] In accordance with an embodiment, to avoid oxidation of the contact pads at the bottom of the PC8 and the flexible fiim contacts, these surfaces can be protected by deposition of additional layers such as gold or other material on top of the copper. Such

processes are often used in PCB manufacture to protect exposed contacts, sn addition, the PCB pad package can be hermetically sealed to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with an inert gas such as nitrogen.

[00278] By optimizing the surface area of the contact pad and the flexibie film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of materia! used.

[00279] The configuration above is provided by way of example, In accordance with other embodiments, it is possible b connect the components in a different manner, or to piace in an external drive circuit in a different configuration to achieve the desired result. A 3 layer board has also been used to demonstrate this approach. Simpler constructions with 1 or 2 layers or configurations wherein the coils in the different layers have different functions or sizes and provide different power levels can also be implemented. The advantages of this approach are:

1- High efficiency: Only the appropriate coil for high coil overlap is activated.

2- Position Independence: The receiver coil can be placed anywhere with its center in the Effective Area and achieve specified power transfer.

3- Low cost: The pad does not use any ic switching elements for connecting b the appropriate coil.

As described above, in accordance with an embodiment the entire package in Figure 44 is connected between points A and C in the circuit of Figure 34. One example of the operation of the system is described in more detail here:

- MCU 1 gives a command to the FET driver periodically to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- Ordinarily, none of the coils is connected to point C in Figure 34. Therefore, no current is sensed in the current sense circuit.
- If a receiver coil is placed on the pad, it will cause the appropriate charger or power supply coil center port to contact the pad on the flexible film and therefore the appropriate coil is contacted to points A and C in Figure 34.
- The receiver coil begins drawing power from the charger or power supply coil. This can be sensed as a higher than norma! current draw in the current sense circuit of the charger or power supply.
- Additionally, the charger or power supply and receiver coil can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified.

* Once MCU 1 determines that an appropriate receiver coil is on the pad and ready to draw power, the FET is turned on and charging starts. An additional verification can be performed.

♦ The charging continues in open or ciosed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00280] The description provided above describes what happens when the activation of the MEMS switch occurs through magnetic attraction. In accordance with some embodiments, the switch can be designed such that it closes at the appropriate location due to static attraction, pressure, temperature change, or other mechanism.

[00281] In the MEMS system described above, a disk or other magnet in the receiver coil attracts a magnet or patterned ferromagnetic layer attached or deposited under the flexibie fiim to dose the contact beneath the appropriate charger or power supply coil to the FET. However, in other embodiments a ferromagnetic layer can aiso be used in the middle of the receiver coil (on the front of the PCB, its back or separate layer from the coi! layer) and use either permanent magnets or deposit or sputter, etc. a patterned ferromagnetic layer that is permanently magnetized behind the flexible Sayer film. in this way, the charger or power supply pad would contain multiple magnetic points corresponding to the centers of the coils. When a ferromagnetic material is brought close to the pad, the appropriate coi! is activated. To avoid false starts with metallic objects placed on the pad, secondary verification techniques, as described above, can be used, inciuding in some embodiments an exchange of code between the charger or power supply and receiver coil.

[00282] Examples of metals that can be used are Ni, Fe, Co_1 or various commonly used alloys. These can be deposited on a flexible film in a variety of ways such as sputtering, evaporation, e-beam, plating, etc.

[00283] The system shown in Figure 44 is mostly designed to operate with a single FET and allow charging of a single device somewhere on the pad. If 2 devices are placed on the pad and 2 coils are connected to the pad, the power transferred may not reach the full specified power and it may not be clear which device is sending or receiving the control signals during charging.

[00284] In accordance with an embodiment, to overcome these issues, a segmented pad where dusters of charger or power supply coils are attached to individual drive and sense circuits and are independent of each other can be used.

[00285] The X-Y area is divided into segments (in this case 4 shown). One coil in each section can be driven by an appropriate FET and sense Circuit for that segment. Top: The pattern for contact pads at the bottom Sayer of the PC8. Each pad is connected to the centra! port of a cot! in one of the 3 iayers above. The top view is shown here. Bottom; The side view of the pad with integrated MEMS switch for contacting individual coi! contact pads. Spacers at the edges and the waüs of the segment areas keep the flexible fiim at a pre¬determined distance from the bottom layer of the PCB.

[00286] Figure 45 shows the architecture of the segmented MEMS charger or power suppiy pad in accordance with an embodiment. Each segment comprising a number of cotis is connected to points A and C of a different driver and sense circuit. Thus, devices piaced inside each segment can be driven with their own driver and are independent. In this way, severa! (in this case 4) devices can be charged or powered simultaneously.

[00287] In Figure 45, additional spacers are piaced at the boundaries of the segments. These spacers may help with keeping the flexibie film/PCB gap constant and operation of the flexibie fiim uniform aiong the X and Y direction. Such spacers interspersed in the X-Y piane between the PCB and flexible film iayer may be used regardiess of whether the pad is segmented eiectrically or not.

[00288] In accordance with some embodiments, the MEMS switching method described here can also be appiied to the duster geometry shown in Figure 41 or any other geometry.

Conductive *M*ulti -Charger or Power Supply Surface

[00289J As discussed above, in accordance with some embodiments, another method for charging or powering rnultspie devices on a common charger or power supply surface is to incorporate a number of connector points or strips into the pad. The user can p!ace a device with an appropriate connector on a pad or similar object and receive power through matching contacts on the pad. Figure 46 shows a genera! diagram for this approach is shown in. in this approach, one or more reguiated power supplies are connected to the charger or power suppiy pad. The pad comprises an array of contacts or strips of exposed connector.

[00290] Figure 47 shows an array of contacts on the surface of a pad. in Figure 47, each position comprises a Voitage and Ground contact. in this picture, the connector is shown as a recessed circSe similar to a washer where one contact is in the middle and the other contact is in the body or outside of the circie. Other connector geometries are possibie,

[00291] A device with an appropriate mating connector at its bottom or in a plug-in unit for after-market appücations can be placed on the pad and the connectors on the device make appropriate contacts to the pad contacts if piaced on one of the contact points. in

accordance with an embodiment, the connectors on the surface of the charger or power supply pad are connected to a number of switches which are connected to regulated power supplies and sense circuits as shown through switch arrays as shown in Figure 48. MCU1 periodically turns ON one of the regulated power supplies. The switches are set such that a connection is made to the 2 contacts of a contact point in the pad. The sense circuit detects any possible flow of current. if a current flow is detected, the system may verify the presence of a valid receiver through exchange of information through the contact with a MCU2 in the receiver. If no current is being drawn or the verification process fails, the MCU1 reconnects the supply to the next contact position. By rastering the entire pad periodically, contact to several devices on the pad for charging or power can be established, A diode D1 can be used for protection against reverse voltage, a Capacitor (C1) to filter any potential noise on the regulated power supply output, and MCU2 to enable communication between the Charger or power supply and the Receiver are shown. The receiver may also incorporate a voltage regulator to provide a constant voitage (or voltage in the acceptable range for operation) to MCU2. This voltage regulator just provides the low power necessary for this, and is not in the path of the main power going into the battery. Any power loss *due* to this regulator is small because it is very low power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained. However, these components are optional and may not be present depending on the architecture used. The description provided herein does not depend on use of these components for operation,

[00292] If the ground (through a sense circuit) contact for all positions is connected together, then Switch Array 2 can be eliminated. Care must be taken to interpret the received signals in interpreting the current sense values since it is the sum of currents from ail devices being charged.

[00293] The switching arrangements discussed above for the Inductive cases can be modified and used for this type of conductive switching as well. In addition, the MEMS based approach shown above are applicable to this application.

[00294] An embodiment for a universal charging pad using conduction is shown in Figure 48. In this case, one of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (Ground through the sense circuit in this case). The other contacts are brought through the charger or power supply surface to the bottom of the surface and contact pads are formed.

[00295] Top: The pattern for contact pads at the layer below the connectors. One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (through Sense circuit to Ground in this

case). Bottom: Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges keep the flexible film at a pre¬determined distance from the bottom layer of the PCB.

[00296] In accordance with an embodiment, a planar conductive iayer or conductive traces patterned with conductive pads similar to the charger or power supply surface contact pattern shown in Top part of Figure 48 and all connected to a common point {called P2 here) is created on a flexible materia! film. Examples of the materia! for the flexible film are mylar, polyimide, flexible PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a smaii magnet or ferromagnetic material is attached to the other side of the fiim. Alternatively, a layer of ferromagnetic material is deposited and patterned b have a pattern similar to the Top in Figure 47 so that it only materia! with a pattern similar to the charger or power supply surface pad pattern remains. The flexible film is attached to the bottom of the charger or power supply surface such that a small gap between the top layer of the film and the bottom of the charger or power supply surface is created by a spacer.

[00297] Figure 48 shows the side view of the MEMS conductive charger or power supply pad. Using the MEMS conductive charger or power supply pad eliminates the need for switching arrays.

[00298] In accordance with an embodiment, the entire package shown in the bottom of Figure 48 has two electrical connection points. One from the top surface, called P1 that is connected to one of the connector points of aii of the connector positions on the charger or power supply surface (Ground in this case). The other connection is to the common pads on the flexible fiim. This is called P2, and is connected to the other position in the circuit. For example, for the geometry discussed here, P1 can be connected to Point B in Figure 49 and P2 connected to Point A. Figure 49 is a generalized biock diagram of a charger or power supply pad with multiple regulated power supplies.

[00299] The case discussed here and the pad in Figure 48 enable connection of one regulated supply to one or more devices placed on the pad. However in the case of multiple devices on the pad, the voltage characteristics of the device would have to be identical to the first one and the sum of powers being drawn from the supply not exceed the maximum rating of the power supply. A more generalized approach wherein different voltages/power can be supplied to different devices is discussed in further detail below

£00300] Ordinarily, none of the connectors are connected to the contact pads on the flexible film and therefore the circuit is not completed, in accordance with an embodiment, if a receiver with a magnet attached to the back or perimeter of the connector and the magnet oriented with correct polarity is brought close to the charging surface, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest contact pad and at the bottom of

the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the contact pad for the appropriate connector at the bottom of the charger or power supply surface and close the circuit. In this way, current can flow only through the appropriate connector into the receiver circuit and the device to be charged.

[00301] As described above, to avoid oxidation of the contact pads at the bottom of the charger or power supply surface and the flexible film contacts, these surfaces can be protected by deposition of additional layers such as gold on top of the Copper. Such processes are common to protect exposed contacts. In addition, the pad package can be hermetically seated to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with *an* inert gas such as nitrogen.

[00302] By optimizing the surface area of the contact pad and the flexible film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of materia! used.

[00303] Top- The pattern for contact pads at the layer below the connectors One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad to form contact point P1. Bottom; Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges and the walls of the segment areas keep the flexible film at a pre-determined distance from the bottom layer of the PCB. The contact pads in each segment of the flexible film are connected together to form contact P2 for each segment.

[00304] Figure 49 shows another embodiment where several regulated power supplies provide power to the pad. This allows charging of several devices simultaneously.

[0030S] Figure 50 shows an alternative embodiment using a segmented surface. The operation of this is similar to previously described except that the top and bottom contact points for each segment P1 and P2 are connected to the appropriate positions in B and A in Figure 49 so that each regulated power supply is connected to one of the segments in the charger or power supply surface when the circuit is closed. In this way, a device placed on each of the segments can be powered by the regulated power supply at its required voltage and power level.

Electromagnetic Shielding

[0030S] Electromagnetic Interference (EMI) is an important aspect of performance of any electronic device. Any device to be sold commercially requires adherence to regulation in different countries or regions in terms of radiated power from it.

[00307] For an inductive charger or power supply comprising a number of coils and electronics switches and control circuitry, the main sources of noise include:

• Any potential radiated noise from switching FETS, drivers, etc. or sense and control circuitry. This noise can be at higher frequency than the **fundamental** drive frequency of the coils and can be emitted away from the charger or power supply because of the frequency. This noise can be minimized by optimizing the drive circuit to avoid sharp edges in the drive waveform and associated noise.

• Noise from copper traces with ac signals. This noise can also be at higher frequency and emit away from the charger or power supply. The length of these paths must be minimized.

• EM emission from the switched coil For coils described here and driven in the tOQ's of kHz up to severai MHz, the waveiength of the Electromagnetic (EM) field generated can be in the hundreds of meters Given the smaSi length of the coils windings (often 1 m or less), the coils used are not efficient far-field transmitters of the EM field and the generated EfV! fiβid is in genera! highly contained near the coil surface. The magnetic flux pattern from a PCB coil is highly contained in the area of a coil and does not emit efficiently away from the coil.

[00308] Care must be taken when designing the current paths, and in some embodiments shielding of the FETs or other ICs or electronics components may be necessary. in addition, switching the coils with waveforms that have higher frequency components, gives rise to noise at higher frequencies. In any of the above geometries described, incorporation of conductive layers and/or ferromagnetic layers in the system can shield the outside environment from any potential radiative fields. The conductive layers may be incorporated in the PCB to eliminate the need for additional separate shielding layers.

[00309] In the examples provided above, while the 3 coil layers can be incorporated into PCB layers, the electronics components can be placed on the lower most surface of the PCB to allow a flat surface on the top and allow receiver coils to get as ciose as possible to the charger or power supply coils. One possible arrangement for the location of the electronics components at the bottom surface of the total PCB stack is shown. In this case, in some or all of the layers above, the PCB layers can incorporate Copper sections in the areas shown in black in this figure. By appropriately grounding these sections and providing additional conductive and/or magnetic layers below the electronics components, the EMI can be significantly reduced.

[00310] In accordance with an embodiment, another method for minimizing the effect of the copper traces in the PCB is to sandwich them between layers of conductors in the PCB. in a muiti-layer PCB, the copper trances and connections to all the components and coils can be for example, be in a middle layer and the necessary connections to the iCs or other layers be made through vias. Given that the magnetic flux is highly contained within

the coil area, the layer containing the coil or another layer below or above can contain a substantially continuous layer of copper covering everything except the area of the flux generated by the PCB (very cfose to the outside ring of the coil). By having two or more conductive PCB layers for shielding sandwiching the signal and current paths, most of the noise generated can be shielded very dose to the source. Since the noise from the PCB is minima! and does not radiate, the remaining source of noise, the electronics, FETS, etc. can be shielded by covering the section with these devices with a metallic cover or shield.

[00311] Similar types of judicious incorporation of grounded Copper layers in the PCB layers in any of the designs above can significantly reduce any potential EMI issues without requiring additional shielding iayers.

[00312] Figure 51 shows a standard used within the European Union for measuring emissions from a product. in this case, the emissions from a product are measured at 10 m distance. This test {EN 55022) looks for emissions from 30 MHz to 1 GHz. Limits for Class A and Class B certification are shown in the Figure.

[00313] Figure 51 shows a typical scan of emissions from an inductive multi-charger or power supply pad. As discussed above, the radiation at the fundamental operating frequency (10G's of kHz to several MHz), can be self-contained within the coil area. However, noise at higher frequencies (such as the test range of 30 MHz to 1 GHz) must be reduced to avoid interference with other nearby electronic devices

[00314] Mβtailic and/or Ferromagnetic layers are often included in eiectronic devices to reduce their EM emission. An example of such iayers is described in U.S. Patent Nos. 6,888,438, and 6,501,364, In these instances, PCB coils are formed on two sides of a PCB, and ferromagnetic and copper iayers are placed on each side of the PCB to iimit emissions from a package containing such a transformer,

Frequency Selective Electromagnetic Shielding

[00315] In accordance with some embodiments of the inductive universa! charger or power supply pad described herein, the inclusion of metallic and/or Ferromagnetic layers at areas that are potential sources of emission such as FETs, etc. may be beneficial. However, a method that would wholly cover the charger or power supply pad package to βiiminate potentia! for escaping Elvl fields may provide benefits.

[0031 6] Given that the inductive charger or power supply pad operates by generating an oscillating magnetic field, such an approach does not seem feasible as it would block such a field from being sensed by the receiver coil.

[00317] In accordance with an embodiment, a method is described herein that allows the inductive pad to emit EM waves efficiently for operation while simultaneously providing

shielding to high frequency EM fields. Such operation is achieved by taking advantage of the skin effect in conductors.

[00318] The skin effect is the tendency of an alternating electric current {AC} to distribute itself wtthin a conductor so that the current density near the surface of the conductor is greater than inside the material. That is, the electric current tends to flow at the "skin" of the conductor.

[00319] The skin effect causes the effective resistance of a conductor to increase with the frequency of the current and has practical consequences in the design of radio-frequency and microwave circuits.

[00320] The current density j in an infinitely thick plane conductor decreases exponentially with depth δ from the surface, as shown below;

$$J^{T} = J_{S}^{T} e^{-\delta/d}$$

where d is a constant caiied the "skin depth". This is defined as the depth below the surface of the conductor at which the current density decays to 1/e (about 0.37} of the current density at the surface. It is given by:

$$d = \sqrt{\frac{2p}{\omega\mu}}$$

Where;

p ~ resistivity of conductor

ω = angular frequency of current = 2τr × frequency

μ = absolute magnetic permeability of conductor = $\mu_0 \cdot \mu_r$, where μ_0 is the permeabiiity of free space and μ, is the reiativa permeability of the conductor.

It is important to note that d decreases rapidly with frequency. The magnetic and electric field similarly get attenuated traveling through a sheet of a conductor. Using the values for conductivity of copper (5.8x10^7 Siemens/m), the absorption going through a single layer of copper with various thickness can be calculated.

[00321] Figure 52 shows the absorption through a copper layer of 70 m and 7 m. While the 70 m layer provides very high attenuation in the region of interest (30 MHz to 1

GHz), the attenuation is excessive in most cases and is only needed in extraordinarily noisy circumstances.

[00322] As described herein, the transmitted power is considered through a very thin conductive layer,

[00323] Figure **53** shows how the attenuation values are shown for Copper and Aluminum (conductivity of $3.76x10^7$ for 99.99% A!) layers for several thicknesses.

[00324] For these calculations, the placement of the layer with respect to the source of the EM field needs to be included. In these calculations, the source is assumed to be 0.5 mm under the layer. This is similar to placing the layer essentially directly on the source of the field.

[00325] It will be noted that, for very thin layers of Copper and Aluminum, down to 1 micron thickness, very high attenuation values at frequencies over 1 MHz are obtained. The attenuation of 1 ¬m layers of Copper and Aluminum at 10^6 Hz are respectively 32 dB and 28 dB and are comparable. However, at 1 MHz or below, the attenuation in either material for such a thin layer is minima!. In accordance with some embodiments, this behavior or characteristic can be exploited.

[00326] Figure 54 shows Transmitted EM Power through Copper and Aluminum layers of varying thickness for an incident EM fieid at 1 MHz which is a typical operating frequency for the type of inductive universal charger or power suppSy described herein. Below 5 J v.im thickness, the transmitted power exceeds 95%. Aluminum in particular (due to its lower conductivity), has a wide range of thicknesses that allows a 1 MHz radiation to transmit through without much attenuation.

[00327] As discussed above, in some embodiments of the inductive charger or power supply device described herein, the generated EM field at the operating frequency of the charger or power supply (typically ~ 1 MHz), is generated by an inefficient PCB coil antenna and is mostly confined b the area immediately near the coil (to be picked up by the receiver coil). However, any noise generated by driving the coil at this fundamental frequency (due to nonlinearities at the components, non-sinusoidal signal, or at the FET or the FET driver) or any noise generated at any other location in the charger or power supply device current paths or components or the receiver (including noise generated at the receiver rectifier), can have components that are much higher in frequency. It is desirable to suppress such noise to the extent possible.

[00328] In accordance with an embodiment, a very thin layer of a conductor (such as Copper or Al, organic conductors, nanotech materials, nanotubes, or other material), covering ali or part of the charger or power supply and/or receiver circuit can be used to aliow the desired low frequency components (Several MHz or below) to travel through without

attenuation while severely reducing the higher frequency noise, In accordance with some embodiments, the entire inside or outside surface of the charger or power supply and/or receiver package circuitry or part of it is covered to achieve this frequency selective shielding without dramatically affecting the fundamental operation of the device.

[00329] In one embodiment, the entire inside or outside of the package for the inductive charger or power supply and /or the receiver for such a charger or power supply is covered by a thin layer of a conductor (15 ¨rn thick or less or preferably less than 5 ¨m thick}. The conductor can be metallic as discussed above, rneta! alloys, organic, nanotech materials, nanotubes, etc. At high frequencies, such a layer reduces the emitted EM power considerably (greater than 20 dB or even 30 dB) while allowing most (>90%) of the fundamental operating frequency power to transmit through the layer. The conductive layer can be directly deposited on the parts. To avoid shorting of any electronics or connectors, contacts, a dielectric layer, paint or other material must be first deposited. Alternatively, the conductive parts can be masked off so as not to contact the EM shielding conductive layer.

[00330] The deposition of the conductive material can be done in a variety of manners (sputtering, evaporation, electroplating, coating through dipping, Langmuir Biodgett, painting, etc.) for different materials. Recently, an inexpensive method (Ecoplate) for conformally coating any materia! with metallic or metal alloy layers at room temperature has been developed. In this process, a spray of moiten metal at controlled temperature and velocity instantaneously cools on incidence with a substrate and forms a conformal layer covering the entire or part of a part.

The EM conductive shield can also be deposited onto a substrate such as a polymer (e.g. mylar, polyimide, polyurethane, plastics, etc.), rubber, etc. and the conductive iayer coated polymer be applied to the inside or outside of the part. Anti-static bags *&r&* an example of a metaiized polymer material. Aluminum is commonly used for this application.

[00331] In another embodiment, the PCB boards, electronics components, and the coils in the charger or power supply and/or the receiver are covered by a nonconductive layer (such as a dielectric, paint, etc.) and then covered completely or locaiiy by a conductive iayer of appropriate thickness either directly deposited on the board and the electronics or indirectly with a polymer or similar backing (as described above).

[00332] The optimum thickness of the conductive materia! is highly dependent on its conductivity. By choosing the materia! composition and thickness, one can obtain the desired combination of Elvl noise suppression and transmission of fundamental frequency,

[00333] It is also possible to combine conductive layer materials and thicknesses to construct a more tailored frequency response. Such an approach is commonly taken in the optical domain to fabricate wavelength dependent filters.

[00334] In those embodiments wherein the conductive layer covers the charger or power supply and/or receiver cot!, it may be desirable to generate an EM field with a charger or power supply coil and then, after passing the emitted field through such a conductive layer, turn it back to DC power through the receiver coil and rectification. Since the conductive layer is a frequency dependent filter, in this process, this removes or weaken any higher frequency signals and enables the receiver to receive a cleaner, and depending on the design, more sinusoidal signal. Such high frequency noise is often related to not-only EiVIS disturbance and lack of signal to noise ratio in the electronic device b be charged. In addition, the higher frequency noise causes non-optimum operation of the receiver and possibly heating of the receiver or other components. By removing the generated noise, electrical and thermal/en vironr πental performance of the charger or power supply and receiver system may be improved,

[00335] Such a physical filtering of an electrical system is analogous to an optical signal being filtered in the wavelength domain (by an optical filter, grating, etc.) before reaching a receiver. The SNR and efficiency of the system is improved in this way.

Use of Magnets for Alignment of the CoUs

[00336] Figure 55 shows a method for obtaining local alignment independence between the coils in the charger or power supply and the receiver are shown therein. In accordance with an embodiment, by using small magnets behind (on the side opposite to the side facing the surface of the charger or power supply) the center of each coil in the charger or power supply, and behind (on the side opposite to the side facing the surface of the charger or power supply) the coil in the receiver, such that the magnets attract each other, a charger or power supply system can be provided wherein the user can easily find the location where the charger or power supply coil is located, without providing any physical features and/or marking on the surface of the charger or power supply. This may be advantageous in enabling charger or power supplies which can be used with any device to be charged without need for special alignment or size features. This allows charging of any si2e and shape device and/or battery. In this geometry, shown in Figure 55, the magnets can be thin flat or other shape magnets placed at the center of the coil and allow the device or battery to be charged to be rotated around the charger or power supply coil with no effect.

[00337J As described above, by enabling the coil in the charger or power supply to move laterally (and somewhat vertically) in the plane of the charger or power supply surface, automatic alignment of the charger or power supply and device and/or battery coil can be achieved when a device and/or battery is laterally brought close to the center of the charger or power supply coil.

[00338] If magnets used for this application are electrically conductive, then some of the field generated by the coil will generate currents in the magnet and heat the magnet, decreasing the efficiency of the system and generating unwanted heat. This effect especially becomes important as the field strength of the cotl is increased for higher powers,

[00339] In accordance with some embodiments, methods for dealing with this problem can be included, such as:

- Since the currents are created by eddy currents generated in the magnets, use of non-conductive and/or low conductivity magnetic material can improve this condition.
- The magnet can be constructed of thin flat magnet material with laminate in between the layers to decrease the current flow and loss of power.

[00340] Figure 56 show an embodiment in which the magnets can be broken or divided into sections, such as semi-circles with a gap or non-conductive material in-between to avoid current circulation. By having each set of magnets behind a coi! to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In this figure, each set of magnets behind a coil are made of semi-circular magnets. The poles of the magnet are aligned with the South or North pole facing the surface of the charger or power supply. The magnet in the device or battery have the opposite polarity so that the magnets of the charger or power supply and the device and/or battery attract. By having each set of magnets behind a coil to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In Figure 58, each set of magnets behind a coil are made of two semt-circular magnets.

[00341] Figure 57 shows an embodiment in which one or more alignment magnets can be used behind each coil. However, in accordance with an embodiment the magnets are placed such that each magnet does not cover an area extending beyond the center of the coil. In other words, the surface of the magnet does not cover the center of the coil and thereby does not allow circular currents to be set up in the magnet as effectively. In this way, the eddy currents set up are much weaker and much smaller power dissipation in the magnets occurs. Alignment magnets at center of charger or power supply and device and/or battery coils for alignment of the two coiis are attached to the back of the coils in such a way that the area of the magnet does not extend beyond the center of the coil. In this way, the eddy currents created are much weaker and much less power is lost to the magnets. In this figure, two magnets are shown per back of each coil (four total for a pair of charger or power supply and receiver magnets). However, any number of magnets from one to many can be used.

Additional Applications - Charger/Power Supply with Se5f-Powered Operation

[00342] Figure 58 shows an illustration of a device for inductive power charging that includes an interna! battery for self-powered operation, in accordance with an embodiment. As shown in Figure 58, an inductive charging unit such as an inductive pad 360 includes a rechargeabie battery 364, The unit is normally operated with, or is occasionally coupled to, power input from an electrical outlet, or from a dc source such as a standard automobile 12 volt dc outlet, or from an outlet in an airplane or an external dc source, or from another power source such as the USB outlet from a computer or other device. Aiternattveiy, the power can come from a mechanical source such as a windmill, or a human-powered crank handle. The unit can include coils 362 that are energized to transfer power to receiver coiSs in mobile electronics devices such as mobiie phones, MP3 piayers, radios, cd players, PDAs, and notebook computers. At the same time, the input power charges the rechargeable battery inside the unit itself. When the external power source to the unit is disconnected, or when no input power is provided, the unit automatically switches its operation from its charged internal battery. Alternatively, the unit's operation can be switch-operated by user. in this way, users can continue to charge their devices by placement on the unit without any outside power source. This use can continue until the external power is restored or until the internal battery is completely discharged.

£00343] The ability of the unit to continue charging depends on the capacity of the battery included. Thus, for example, with a 1500 mAH interna! battery, the unit is able to charge a mobile phone with a 1000 mAH battery completely if the losses due to conversion efficiency, operation of the circuitry in the unit, and other losses are up to 500 mAH.

|00344] In other embodiments of an embodiment, the unit can be powered by other power sources such as a fuel cell that generates power from methanol or other sources. The unit can also be connected to the electric grid through an outlet or to an external DC power source such as power from an outlet in a car or airplane or be itself charged or powered inductively by another unit. However, when not connected to outside power, the unit can be powered by its internal power generator from the fuel cell and can charge devices placed on it inductively.

[00345] Figure 59 shows an illustration of art alternate embodiment of art inductive charger or power supply unit or pad 370 with a solar cell power source for self powered operation, in accordance with an embodiment. As shown in Figure 20. the surface of the unit can be covered by a solar panel or solar ceil 378. In normal operation, the unit can be powβrβd-up or charged by connection to an electric outlet or external DC source. But without external electric power, the pane! generates electric power that is used to power the charger

or power supply which in turn can charge devices placed on if through the inductors in the unit. In some embodiments the unit can also include a rechargeable battery 374 that can be charged when the unit is either connected to externa! electric power or charged by the solar cells on the surface of the unit. This battery can then operate the unit when the unit is either not connected to external electric power or the solar eel! is not generating enough power to run the unit such as during operation at night.

[00346] **Figure 60** shows an illustration of an inductive charger or power suppiy unit with an incorporated communications and/or storage unit, in accordance with an embodiment. As shown in Figure 21, in accordance with some embodiments the charger or power supply, including for example the regular charger or power supply 380, and the solar-cell powered charger or power supply 382, can further comprise an optional communications and/or storage unit, for storage of data and transmission of data to and from a mobile device being charged. Examples of components that can be incorporated include Bluetooth, Near-field Communications (NFC), WiFi, WiMax, wireless USB, and proprietary communications capabilities, including means of connecting to the Internet.

Additional Appiications - Inductive Charger Applications and Kiosk

[00347] The technology described herein may also be used for other appiications. in some applications, it may be desirabie to buiid the inductive (as described above) or wire free charger or power supply into a case for an electronic device, a briefcase, or other carrier such as a box, holder, or container in a car or other wise. An example can be a brief case, hand bag, or back pack where the bottom part or the outside surface has an integrated charger or power suppiy. Any device enabled to receive power from such a charger or power supply (device containing coiis and the appropriate electronics to receive power or with appropriate contacts for wire free charging) can be placed on or inside such a briefcase and be charged. The charging circuitry can be powered by plugging the briefcase, handbag, or back pack into an outlet power or having internal batteries that can be charged through power from a wai! plug or by themselves being inductively charged when the briefcase, handbag, or backpack is placed on an another inductive or wire free charger or power suppiy. Uses can be applied to any bag, container, or object that can be used to essentially charge or power another device. This first object can itself be charged or powered through an outlet directly by wires or wirelessly through an inductive or wire free charging system. As an alternative, the first object (the charger or power suppiy) can be powered by solar cells, Fuei cells, mechanical methods (hand cranks, pendulums, etc.).

[00348] In ail of the above case, it is possible for the functions of the inductor or wire free charger or power supply and the power source for the charger or power supply (battery,

fuel cell, solar cell, etc.) to be separated. Furthermore, in some cases, the charger or power supply part can be separated from a portable power source to operate it (such as a rechargeable battery) which is in turn powered or charged by another source (power outlet, fuel ceil, solar cell, mechanical source, etc.). The three parts can be in the same enclosure or area or separate from each other.

[00349] An additional example may be an after market inductive or wire free charger or power supply for a car where the inductive or wire free charger or power supply or pad including a solar ceil on the pad or in another area and connected to the pad by wires is used to charge mobile devices. Such a device placed on the dashboard or tray between seats or a special compartment can be used to charge a number of devices such as phones, MP3 players, cameras, etc. Devices such as GPS navigation systems, radar detectors, etc. can also be powered from such a device. in another application, mugs, cups, or other containers with a receiver circuitry and means of heating or cooling the contents can be used in combination with the inductive charger or power supply to keep the contents hot or cold. A dial or buttons on the cup or container can set the temperature. The charging device or pad can also contain rechargeable batteries that allow the device or pad to store energy and operate in the absence of any external power if necessary.

[00350] Other applications of this technology include clothing, jackets, vests, etc. that have an integrated inductive charger or power supply such that a user can power or charge a device by simply placing it on or near a pocket or an area where wireless inductive power is available. The jacket or clothing can in turn be powered by solar cells, Fuel cells, batteries, or other forms of energy. It can also be powered by batteries that are recharged through solar cells sown onto the clothing or be recharged by placing or hanging the clothing item on a rack or location where it is recharged wirelessly or inductively. By using inductive charging, the user does not have to plug in devices into individual wires and connectors at the appropriate jacket pocket.

[00351] In some cases, it may be desirable to build the charger or power supply or the secondary part (receiver for a charger or power supply) into the protective case of another device. For example, many products exist today that are after-market or optional items such as a skin or case for a music player, phone, PDA, or notebook computer. In one implementation, the case or skin can contain the electronics and the coil necessary to allow the device to be charged or charge other devices or both. The charger or power supply can be powered by the device if is attached to or can receive power from a separate source such as a solar cell, fuel ceil, etc. that is integrated with the charger or power supply or in another location and electrically connected to the charger or power supply. For example, in a briefcase, while the charger or power supply is inside the briefcase and can charge devices

inside, the surface of the briefcase can have solar cells that power the charger or power supply inside. The briefcase can aiso contain rechargeable batteries that store power generated by the solar ceiSs and use them when necessary to charge devices inside. Similarly, the charger or power supply can be built on the outside or inside surface of the case and charge devices piaced on or near the surface.

[00352] It is also possible to provide a charger or power supply with modular components that allow other capabilities to be added later or simultaneously as an option. In one embodiment an inductive charging pad that contains a rechargeable battery can have a separate top surface module or ali around cover or skin that contains a solar cell array and simultaneously electricaiiy connect to the charger or power suppiy pad to enabie the battery internal to the unit to be charged without any externa! power input. It is also possible to have the cover or the outside skin to provide other capabilities such as communications, or simpiy provide a different look or texture so that the pad fits in with the user's taste or decor.

[00353] **Figure** 81 shows an iiiustration of a kiosk that incorporates an inductive charger or power supply unit in accordance with an embodiment. As shown in Figure 81, the kiosk 390 includes a control screen 392 and an inductive charging pad 394, to aiiow individuals to walk-up and purchase an occasionai charge for their mobile device. Currently, the usage mode! of typical mobile user consists of charging their most essential device (phone, MP3 player, Bluetooth headset, etc.) during the night or at the office or car. In cases where the user is outside their environment for a long time such as traveling, this may not be possible. A variety of public mobile device charging stations have appeared that allow the user to charge their device in a public setting by paying a fee. An inductive or wire free public charging station or kiosk would allow the user to place their mobile device that is 'enabled' (i.e. has the appropriate receiver or components to allow it to receive power from the charger or power supply) on or in the wire free or inductive charger or power suppiy station and charge the device. The customer can pay for the service or receive the service for free depending on the service providers' approach. The payment can be cash, credit card, debit card, or other methods.

[O03S4] In accordance with an embodiment, a single pad with multiple stations can charge multiplicity of devices simultaneously. The user may be asked to pay for the service before charging a device or the service may be for free. Alternatively, each charging station can be in a compartment and the device is secured by a door that can only be opened through a code given to the device owner when charging starts or payment occurs. The door can also be secured by a combination lock or physical key.

[00355] Alternatively, the charging station or kiosk can be open and not physically secure but when the user pays for the service, a code is issued. The user proceeds to place

their device to be charged but when the charging ends or the user wants to pick up the device, the code must be entered first. If no code is entered, an aiarm is sounded or the device is deactivated or some other warning occurs. In this way, a thief or the wrong user can not remove the device without attracting attention that may act as a deterrent, A combination of the above techniques may be used in implementing a public charging kiosk,

[0035S] Since a typical charging process can take up to 30 minutes or more, it is possible to aiso synchronize data, downioad songs, movies, etc. into the device during this time. Many of current mobile devices have Bluetooth or WiFi capability. Other communication protocols such as WtMax can increase the data rate further. By combining the charging and information transfer process, the service provider can charge for additional services. In addition, if a camera is being charged and has wireless capability, it can download the pictures or movies to a designated website or online storage area or be ©mailed to a designated email address while charging. In this way, a traveler can simultaneously charge a camera while downloading the contents of its memory to a location with larger memory. This would enable the traveler to free up limited memory space in their camera or other mobile device. Such a service would enable devices that have limited or short range wireless communication capabilities (such as mobile phones, MP3 players, cameras, etc.) to be able to connect to the internet and send or receive data indirectly. It is important to recognize that without the charging capability, a device conducting such downloading or synchronization through an intermediate device (Bluetooth to internet gateway for example) often run out of power due to the length of time this takes. In this manner the charging capability of the kiosk enables a more effective operation.

Additional Applications - Inductive Charger Applications and Kiosk

[00307] With increased functionality in mobile devices, there is an ever-increasing focus on maximizing the battery life. Currently, the rate of increase of power usage continues to outpace new and improved battery technologies. Given the desire to minimize mobile device size, the battery power limitation has required some mobile device manufacturers to begin shipping mobile devices with several batteries and a desktop charger to keep ail of those batteries regularly charged. The user is sometimes expected to change the batteries for the device during the day while using the device. Such a situation is not ideal and puts the burden on the user to carry multiple batteries, and to keep those batteries charged,

[003S8] Methods for extending the battery life in mobile devices, but which do not greatly increase the size and weight of the mobile device, are extremely useful for new power hungry enhanced multi-media mobile devices. By way of example, one solution that has

been proposed is described in U.S. Patent No. 6,184,854. However, such a technique and geometry is incompatible with the variety of mobile devices and connectors in use today, and requires the user to piug the device into a connector inside the holster whiie fastening it to hold it securely.

[00309] Described herein is a system and method for extending the battery life of mobiie devices by integrating a wireiess charger into the case, carrier, or holster for the device. The system and method has the advantage of keeping the size and weight of the mobile device iow while enabling the user to automatically recharge the device when placed in the case thereby dramatically increasing the device run time.

[00360] In one embodiment, the case recharges the mobile device inductively, and can itself be recharged by an inductive base charger. Various embodiments including additional integrated functionality such as data storage and communication in the case are aiso described herein.

[00361] Figure 62 illustrates some common regular (non-charger) mobile phone holders types, including a belt holder 1000 and case 1002.

Powering Mobile Devices and Inductive Charging Case

[00362] Mobile devices continue to converge and to combine multiple functions and protocols into ever-smaller packages While mobile TV, radio, high resolution cameras, GPS, etc. are becoming standard in many mobile phones, the power usage of the devices continues to rise. One solution that has been applied to several devices is the use of external battery packs.

[00363] Figure 63 illustrates various products for a music player, (e.g. an iPod or MP3 player) that include an external rechargeable battery pack.

[00364] As shown in, the external battery pack provides extra running power for the device when it is plugged into the music device and clipped to its back. by providing power through the battery pack's internal higher capacity batteries. However, this battery pack is expected to remain connected to the device at all times and increases the size and weight of the device considerably. This is very undesirable from the customer perspective and inhibits mobility/use and adoption.

[00365] In accordance with embodiments of an embodiment, the battery power of the mobile device is extended by providing a holster, case, pouch, bag, wallet, or an equivalent holding, carrying, or storage device (which for convenience are herein referred to as a "case") for the mobile device {e.g. mobile phone, Bluetooth headset, camera, laptop, PDA, MP3 player, game player, etc.). The case can incorporate one or more rechargeable batteries, and one or more inductive charger or power supplies. A mobile device can be

'enabled' to receive power inductively by providing a receiver (such as a coil, etc.), and circuitry integrated by the manufacturer, or by a battery with a built-in receiver, or by a plug-in unit to receive power, etc. A suitabiy enabled device can thus receive power when placed in the case, in accordance with some embodiments, the case can aiso incSude means of recognition of the device automatically by, for exampie, RFiD, Feiica, detection of coii from change in the case's coil's induction, or by verification using proprietary techniques, etc. in some embodiments, the system or coil can be enabled to turn on automatically as necessary and to begin charging the device. Alternatively, the case and/or coils can turn on when a device is placed in it by sensing the presence of a device through a magnetic, mechanical, or other form of switch. Alternatively, the case can include a mechanical or sensory switch that must be manually activated by a user to begin charging the device.

[00366] In accordance with some embodiments, the case can accommodate more than one device. For example, the case can include a location for a Bluetooth headset and a mobile phone. Either or both of these devices can be inductively charged by the case when placed inside the case. This enables the user to have a simple way to carry both parts or devices together, and to extend the battery capacity of both without needing them to be any larger, thus providing great advantages for the consumer.

[00367] In accordance with an embodiment, the batteries inside the inductive charger case can themselves be charged by either a regular charger/power supply, or through another inductive charger or power supply. For example, a desktop inductive charger can charge the inductive charger case, and simultaneously charge the mobile devices (mobile phone, Bluetooth headset, camera, etc.) or battery. Alternatively, the desktop charger or power supply or base can be designed so that it can also charge the mobile device directly when the device is placed on it (without any case present). As described above, the inductive case can aiso be designed so that it will charge its internal batteries, and the devices inside, when it is connected to a regular power supply/charger.

[00368] Some embodiments of the case can include data storage, communication or other capabilities (for exampie, GPS, WiFi, etc.).

[00369] Figure 64 illustrates a multi-function device that includes a hard drive, rechargeable battery, Bluetooth, and WIFi connectivity.

[00370] Typical multi-function devices such as that shown in Figure 64 are of the size of a credit card and about 10mm in thickness. The multifunction device allows a mobile phone user to store the majority of their digital data (pictures, movies, music, etc.), and to have that data available wirelessiy on their mobile devices. The mobile phone and multifunction device can also connect wireiessiy to a computer or laptop, for download or upload of information.

[00371] In accordance with an embodiment, a multifunction device such as that shown in Figure 3 can be integrated into the case, and can have a wireless charger or power supply built into it. Once a mobile device is placed into the case or on the modified multifunction device, it can establish communication, and/or can be charged simultaneously. Since a typical multifunction device already has internal rechargeable batteries, the same batteries can be used to power the charger for the mobile device. The multifunction device case can also be charged wirelessly (using an inductive charger or power supply pad or similar device), or through conventional means.

[00372] In other embodiments, the wireless charger or power supply case can be integrated into a compartment in a briefcase, handbag, backpack, carrier, clothing, automobile, airplane, or other transport vehicle, etc. Some of these are applications are described in further detail in copending U.S. Patent Application titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application No. 11/869,113, incorporated herein by reference.

[00373] Figure 65 illustrates a system for use with a charger or power supply case to inductively power or charge a mobile device. As shown therein, an inductive charger or power supply base or pad charges a case, holster, or other small, portable charger that in turn can charge or power a mobile device or battery placed in proximity to it. The second part (charger case) can be a stand-alone device or be integrated into another device, as in the case of the multifunction device example described above. In other embodiments, the charger or power supply case can be charged or powered through a conventional, wired charger or power supply, In accordance with an embodiment, the system comprises:

[00374] Inductive Charger or Power Supply Base; In accordance with an embodiment, this part can be a stand-alone charger or power supply or desktop charger or power supply that comprises a Field Effect Transistor (FET) that periodically turns the current through a coil on and off. In one embodiment, for a typical 9 turn PCB coil with 1" diameter, a drive frequency of 1-2 MHz is ideal, and the power transfer efficiency is increased when a capacitor of appropriate value is placed in parallel with the FET. When the circuit is driven at a resonant frequency, the amount of current through the FET can vary greatly by proximity of another coil (L2) to LI To allow the system to operate automatically, a current sensing system can be used to sense the secondary (L2) being in close proximity to the primary (L1). In other embodiments, a separate circuit for positive identification of a device to be charged being in proximity can be integrated. These can include wireless identification systems such as $RFID_1$ Felica, Bluetooth, WiFi, WiMax, etc. In another embodiment, the system of the charger or power supply case can be designed so that a chip in the charger or power supply case (near L2) senses an input voltage and modulates the current through L2 in a pre-

programmed manner. This results in a modulation in the current in 11 that can be sensed with the current sensor and positively identifies the charger or power supply case and initiates power transfer and operation if the pattern matches a pre-storβd pattern for verification. In some embodiments, the inductive charger or power supply base can *have* the shape of a formed piece that the inductive case would fit into, or a pad for placement of the inductive case and/or mobile devices or both.

[00375] Inductive case: In accordance with an embodiment, the case has means for receipt of power inductively (from the charger or power supply base} and charging another device (or number of devices) inductively. Alternatively, it may be possible for the case to be designed so that it operates by being charged or powered directly by a wired power supply/charger. The case has a receiver part that is connected to a battery charger circuit that charges one or more internal batteries and simultaneously, can also operate the circuitry in the charger or power supply case to charge a nearby mobile device or battery. The case has charger or power supply circuitry similar to the charger or power supply base that can be powered by its internal battery or the power from the charger or power supply base. The case can in turn recognize a nearby mobile device automatically or through mechanical or other means as described earlier and commence charging when a mobile device is placed in or near the case/holster. In another embodiment, the charger or power supply case may contain two or more charger or power supply sections so that several devices in the case (e.g. mobile phone and a headset) can be charged simultaneously. As described earlier, the circuitry/functions described here can be integrated into a device that also extends the functionality to storage, WIFi or Bluetooth connectivity, etc. In one embodiment, the batteries in the charger or power supply case are identical to the batteries used in the mobile device and are removable. In this case, the user may exchange the batteries between the charger or power supply case and the mobile device (such as a mobile phone) in an emergency to allow quick use of the mobile device without waiting for the charging of the mobile device to occur. This can provide an additional desirable feature for the user,

[00376] Mobile Device Receiver: In accordance with an embodiment, the mobile receiver part comprises a coil and circuitry that can be either integrated into a mobile device by the manufacturer (i.e. an OEM), integrated into a battery that can be swapped with the original battery to enable a mobile device to receive power inductively, or provided as a plug in unit that plugs into the existing power jack of a device and has the coil and the circuitry to enable the device to receive power inductively. Alternatively, the receiver can be built into a jacket or skin for a device that plugs info the device and allows the device to become 'enabled'. Variations of these are described in further detail in copending U.S. Patent Application titled INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application

No. 11/689,113, The above-referenced patent application also describes the use of attracting magnets placed at the center of an inductive charger or power supply's PCB coil, and the center of the receive coil, to align and center the two parts conveniently. Such techniques can be used in the base to case coil alignment, or the case to mobile device aiignment or both. In addition, the alignment can be achieved through visual or mechanical marks, indentation, or mechanical design of the parts to enable easy alignment.

Heat Reduction and Dissipation

[00377] In order to generate the magnetic field for an inductive charger and/or power supply, a coil made of wires or printed on PCB is typically used. Such a coil can be in a simple way, modeled by an inductive and resistive element in series. The resistance of the coil can be estimated by using the dimensions of the wire or PCB trace, its length, and the resistivity of the material used (such as copper). At higher frequencies, the resistance increases due to the skin effect whereby the electrical current travels near the surface of the wire or trace rather than throughout its cross section, thereby decreasing the wire's or trace's effective cross section. in order to obtain reasonable inductive values, several turns of wire or PCB trace are necessary.

[00378] For example, in a PCB spiral coii of **1.25"diamet**βr, about 10 turns are necessary for a 1 micro Henry inductance value. To design a high efficiency inductive power transfer coii, the resistivity of the coii must be minimized while the resulting induction is kept at desired levels. it must be noted that any heat generated at the coil will increase the resistivity of the coil materia! in turn leading to higher heat generation and temperature increase. To avoid this positive feedback for heat generation, the main methods for reduction of temperature at the inductive coil include reduction of heat generated and dispersal of heat away from the coil.

[00379] In addition, electronic devices generally need to satisfy reguiatory and safety requirements which include the requirement not to interfere with the operation of nearby devices. For an inductive charger and/or power supply that creates a time varying magnetic field to transfer energy to a receiver, care must be taken to keep the level of interference to below allowed limits.

[00380] In general, the magnetic created by a small coil <~1"diameter) of several turns when it is driven by an electrical voitage at around 1 MHz, does not radiate more than severai mm beyond the coil and is confined to the near field. To reduce the effect of such radiation (for example, as provided in Near Field Power™ radiation devices) at higher frequencies, which are of bigger concern for most devices, the driving voitage of the circuit must be made to have weaker higher harmonics.

[00381] Another concern for generation of Electromagnetic interference (EMi) is the electronic circuitry and switching Field Effect Transistor (FET) incorporated in the circuit. Such components can be additional noise sources. Described herein are some ways of reducing the effect of above EMI sources.

[00382] Another important factor in efficient operation of an inductive charger/ power suppiy is the alignment of the charger/power supply coi! and the receiver coi! in the device to be charged/powered. Various methods of alignment of the coiis using magnets have been described in prior applications. in addition, also described are the use of moving coiis and other methods by which severai coils or dusters of coils can be used to provide position tolerance between the coils for efficient power transfer.

[00383] In accordance with an embodiment, to reduce the temperature increase at the inductive coil, severai methods can be used.

[00384] In accordance with an embodiment, the coil can be optimized by using the minimum number of turns necessary thereby decreasing the length and resistance of the coii. The diameter, thickness, or width of the wire or PCB trace can be optimized to provide optimum resistance.

[0038S] For coiis such as PCB coiis discussed above, the magnetic fieid created is strong inside the coil, and drops very rapidiy as the radial distance b the center of the coii exceeds the radius of the coil This dependence can be verified using electromagnetic modeling (such as described in Xun Liu; HuL S.Y., Optimal Design of a Hybrid Winding Structure for PSanar Contacfless Battery Charging Piatform, IEEE Transactions on Power Electronics, Volume 23, Issue 1, Jan. 2008 Page{s);455 - 463), and aiso by experimental means. The heat generated at the coii can be dispersed away from the coii by use of high heat conductivity PCB substrates or materia! for the coiis. Since the magnetic field is minima! in the area outside the coii, use of high conductivity metai iayers wil! not have a iarge effect on the fieid and wiii not create undesirable eddy currents. Therefore, the surface of the area surrounding the coii can be designed to have metal or other materia! that have high heat conductivity and remove the generated heat rapidly,

[00386] Figure 66 is an illustration that shows a geometry for an arrangement 1030 in which the area surrounding a PCB coil is designed b have meta! on the top, bottom or another layer of the PCB. As shown in Figure 66, the area surrounding a PCB coi! is designed to have meta! on the top, bottom or another layer of the PC8. The metal pattern can be incorporated at the same layer as the coii or a separate PCB layer. This metai layer can be continuous or have a gap in one area to avoid generation of eddy currents due to circulating eiectrons due to magnetic fields generated by the coii. in a typical PCS, the coil and the metai layer are made of copper. In this manner, any heat generated at the coii is

dispersed laterally rapidly and thus does not result in large temperature increase. In accordance with an embodiment, such a PCB can be itseSf the top layer of an inductive charger in which case, any heat carried away by the metal layer can be additionaiiy evaporated to the surrounding environment, Aiternativeiy, the heat can be further dispersed by removal to another area or surface or use of eSements such as fins or slits. Similarly, the receiver coil and the circuitry for receiving power that is integrated into a device,, battery, outside carrier of an electronics device,, etc. can have a similar geometry to enable dispersal of heat generated.

[00387] In accordance with an embodiment, for typical applications with a PCB, the metal layer can be made from copper materia! similar to that of the PCB coil itself, and it is desired to have sufficient thickness to provide a low thermal conductivity path for the heat. For example, a copper layer of several microns or even 10s of micrometers can be used.

[00388] Any such high thermal conductivity or metal layer may begin at the edge of the PCB coil or with a gap to the PCB coil. Since the layer is not covering the PCB coil, it may not cause eddy current loss in the layer. In those instances that eddy currents are generated, a gap in the metal iayer as shown in Figure 66 can be used to reduce the effect of circulating currents, and reduce the resultant heating and power draw. In accordance with an embodiment a metal layer can be used on top of the coil (with a thin non-conducting layer or dielectric in between) if its thickness is smaiS. For example, in previous applications as referenced above, the use of a thin iayer of metal (several micrometers) on top of a PCB coil was described to act as an EMI shield for high frequencies while transmitting low (around 1 MHz and below) frequencies of the inductive charger. Such a layer may also be used in addition to the metal iayer surrounding the coil to facilitate heat dispersal

[00389] Figure 6? is an illustration that shows, in a multi-charger or power supply where multiple coils are used, such a high heat conductivity iayer 1040 may be repeated around each coil or cover all areas between the multiple coils.

[00390] Figure **68** is an illustration that shows a similar method may be used for heat removal from wound coils of other shape and type 1050, 1058. in accordance with the geometry of this embodiment, to facilitate heat removal from a coil that may be a wound coil around a core, the coil may be attached to a high heat conductivity iayer or a metal layer. In the case of a metal layer, such a layer can be designed to be in the area surrounding the outside of the coil to avoid interference with the field generated inside the coil. Similarly, to avoid eddy currents, the metal layer or the core of the wound coil or both can have a gap or discontinuous portion to reduce circulating currents.

[00391] In above examples, a metal or high heat conductivity layer has been shown. Figure 69 shows an illustration of an embodiment 1060 in which the layer can be patterned to provide heat conductivity channels rather than a continuous layer if needed.

[00392] In accordance with any of the above geometries, additional means of heat removal such as use of fins, fans, additional surfaces, heat pipes, thermal grease, thermally conductive epoxies, etc. can be incorporated to facilitate heat removal. in addition, it is possible to incorporate heat conducting layers, such as ceramics or polymers can be incorporated below or above the main PCB to help in heat removal.

[00393] In the above discussion, round shape coils are generally shown. It will be evident that the techniques described herein are appiicabSβ to coils of other shape or multiple coils in a duster or separated to power or charge separate devices. In many instances, the increase of the temperature at the center of a PCB coil is largest. To remove this heat in accordance with an embodiment the surface of the charger or a layer behind the coil that contains high heat conductivity materia! can be used to disperse the generated heat laterally. An example of such a layer is ceramic material. High alumina ceramics can provide high heat conductivity and low electrical conductivity, which characteristics are important for this application.

Reduction of EMI from Jnducttve Charger and/or Power Supply

[00394] An advantage of the metal layers discussed above is that any EMI generated inside the inductive charger or power supply will be greatly shielded from the outside and will be attenuated outside the charger or power supply device by the metal layer,

[0039SJ Additionally, in the above geometries, the metal layer on the top layer can be made to contact electrically to other metal layers on the side and/or bottom of the charger and/or power supply, thereby forming a box or other enclosed shape where only the coil is not covered by metal. Such an enclosure will greatly attenuate EMI from the switching electronics or other parts in the charger. To reduce the effect of the potential eddy currents generated in the metal box due to the magnetic field, in some embodiments it is useful to eliminate use of metal directly below the coil area where magnetic fields may exist. In addition, to avoid generation of eddy currents in the walls of the metai box or similar outside surface, the wall can be cut in one or more location so that a continuous metal circuit or ring is not formed, and does not allow the electrons to circle unimpeded. This gap can be filled with a non-conductive material to provide rigidity.

[00396] In the geometries shown above, it is possible to use a PCB whereby the coi! is formed in one area and the electronics is on the same PCB. sn accordance with an embodiment, to provide shielding and heat dissipation discussed above, the metal layer

around the coil may be in a layer on fop (closer to the outside surface) of the PCB, For example, the coil may be formed on the top layer of the PCB aiong with the heat dissipation and/or EMI shield layer and the PCB electronic components may be on the bottom layer of the PCB, Alfernafiveiy, the metal layer can be in a separate layer in the middle or even the bottom layer with the PCB electronic components. However, the EM! shielding effects from the electronics components will be reduced if the metal layer surrounds the electronics area and does not provide an eiectrical barrier directly above it.

[00397] Figure 70 shows an illustration of the electronics for the PCB coil inductive charger and/or power supply or the inductive receiver as fabricated on the same PCB as the coil in accordance with various embodiments 1070, 1076. The electronics in this case may be at the bottom layer, whiie the coil and the metal layer surrounding the coil are on the top layer and shield any electronic noise generated by the electronics from the outside,

[00398] Any of the shapes and geometries discussed above are equally appropriate for incorporation into the charger and/or power supply coil or the receiver coil and for dispersal of heat and reduction of EM! from a device to be charged/powered inductively as well as the coil in the charger/power supply itself.

Magnetic Alignment of Coils

[00399] In accordance with an embodiment, to enable efficient power transfer in an inductive charger and/or power supply, the coiis in the charger and/or power supply and the receiver must generally be aiigned with on another.

[00400] Figure 71 shows an embodiment 1080 in which magnets placed at the center of a stationary coil or a moving, floating charger and/or power supply coil and the receiver coil can provide a method for alignment of the coils and to achieve this result.

[00401] A problem with this method is that, since the magnetic material is composed of electrically conductive materia!, eddy currents can be generated when the coils are operated to generate a time-varying magnetic field. This can cause lost power and can also cause heating in the magnets which is not beneficial

[00402] To address this problem, Figure 72 illustrates an embodiment 1090 in which two or more magnets that do not cross the center of the coil are used. This geometry reduces the eddy currents created greatly. in accordance with an embodiment, the system can use an alternative magnet geometry that provides a simple and inexpensive method for alignment of coiis. In addition, this method provides for a considerable amount of alignment tolerance when placing a device on the charger and/or power supply.

[00403] To provide alignment magnets that will not draw current due to eddy currents created in them when a magnetic field is applied, in accordance with an embodiment the magnets are piaced outside the PCB coil area.

[00404] **Figure 73** is an illustration of two embodiments 1094, 1098 that shows how the magnets may be placed outside the PCB coi! area. The magnet shown in Figure 73 comprises a ring that surrounds the coi! or overiaps each coil such that little effect on eddy current generation or loss is created. If any eddy current effects are observed, then in accordance with an embodiment gaps can be inserted in the magnet ring by cutting after manufacture or by inserting this separation dunng manufacture. In this manner the eddy currents can be significantiy reduced or eliminated. The magnet in the case shown is magnetized perpendicular to the surface of the ring. By attaching one magnet to around the charger and/or power supply coi! and another magnet with opposing polarity to the receiver coil, the two coils can easily be aligned with minima! effort by the user.

£00405] In addition, the use of a ring has the advantage of allowing circularly symmetric operation so that the two coils can be rotated with respect b each other with no effect on charger/power supply operation or efficiency.

[00406] A typical geometry for the charger/power supply can comprise the PCB shown in Figure 8 such that the coi! can be fabricated on the top surface of the PCB, and the magnetic ring is attached to the bottom side of the PCB where the eiectronics may be located. A similar receiver can have a magnet attached with opposing polarity so that whan the receiver is brought close to the charger/power supply, the two magnets can attract and pui! the coils into alignment. TOIh this geometry, the magnetic field of the coils create attraction and alignment as long as the coils have any overlap.

[00407] For example for coils of 1.25" outside diameter and using ring magnets of 1.25" inner diameter, as long as the centers of the coils are less than 1.25" away laterally, the coils can be brought into alignment when the two magnets are vertically (distance in the axis perpendicular to the plane of the coil) brought close enough to allow the magnetic fields to sense each other. Thus in this case, if the user brings the center of the receiver coil to be within a circle of 1.25" radius of the center of the charger/power supply coil, the coils can attract and provide automatic alignment of the parts.

[00408] For most applications, this amount of alignment tolerance is sufficient. By using marks to outline the location for the coi! on the surface, this degree of tolerance allows the user to piace a device or battery incorporating the receiver coil very easily into the right location.

[00409] Examples of magnets that can be used include those manufactured from various magnetic material such as Neodymium iron Boron, Samarium Cobalt, AINiCo,

ceramics, bonded magnetic material, etc. The magnetic strength can be designed to provide alignment or secure attachment without being too strong or difficult for separation.

[00410] Alternatively, the coils can be manufactured on the lower surface ciose to the magnet and the electronics or can be manufactured on another layer in between. Various geometries are possible. In any case, the magnets can be used to align the two coils for optimum operation.

[00411] In above description, ring shaped magnets are described. However, in many cases, size and spacing requirements may require use of a different geometry.

[00412] Figure 74 shows an embodiment 1100 in which magnetic arc shaped parts around a circular coii are used. This case may be combined with the matching magnet on the other coil having the same shape or a ring shape similar to Figure 73. For example, in a mobile battery application where the battery with an integrated inductive receiver is charged by placement on an inductive charger pad, the size of the coil determines the received power and may require the width of the battery to be equal or similar to the receiver coil. To allow attachment of alignment magnets, two arcs as shown in Figure 9 can be attached to the coil. In this case, the magnets can be placed in between the battery and the cos! PCB to allow the coil to be on the top surface and therefore closest to the charger coil. The matching magnet in the charger can be a ring or a similar set of arcs or another shape or size to facilitate alignment If a ring is used behind the charger coil, then central symmetry between the two parts is retained and the parts can be rotated with respect to each other while keeping alignment for optimum operation.

[00413] Other geometries are possible. For example, Figure 75 illustrates embodiments 1120, 1126 in which the use of bar magnets on or around the coil is shown. Such a geometry does not have the symmetry offered by a ring magnet. However, this may be useful if only one dimension of alignment insensitivity is desired,

[00414] In any of the above geometries, use of two magnets with opposing polarity to attract each other is described. However, in accordance with some embodiments it is preferable for one of the parts to be non-magnetized. This may be advantageous in cases where it is not desirable for the mobile device to attract metallic parts when not being charged or powered by the inductive charger/power supply. An example may be a mobile phone where it is not desirable for the phone to attract metallic objects during normal use. in this case, the charger and/or power supply can contain a magnetized part and the other matching part in the mobile device/battery, can be made of appropriate magnetic material but not magnetized. For example, the charger/power supply may contain a magnetized ring as described above and a mobile phone can have a matching ring or arc made of magnetic material but not magnetized.

[00415] In addition, it is possible for the charger and/or power supply magnet to be activated electrically and be normally non-magnetized. For example, a wire winding or PCB trace is placed around the perimeter of the power transfer coil and powered to create a DC magnetic field for alignment of the two coils for power transfer/charging. in this way, neither of the two alignment parts need to be normally magnetized and therefore eliminate any concerns regarding unintended attraction of metallic objects or effects on magnetically sensitive parts such as credit cards, etc. The generated magnetic field can be further strengthened by using a non-magnetized magnetic material on or near the alignment trace area.

[00416] As an example, a circular path around the main charger/power supply PCB coil can be powered by a DC current periodically or when a user desires to charge or power a mobile device. This can be done by the user or can also be activated automatically by a sensor that senses the approach of an appropriate device to be charged or powered through RF, optical, magnetic, or other methods. Once the magnetic field (such as a ring pattern as described above), is generated it wiSI attract and align a magnetic meta! part or magnet of appropriate shape in the mobile device or battery into the correct alignment and placement and help the user place the mobile device in the correct position. Once the device is placed in the right location, the DC magnetic field may no longer be necessary and can be shut down or reduced to save power. Thus only for a very brief period this alignment magnet may be needed. During other times, neither the charger and/or power supply or the mobile device can be designed to have any magnetic field around them or contain weaker magnets.

[00417] The use of magnets as described above is especially useful for cases where movement between the power suppiy and/or charger and the device or battery to be charged or powered may occur. As an example, in an automobile environment, it is desirable to keep a mobile device such as a phone from moving during charging. Thus the use of the magnets described above, in addition to the above benefits, can enable use in moving environments. In addition, in some cases, it may be beneficial to have the charger and/or power supply in a position that is not horizontal. For example, a charger can be installed vertically. In this case, the magnets can be designed to be strong enough to hold the mobile device or battery in piace vertically during the charging or powering process.

[00418] In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating the coil from low electrical conductivity materials or ceramics, layering the magnet into thin sheets to increase resistivity, using bonded materia! in an epoxy matrix, roughing the surface, cutting gaps in the material to reduce circular motion of electrons, or other common techniques to increase the resistivity. The magnet can also be manufactured from segments that are not

electrically connected to prevent electrons to be able to trave! around a circular path. For example, the ring magnet can be manufactured, formed or attached to the coils from two or four ring arcs that are not electrically in contact or attached to each other, using a non¬ conducting epoxy to form a full ring, or parts of a ring,

[00419] In addition, the coils shown above are generally circular. However, the methods and discussion above can be applied to coils of any shape and size as well as an array or cluster of coils and can provide in performance of any size and type of coil.

[00420] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical application, thereby enabling others skilled in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of an embodiment be defined by the following claims and their equivalence.

[00421] Some aspects of an embodiment may be conveniently implemented using a conventional genera! purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as wii! be apparent to those skilled in the art.

[00422] In some embodiments, an embodiment includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of an embodiment. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, *DVD,* CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROIvIs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00423] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. Particularly, whiie the embodiments of the systems and methods described above are described in the context of charging pads, it will be evident that the system and methods may be used with other types of charger or power supplies. Similarly, while the embodiments described above are described in the context of charging mobile devices, other types of devices can be used. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical

application, thereby enabling others skied in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particuiar use contemplated. ɜ is intended that the scope of an embodiment be defined by the following claims and their equivalence.

Claims;

What is claimed is:

1. A system for inductive powering and charging of portable devices or batteries, comprising:

a base unit, including one or more primary coils composed of a non-ferrite materia! and shaped as planar spiral coils, which are capable of generating an inductive energy for use in powering or charging multiple devices or batteries simultaneously;

a receiver unit, including a receiver coil also composed of a non-ferrite materia! and shaped as a pianar spiral coil, which is coupled to or incorporated into a portable device or battery, wherein the secondary coil receives energy inductively from the primary coil and uses it to charge or power the portable device or battery;

means within the base unit for allowing a degree of position independence of the devices or batteries on the base unit and selectively activating the one or more primary coils; and

wherein the base unit can simultaneously charge or power additional portable devices or batteries with additional secondary coils.

2. The system of claim 1, wherein the charger or power supply includes a plurality of coils, and wherein the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery.

3. The system of claim 1, wherein the charger and a receiver in the device or battery both include microcontroller units, wherein the microcontroller unit in the charger monitors current flow, and wherein the microcontroller unit in the portable device or battery provides communication between the charger and the receiver for use in controlling charging.

4. The system of claim 1, wherein the charger or power supply includes an additional verification step prior to activating charging, to verify the identity or permissions of a device or battery.

5. The system of claim 1, wherein a plurality of coils are integrated into a pad-like charger or power supply and wherein the coils are used to form a coil mosaic and an effective area of charging or power that does not cover more than approximately 90% of pad surface.

6. The system of claim 1, wherein each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more

COilS,

7. The system of claim 1, wherein one or more coils includes a switch component, and wherein the microcontro üer unit periodically starts the switch components, monitors the current therein, and uses the current to sense the proximity of a receiver and device or battery to that coil and activate charging in that coil, or a selection of coils in that region.

8. The system of claim 1, wherein a plurality of iayers of coiis are layered upon one another to create an effective area, and so that powering any one or a seiection of the coiis ailows a receiver whose center is within the effective area to be charged.

9. A mobile device capable of being inductively powered or charged comprising;

a battery; and

a receiver for one of ind ʊctiveiy powering the device or charging the battery in the mobile device, and wherein the receiver is one of attached to or incorporated into the battery or the mobiie device.

10. The mobiie device charger or power supply of claim 9, wherein the coiis or wires are formed within a printed circuit board PCB iayer of at least two different sizes or shapes.

11. The mobile device charger or power supply of claim 9, wherein the charger or the power supply, and the mobile device, communicate with each other to transfer data,

12. The mobile device charger or power supply of claim 9, wherein the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply and/or wherein the charger or power supply stores charging or power requirements for mobile devices which can be charged or powered by the charger or power suppiy.

13. A system for use with a mobile device or battery for charging or powering the mobile device or battery inductively, comprising;

a base unit including one or more pnmary coiis therein, the primary coil having a generally pianar shape so that when a current is passed through the primary coil a magnetic field is generated in a direction substantialiy perpendicular to the plane of the primary coil; and

wherein the perpendicular magnetic field inductively generates a current in a matching receiver coil or coils within a mobile device or battery placed close to and aligned with the base unit, to charge or power the mobile device or battery.

14. The system of claim 13 wherein one or more of the coils are manufactured on printed circuit boards and are manufactured to have a !ow resistance.

15. The system of claim 13 further comprising a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an externa! power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time.

16. The system of claim 13 further comprising one of a soiar ceil coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface of the base unit or pad includes a decorative or non-slip surface,

17. The system of claim 13, wherein a plurality of modular chargers or power suppües can be interconnected to form a single unit

18. The system of claim 13, wherein the mobile device to be charged or powered includes a charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device or battery to a predetermined maximum voltage, and a switch means that includes a MOSFET and the circuit includes a capacitor connected in parallel to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the tviOSFET when the base unit detects a mobile device or battery placed close to or aligned with the primary coil.

19. The system of claim 13, further comprising means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power into the coils under different load conditions, to maintain high efficiency during different load conditions or charging stages.

20. The system of claim 19, wherein the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation.

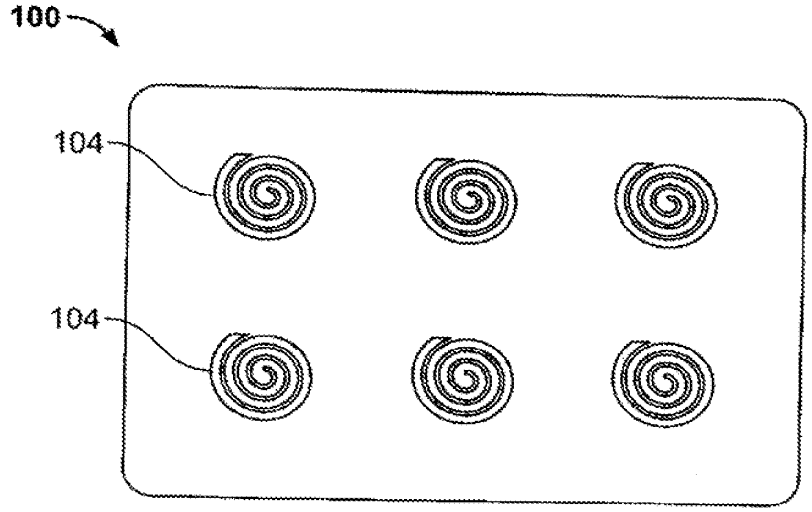

100
104
104

FIG. 1

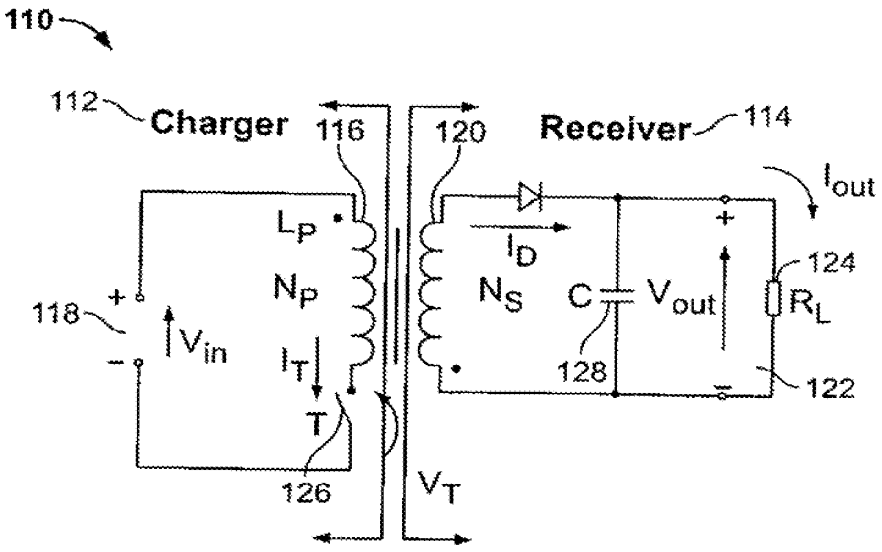

110
112
Charger
116
120
Receiver
114
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
124
R_L
118
+
V_{in}
−
I_T
T
128
122
126
V_T

FIG. 2

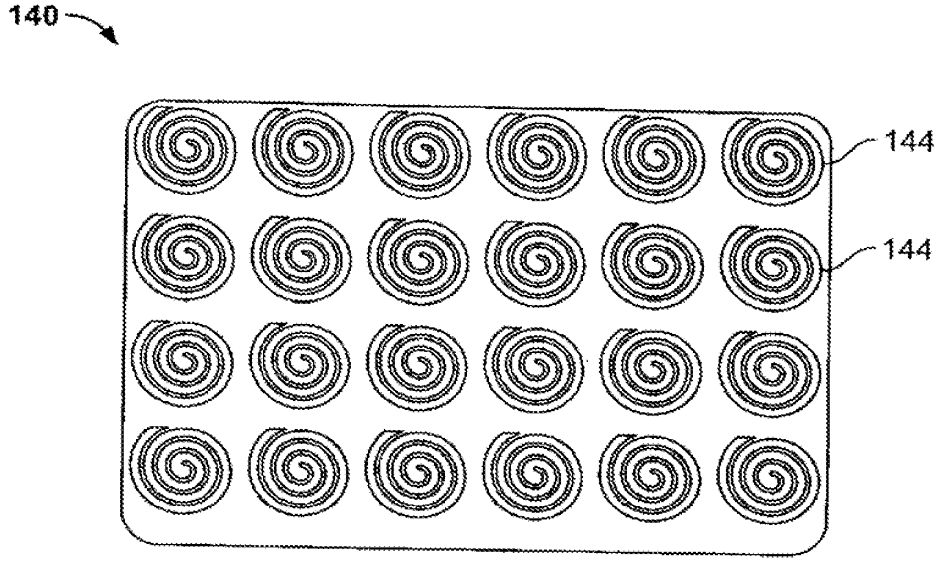


FIG. 3

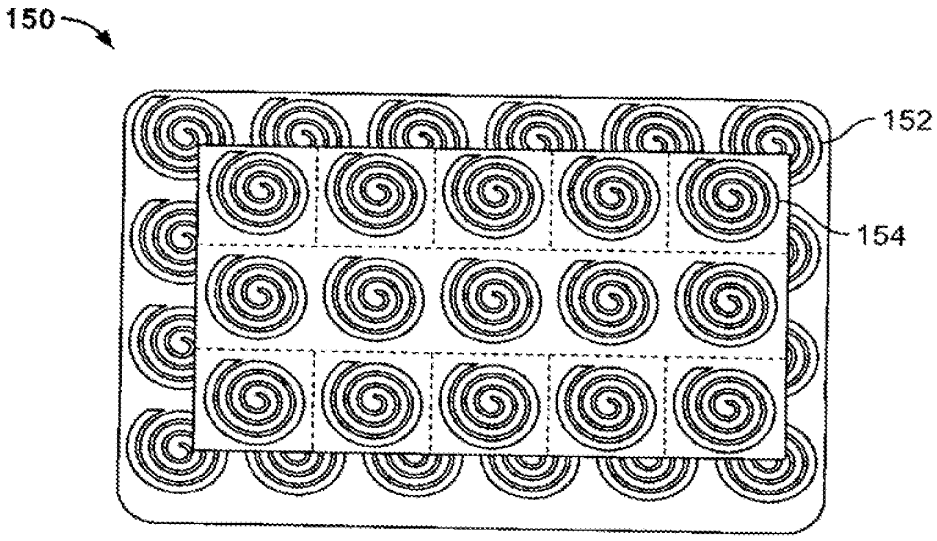


FIG. 4

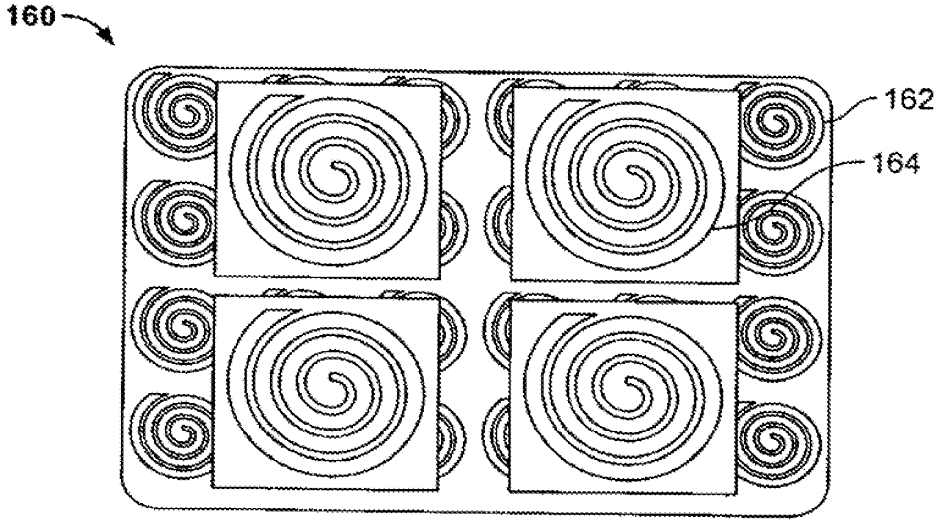

160
162
164

FIG. 5

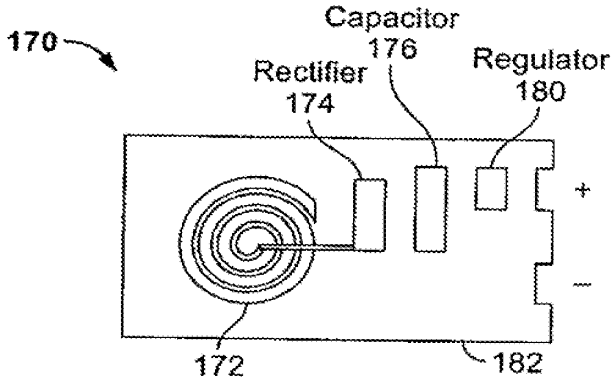

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

FIG. 6

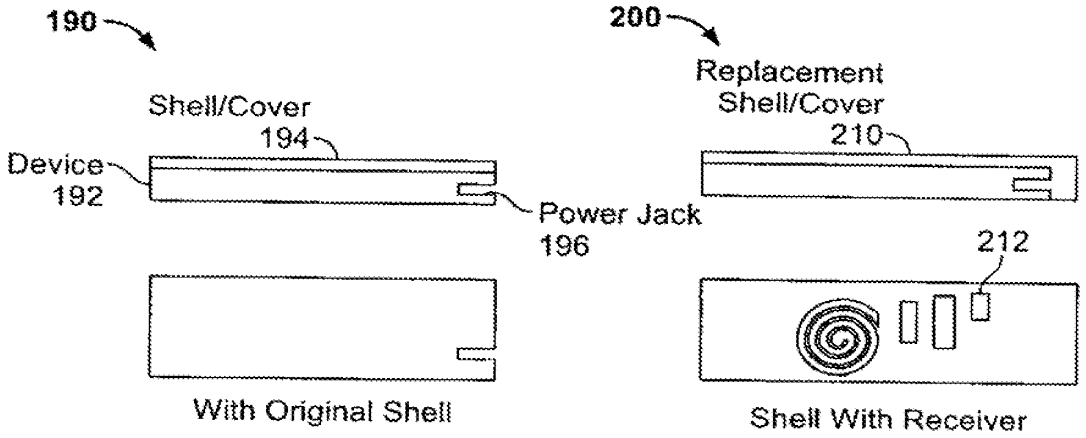

190
200
Shell/Cover
194
Device
192
Power Jack
196
Replacement
Shell/Cover
210
212
With Original Shell
Shell With Receiver

FIG. 7

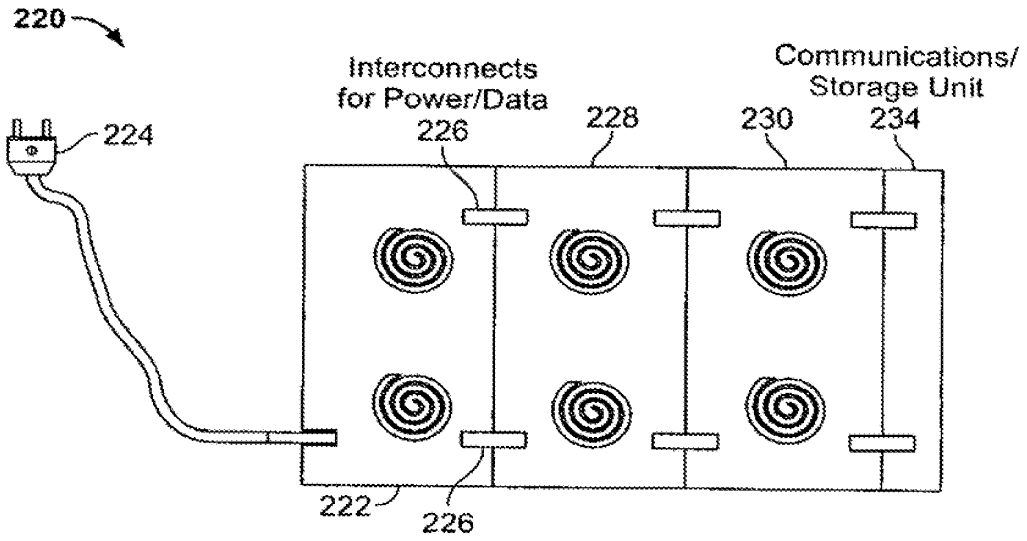

220
224
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
222
226

FIG. 8

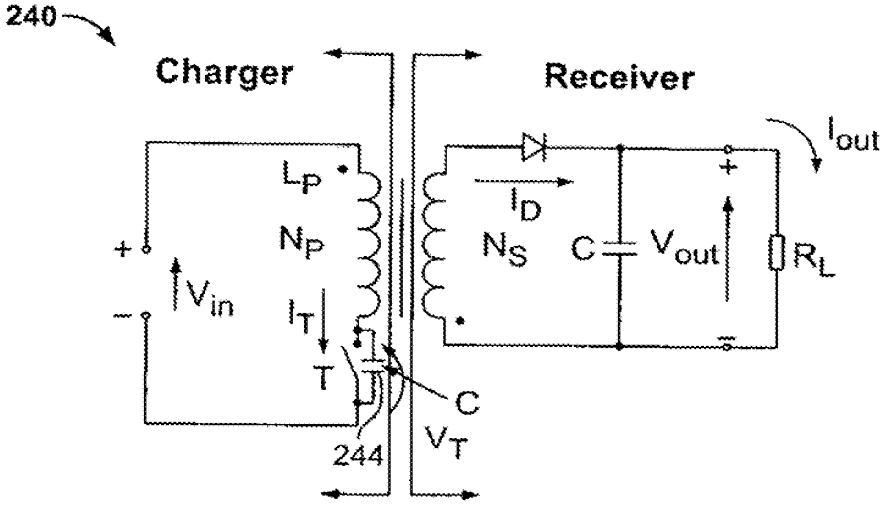

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
244
V_T

FIG. 9

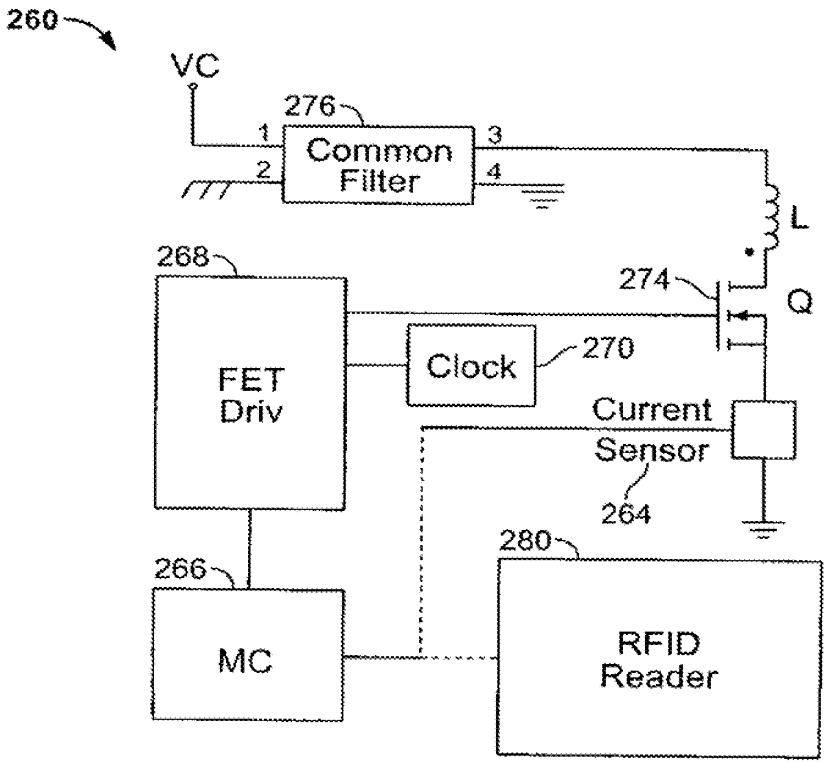

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

FIG. 10

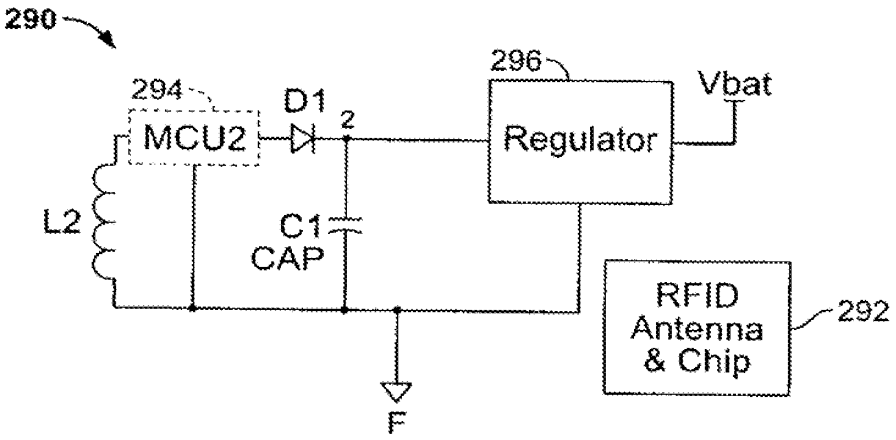

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

FIG. 11

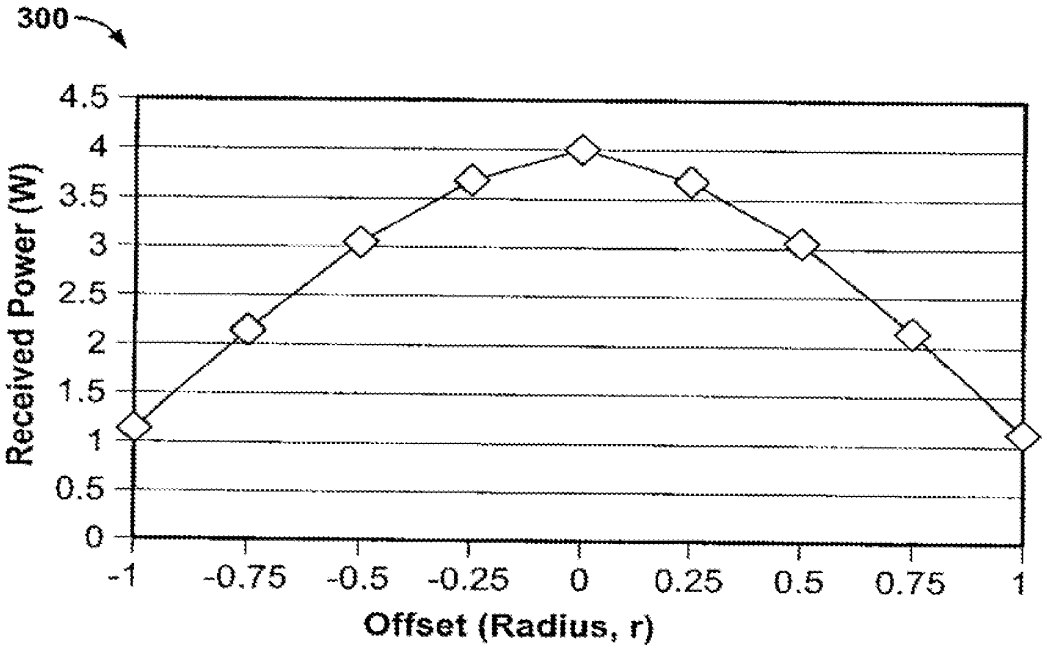

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

FIG. 12

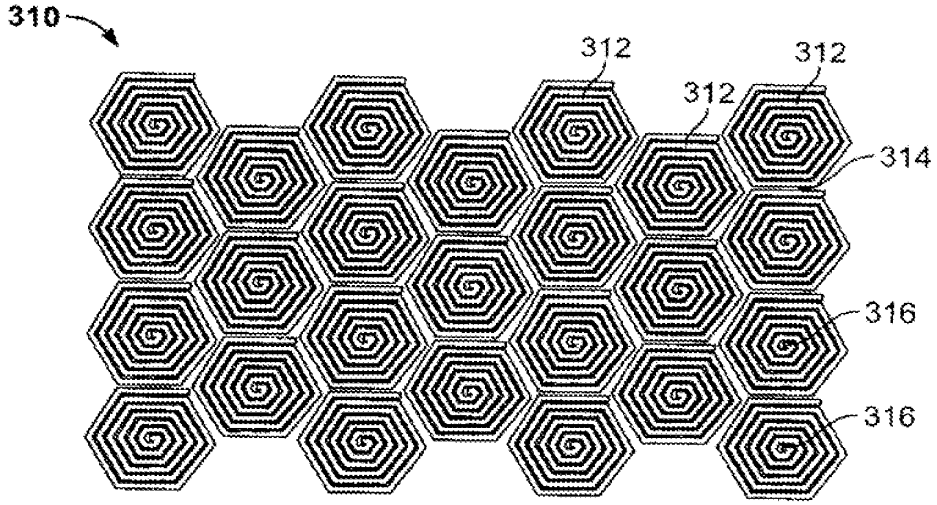


FIG. 13

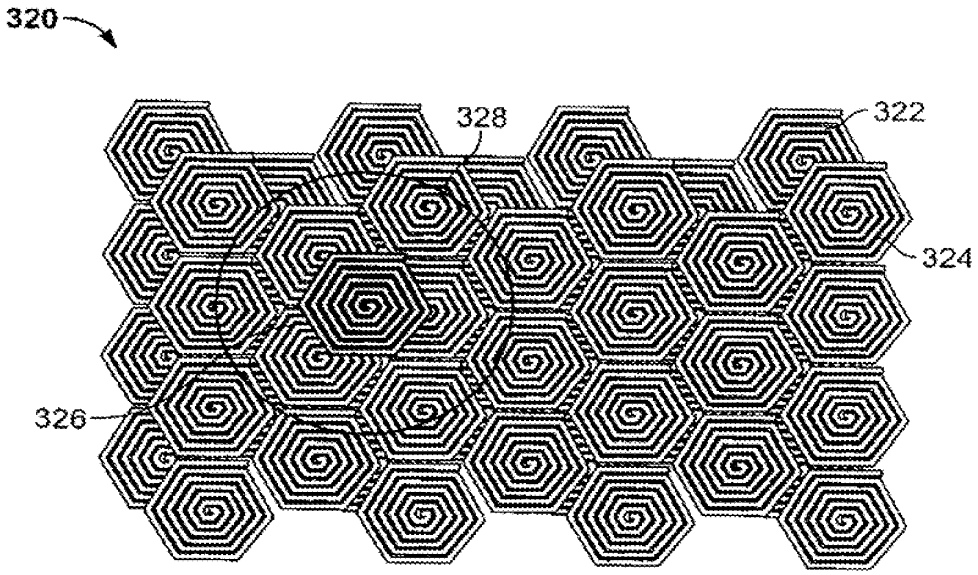


FIG. 14

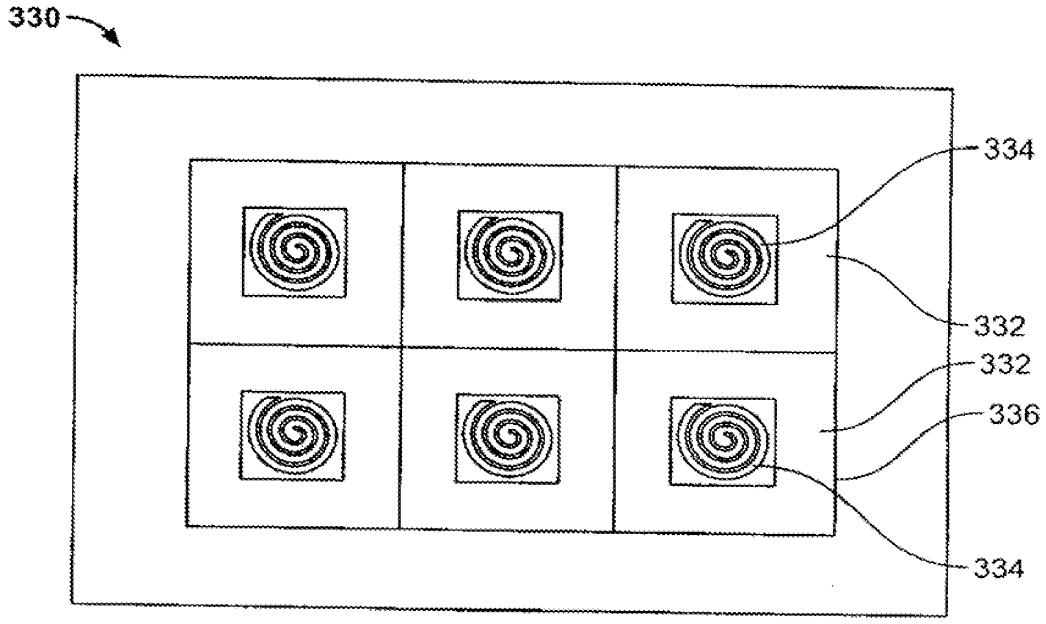


FIG. 15

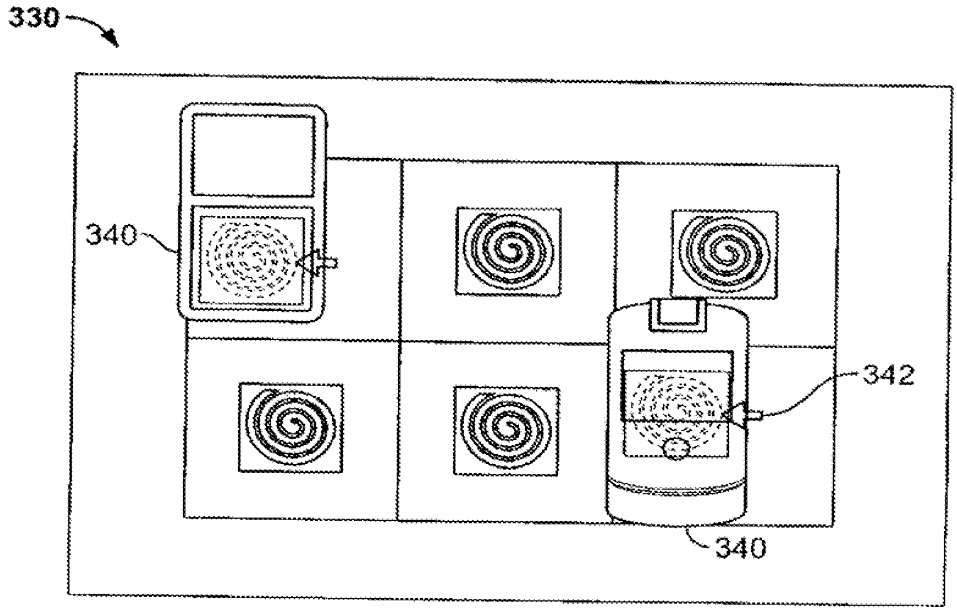


FIG. 16

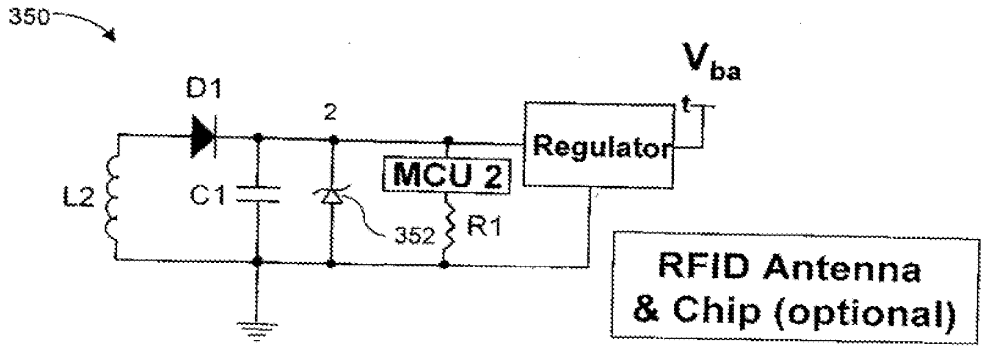

350
D1
2
V_{ba}
Regulator
MCU 2
L2
C1
352
R1
RFID Antenna
& Chip (optional)

FIG. 17

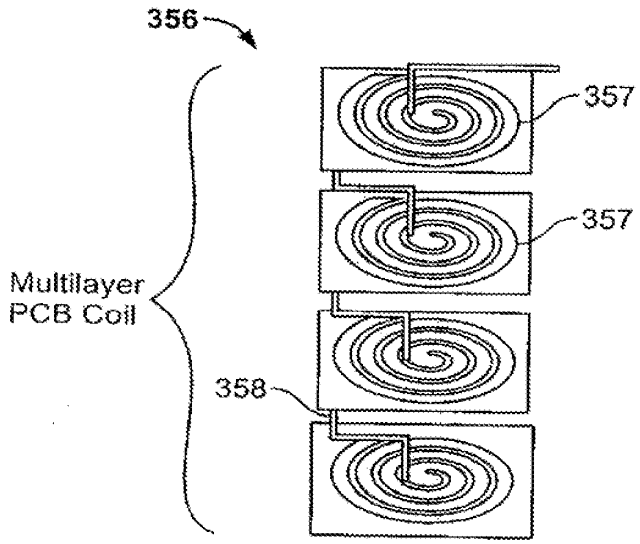

356
357
357
Multilayer
PCB Coil
358

FIG.18

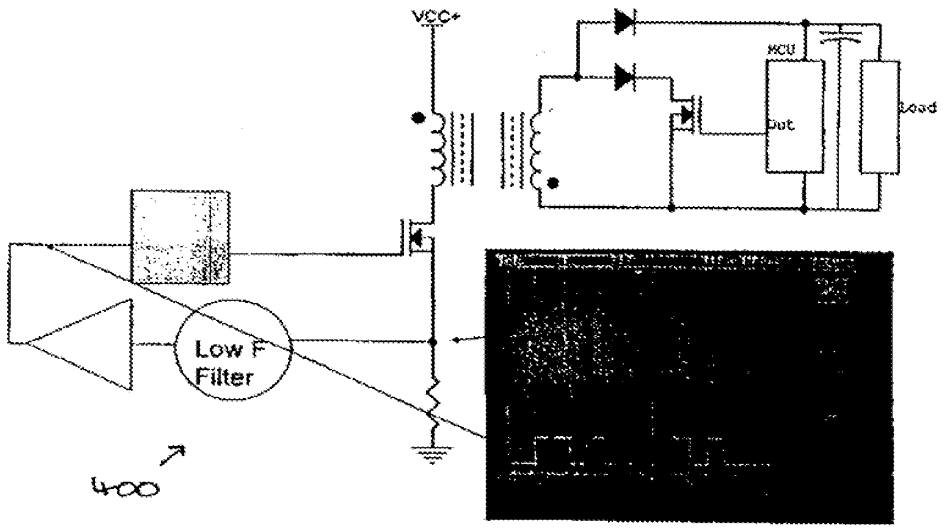


FIG. 19

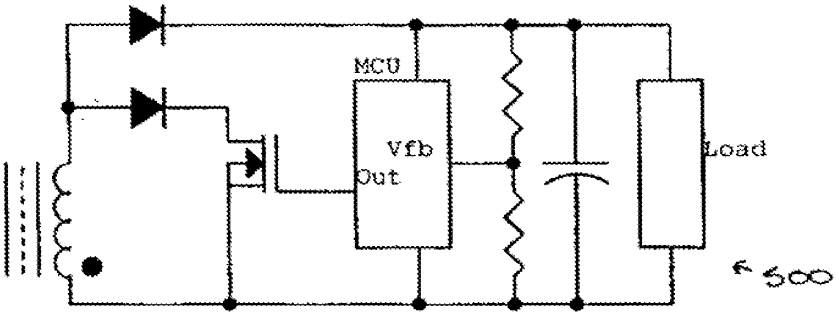


FIG. 23

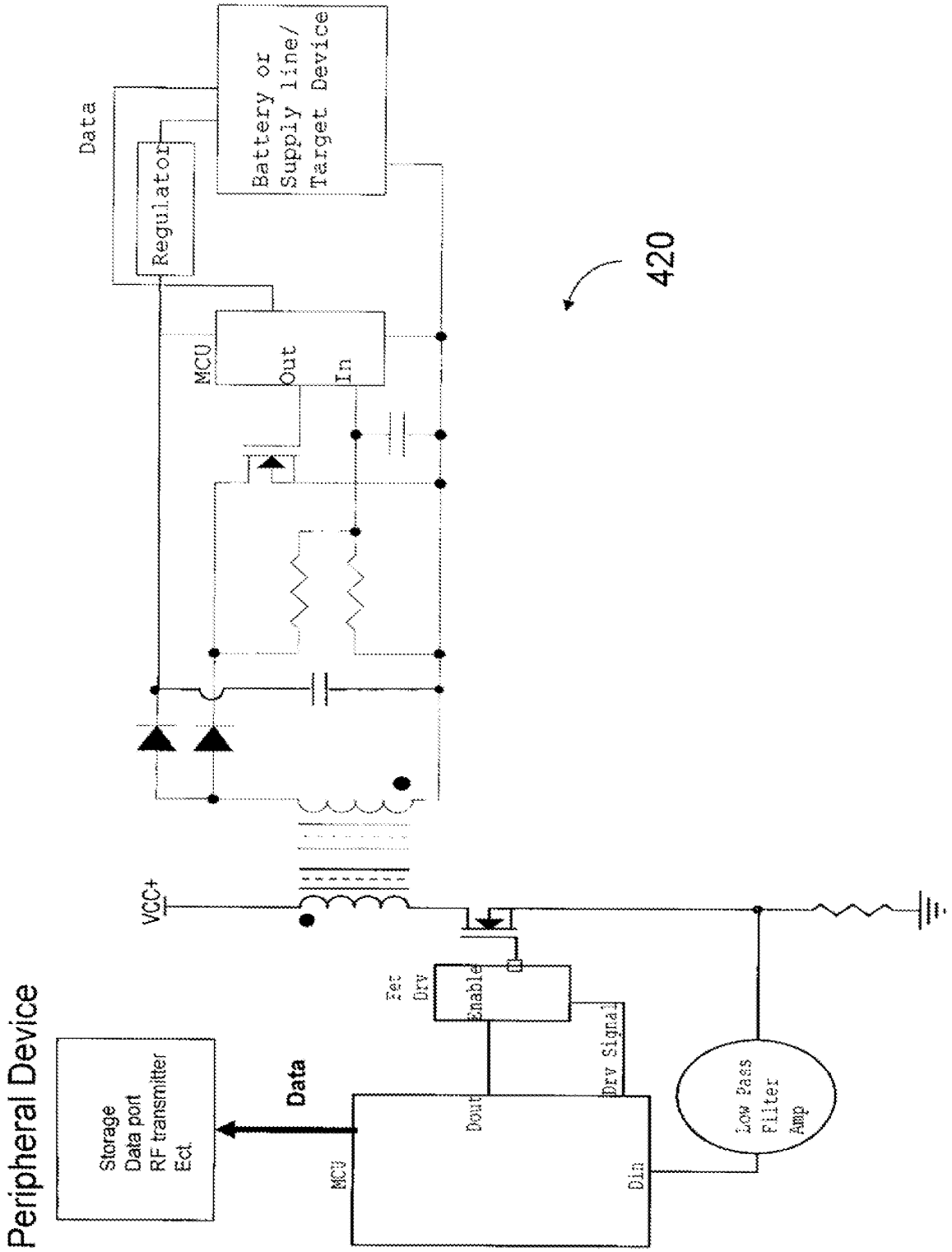

Peripheral Device
Storage
Data port
RF transmitter
Ect.
Data
MCU
Dout
Din
Drv Signal
Enable
Rec
Drv
VCC+
Low Pass
Filter
Amp
MCU
Out
In
Regulator
Data
Battery or
Supply line/
Target Device
420

Figure 20

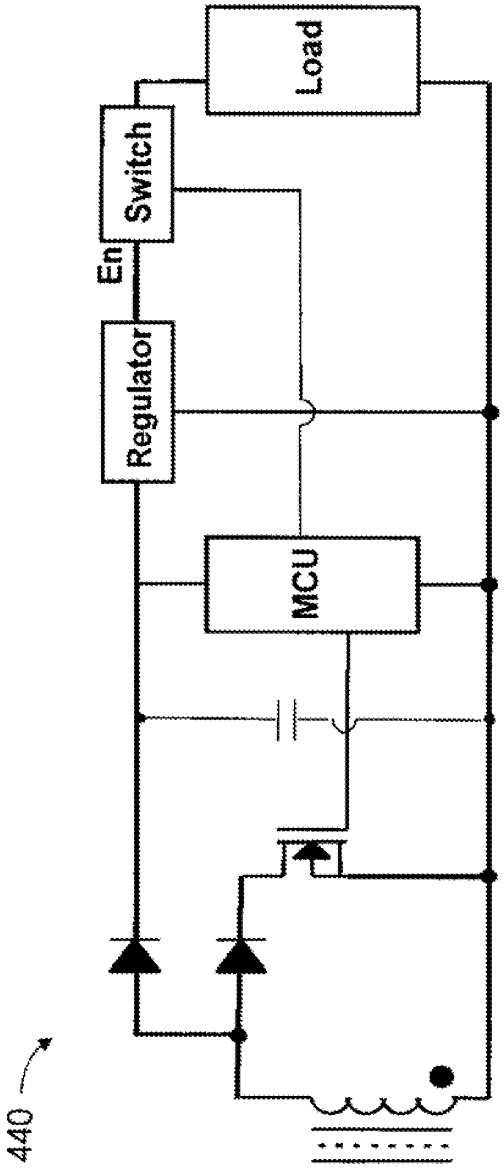


Figure 21

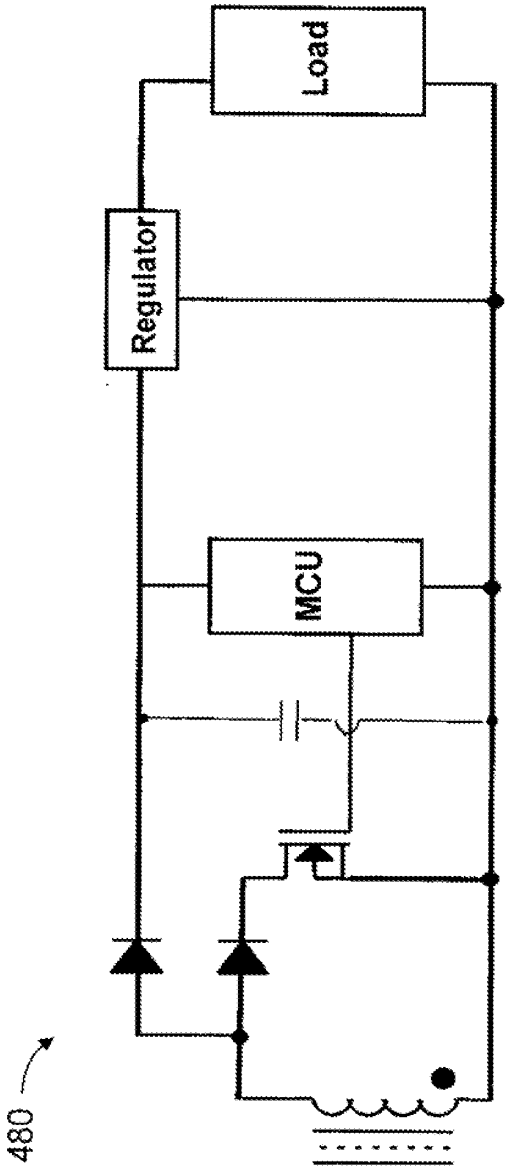


Figure 22

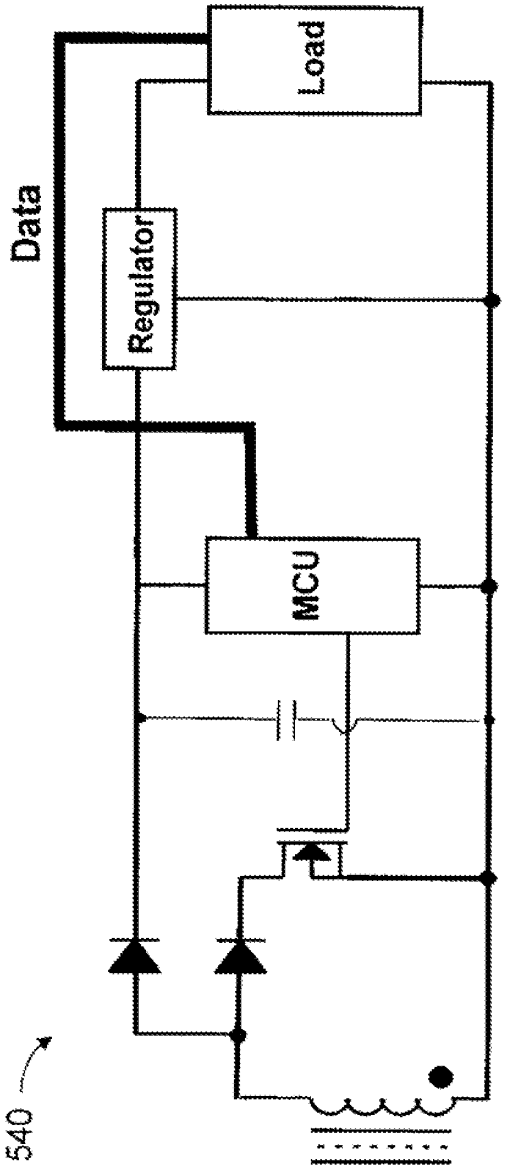


Figure 24

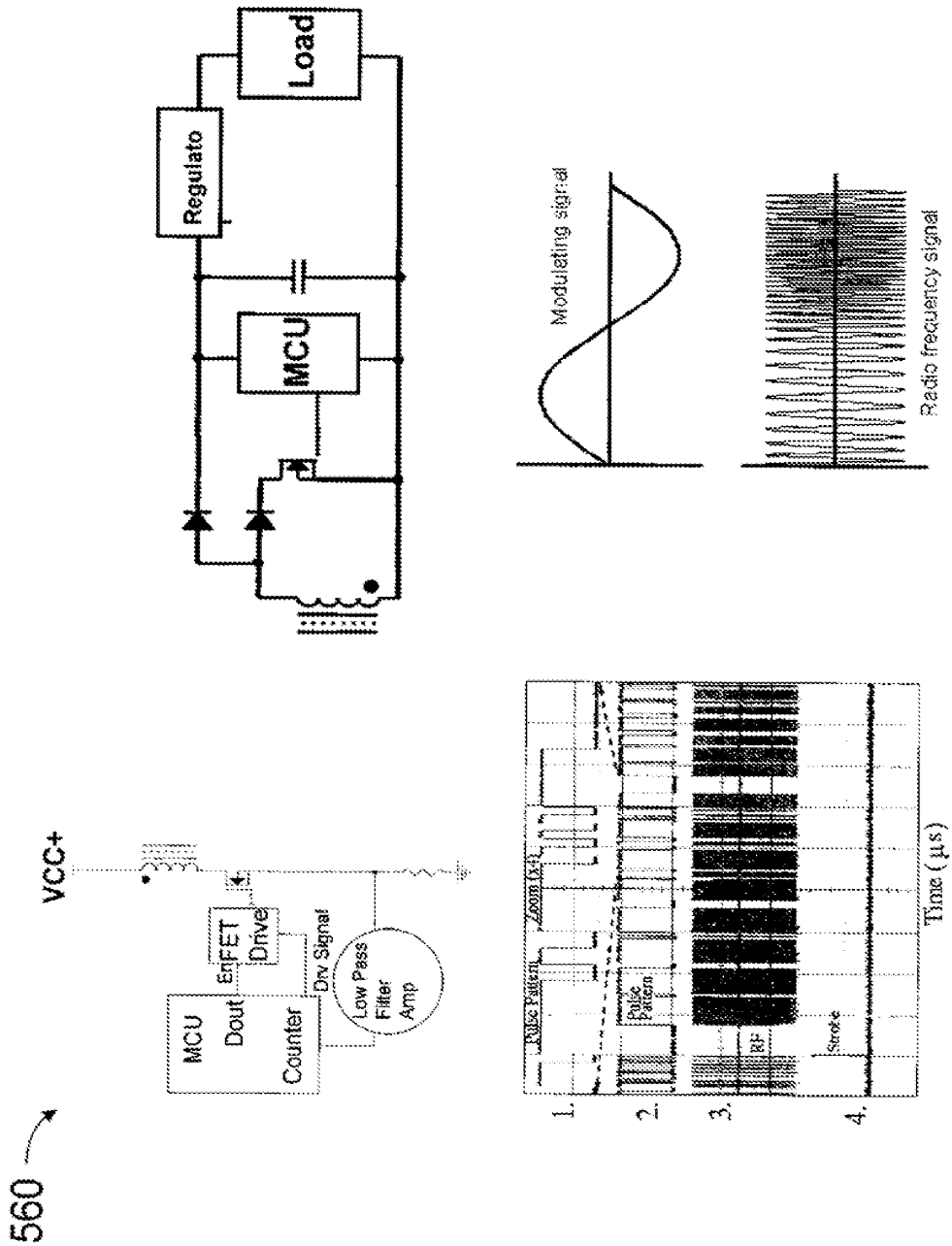

Load
Regulato
MCU
Modulating signal
Radio frequency signal
VCC+
EnFET
Drive
Dout
MCU
Counter
Drv Signal
Low Pass
Filter
Amp
560
Pulse Pattern
Zoom (x1)
Pulse Pattern
RF
Stroke
1.
2.
3.
4.
Time (µs)

Figure 25

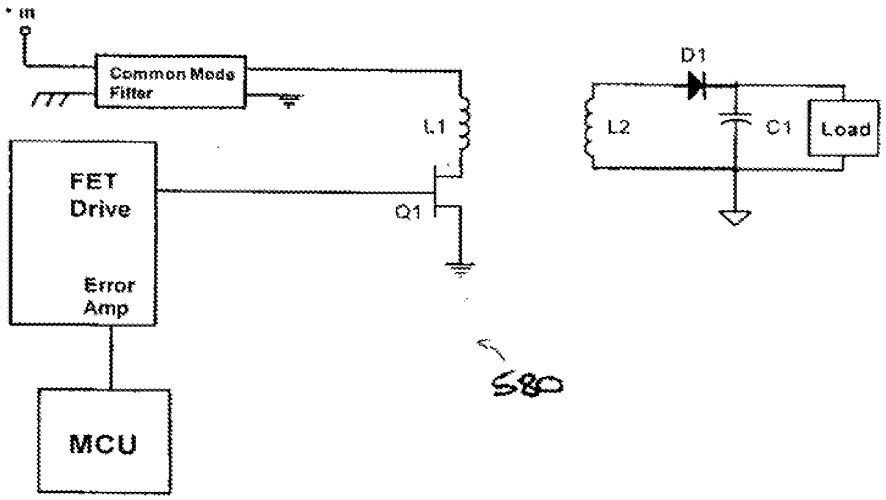

Common Mode Filter
L1
FET Drive
Q1
Error Amp
MCU
D1
L2
C1
Load
580

FIG. 26

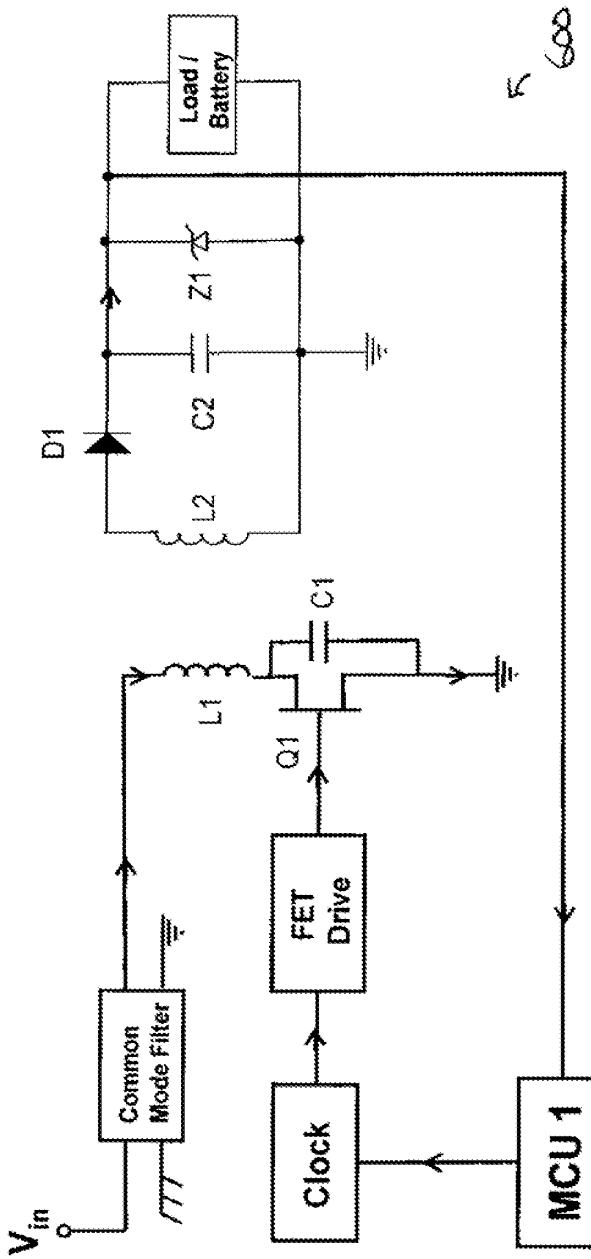

600
Load / Battery
Z1
C2
D1
L2
C1
L1
Q1
FET Drive
Common Mode Filter
Clock
MCU 1
V_{in}

Figure 27

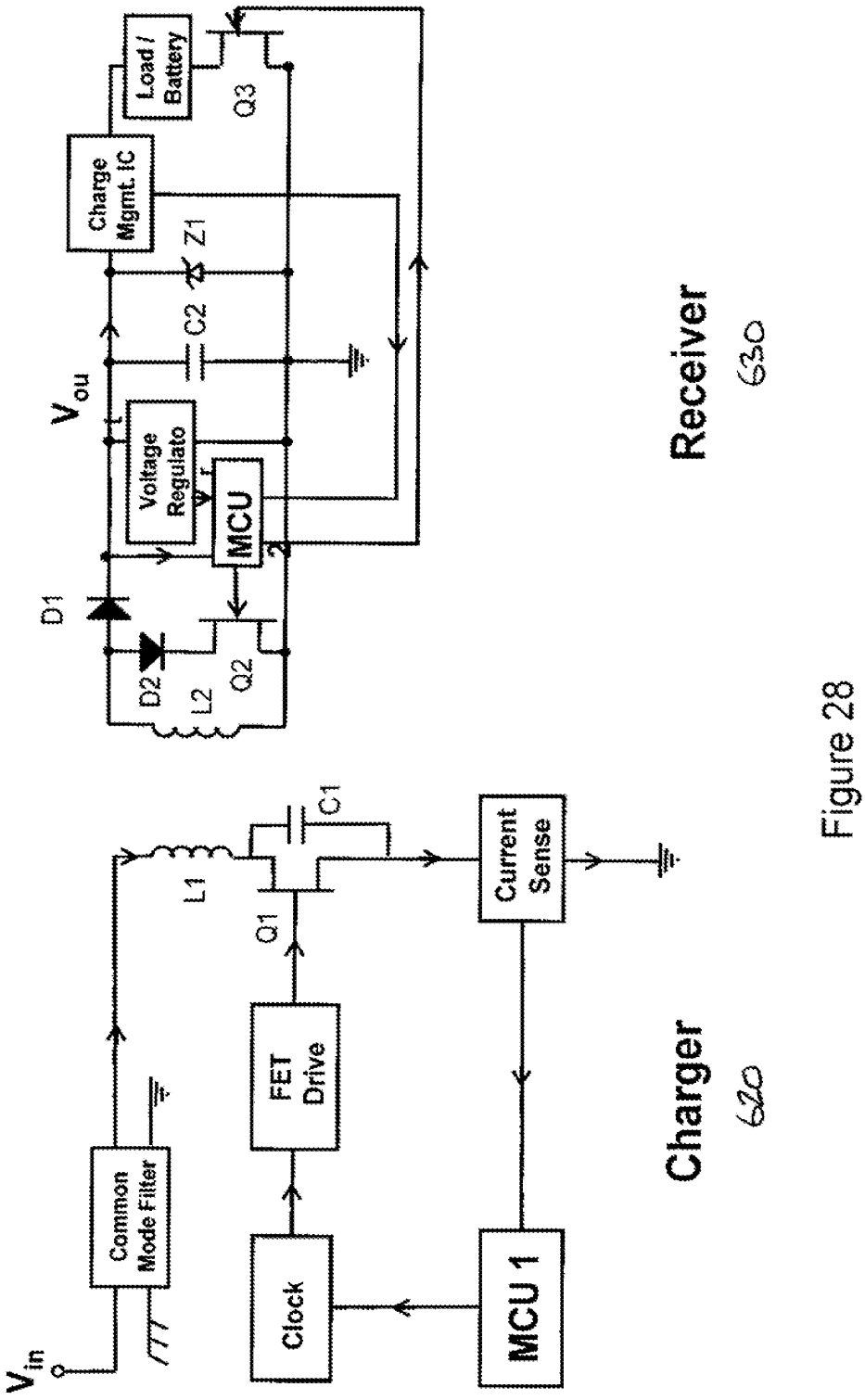

Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
Vou
Voltage Regulato
MCU
D1
D2
L2
Q2
Receiver
630
C1
L1
Q1
Current Sense
FET Drive
Common Mode Filter
Vin
Clock
MCU 1
Charger
620

Figure 28

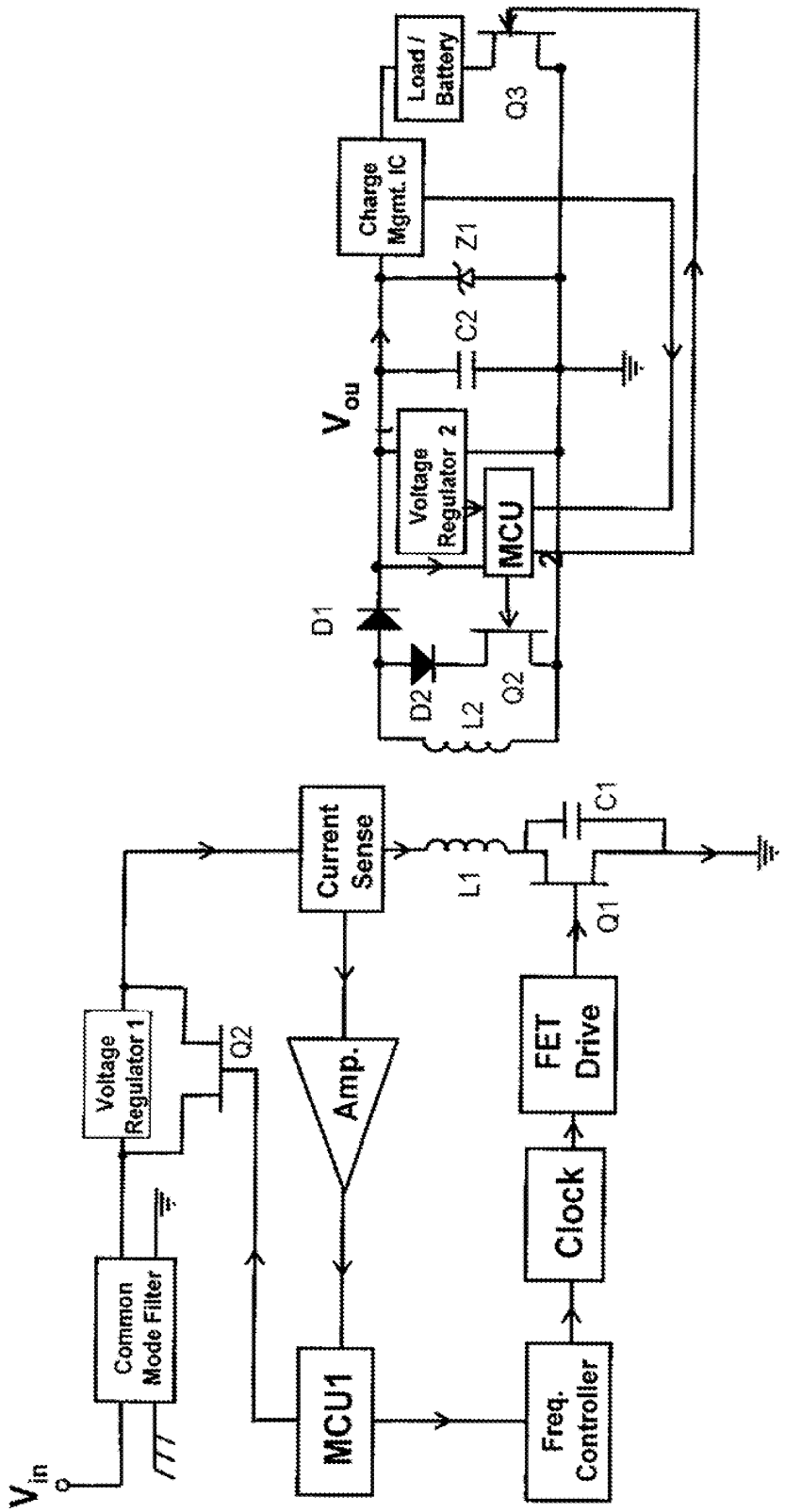

Load / Battery
Q3
Charge Mgmt. IC
Z1
C2
V_{out}
Voltage Regulator 2
MCU
D1
D2
L2
Q2
Receiver
640
Current Sense
L1
C1
Q1
Voltage Regulator 1
Q2
Amp.
FET Drive
Clock
Common Mode Filter
MCU1
Freq. Controller
V_{in}
Charger

Figure 29

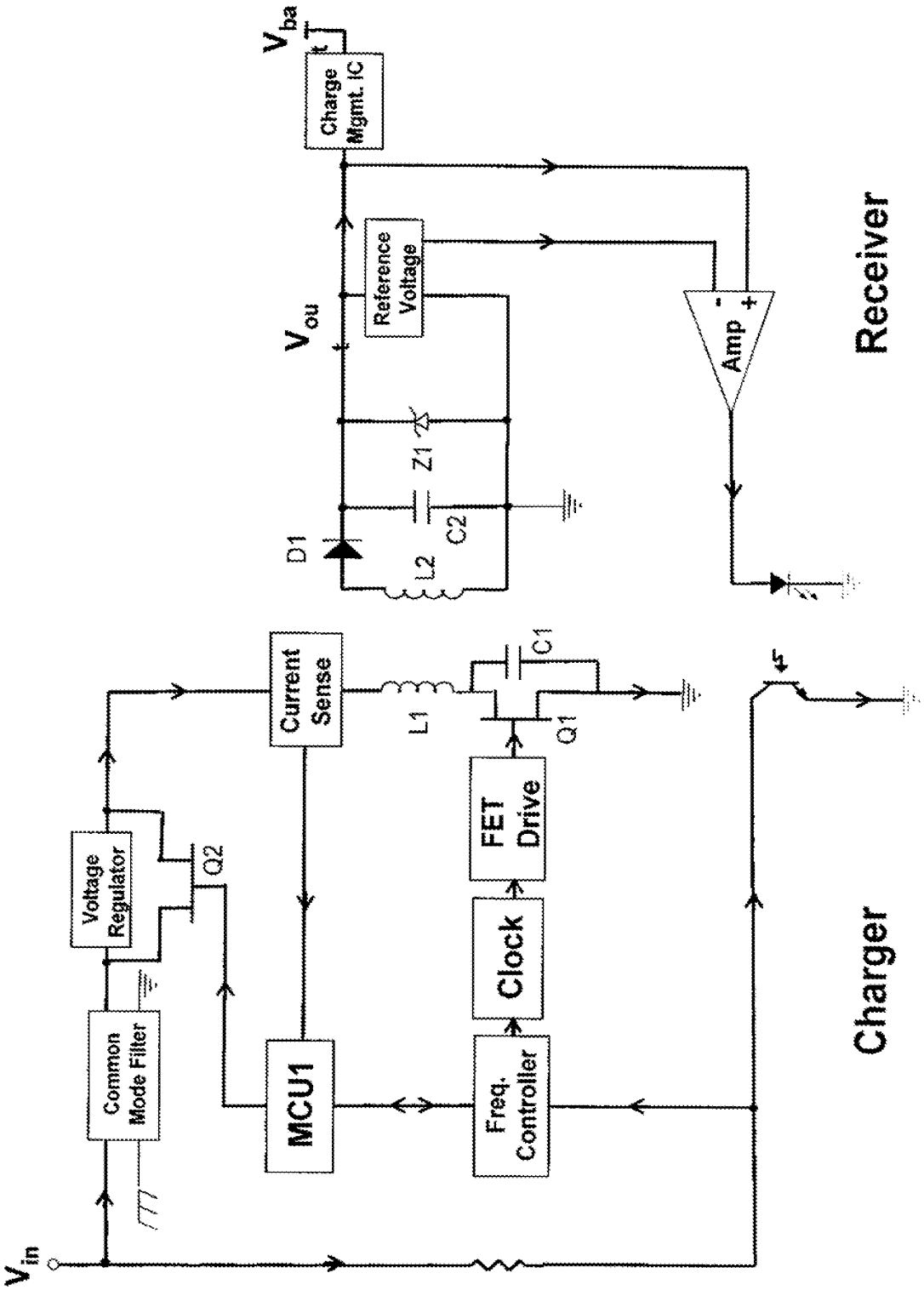

V_{ba}
Charge Mgmt. IC
V_{ou}
Reference Voltage
Amp
Receiver
650
Z1
C2
D1
L2
Current Sense
L1
C1
Q1
FET Drive
Clock
Voltage Regulator
Q2
Common Mode Filter
MCU1
Freq. Controller
Charger
V_{in}

Figure 30

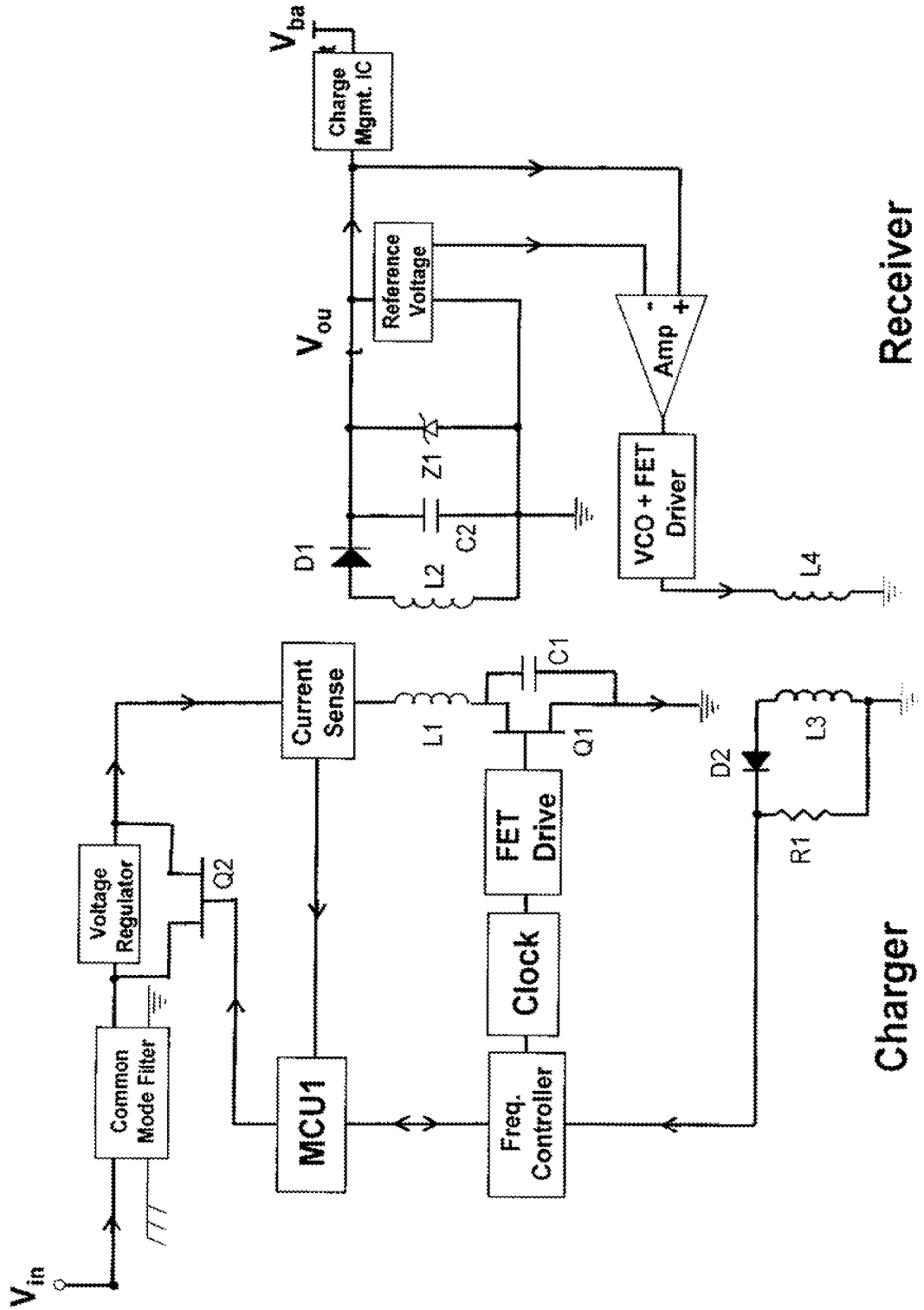

V_{ba}
Charge Mgmt. IC
V_{ou}
Reference Voltage
Amp
Receiver
Z1
C2
D1
L2
VCO + FET Driver
L4
660
Current Sense
L1
C1
Q1
D2
L3
R1
FET Drive
Clock
Voltage Regulator
Q2
Common Mode Filter
MCU1
Freq. Controller
Charger
V_{in}

Figure 31

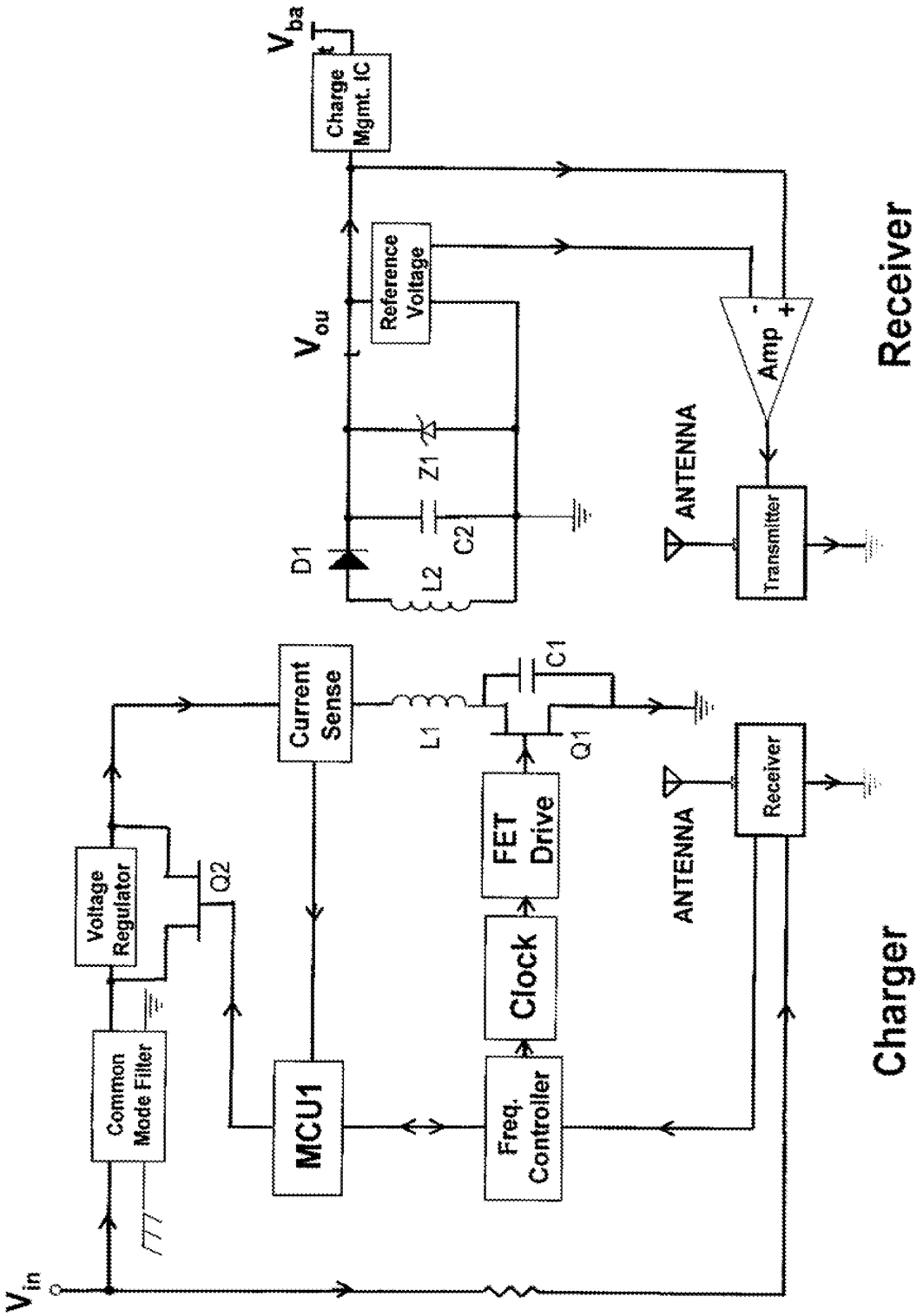

Charger
Receiver
V_{in}
V_{ba}
V_{ou}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
C1
Q1
FET Drive
Clock
Freq. Controller
ANTENNA
Receiver
Charge Mgmt. IC
Reference Voltage
D1
L2
C2
Z1
Amp
ANTENNA
Transmitter
670

Figure 32

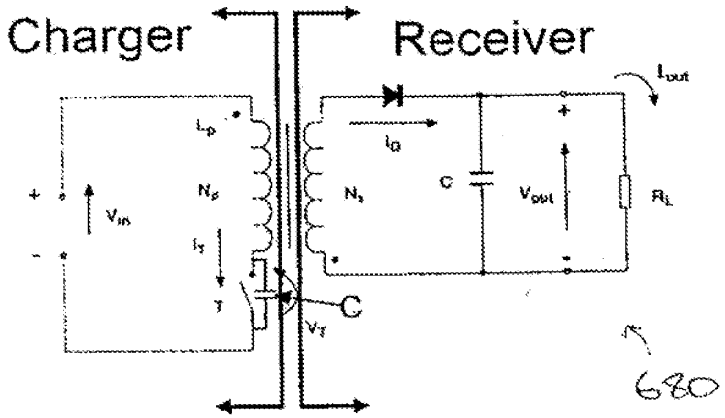


FIG. 33

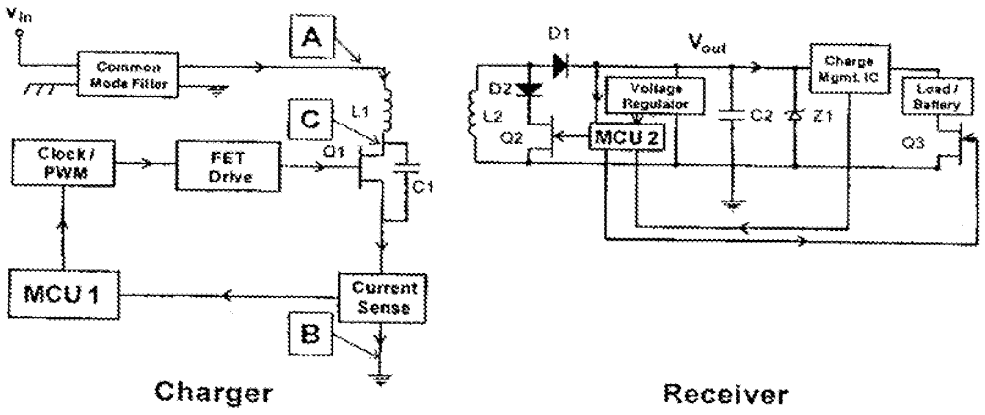


FIG. 34 700

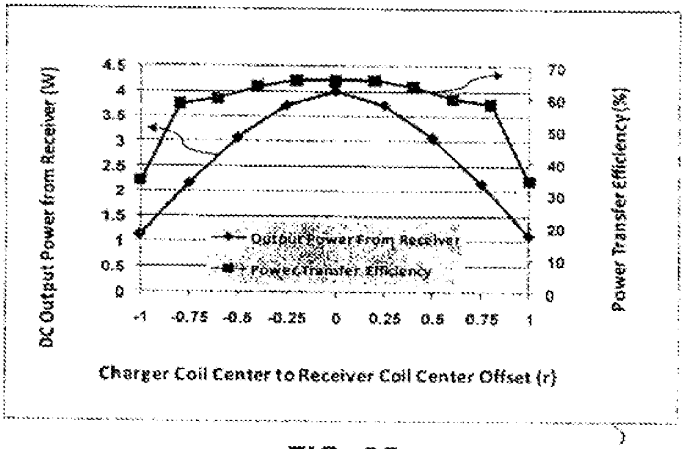


FIG. 35 720

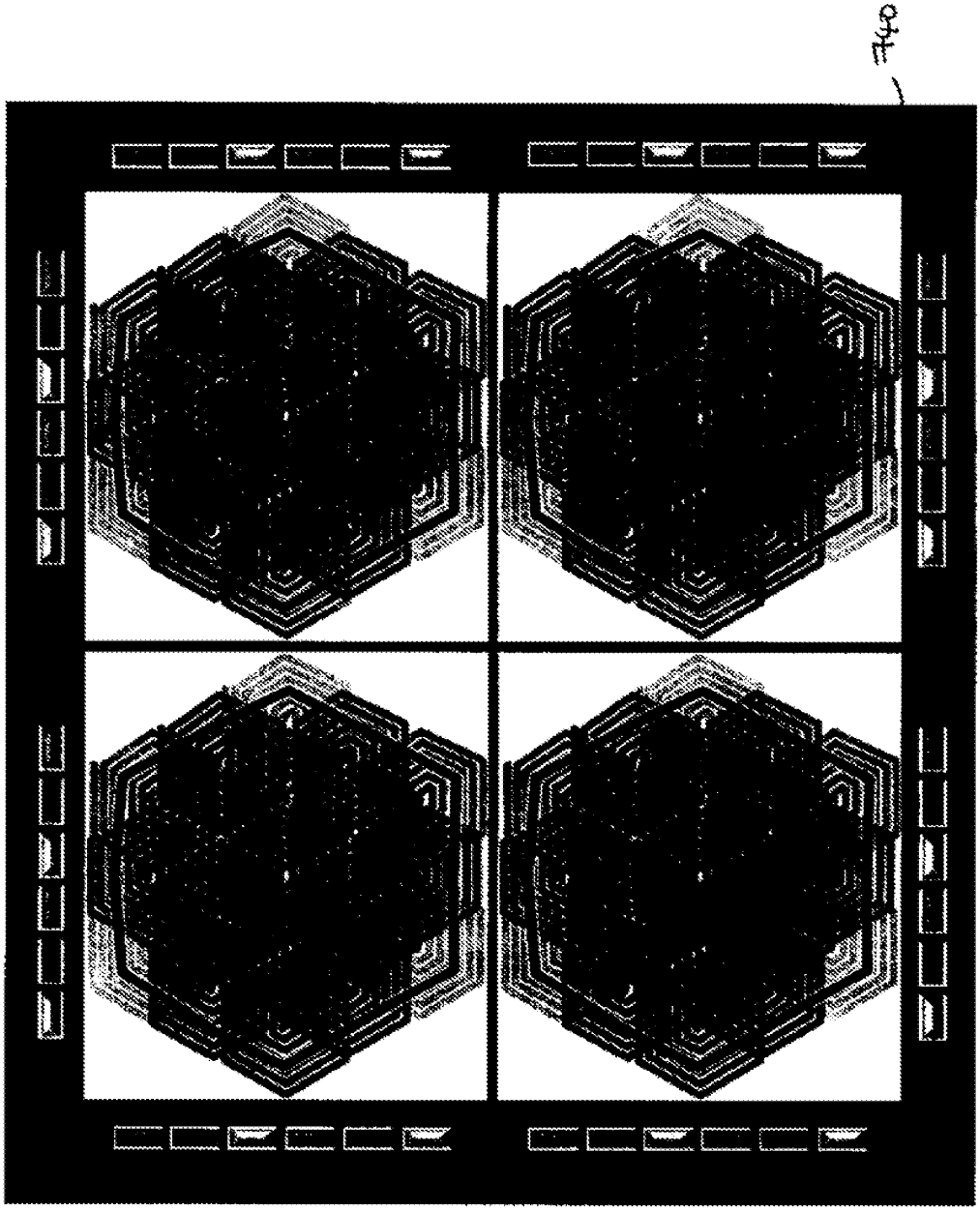


Figure 36

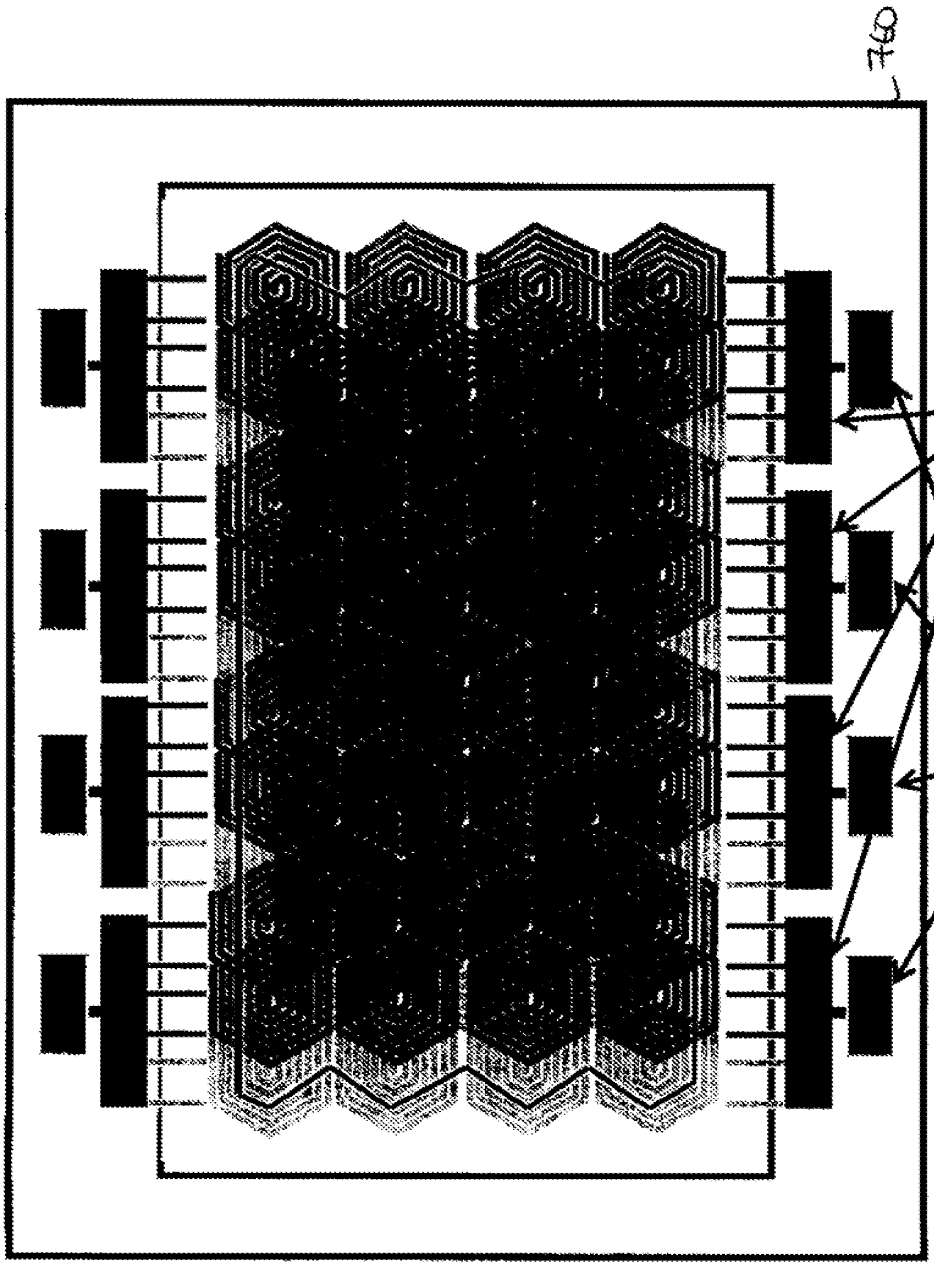


Figure 37

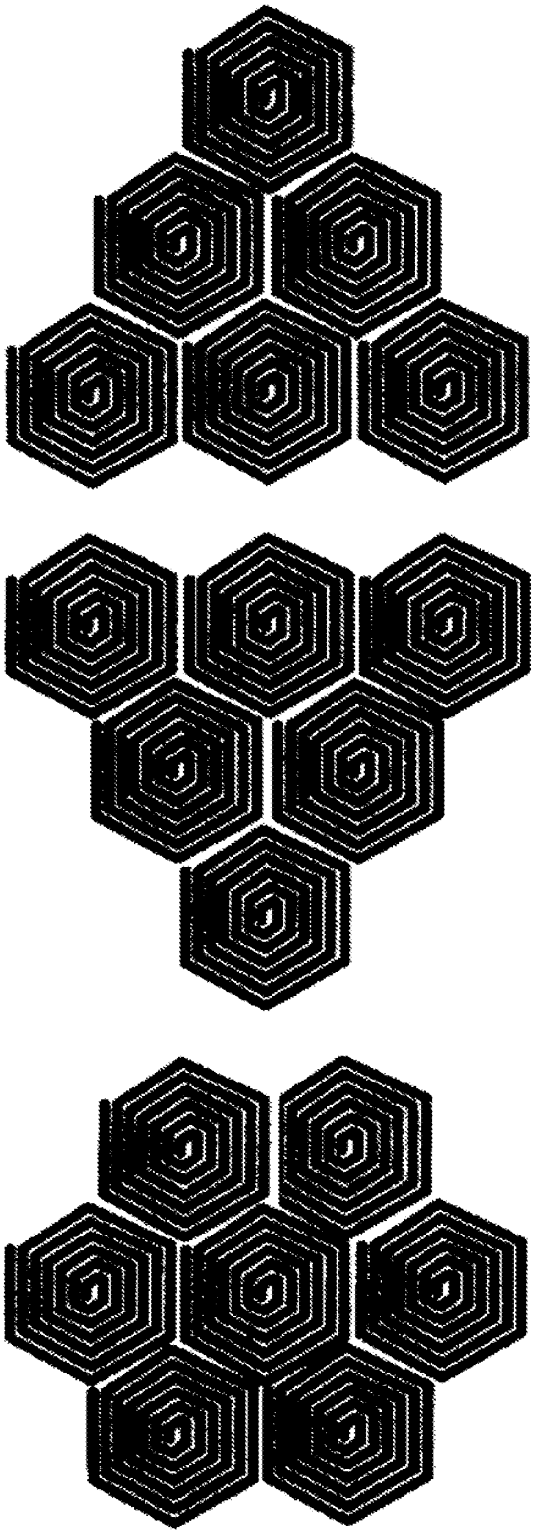

(1,1)
(1,2)
(1,3)
(1,4)
(1,5)
(1,6)
(1,7)
(Layer 1)
(2,1)
(2,2)
(2,3)
(2,4)
(2,5)
(2,6)
(Layer 2)
(3,1)
(3,2)
(3,3)
(3,4)
(3,5)
(3,6)
(Layer 3)
780

Figure 38

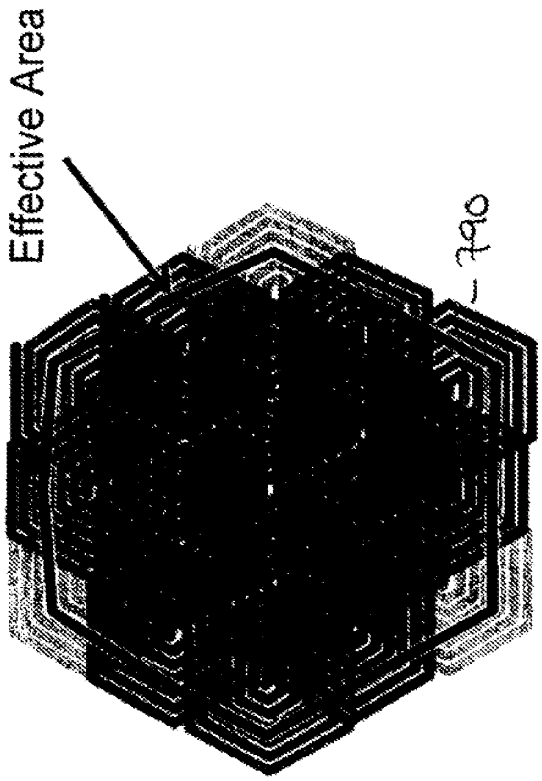


Figure 39

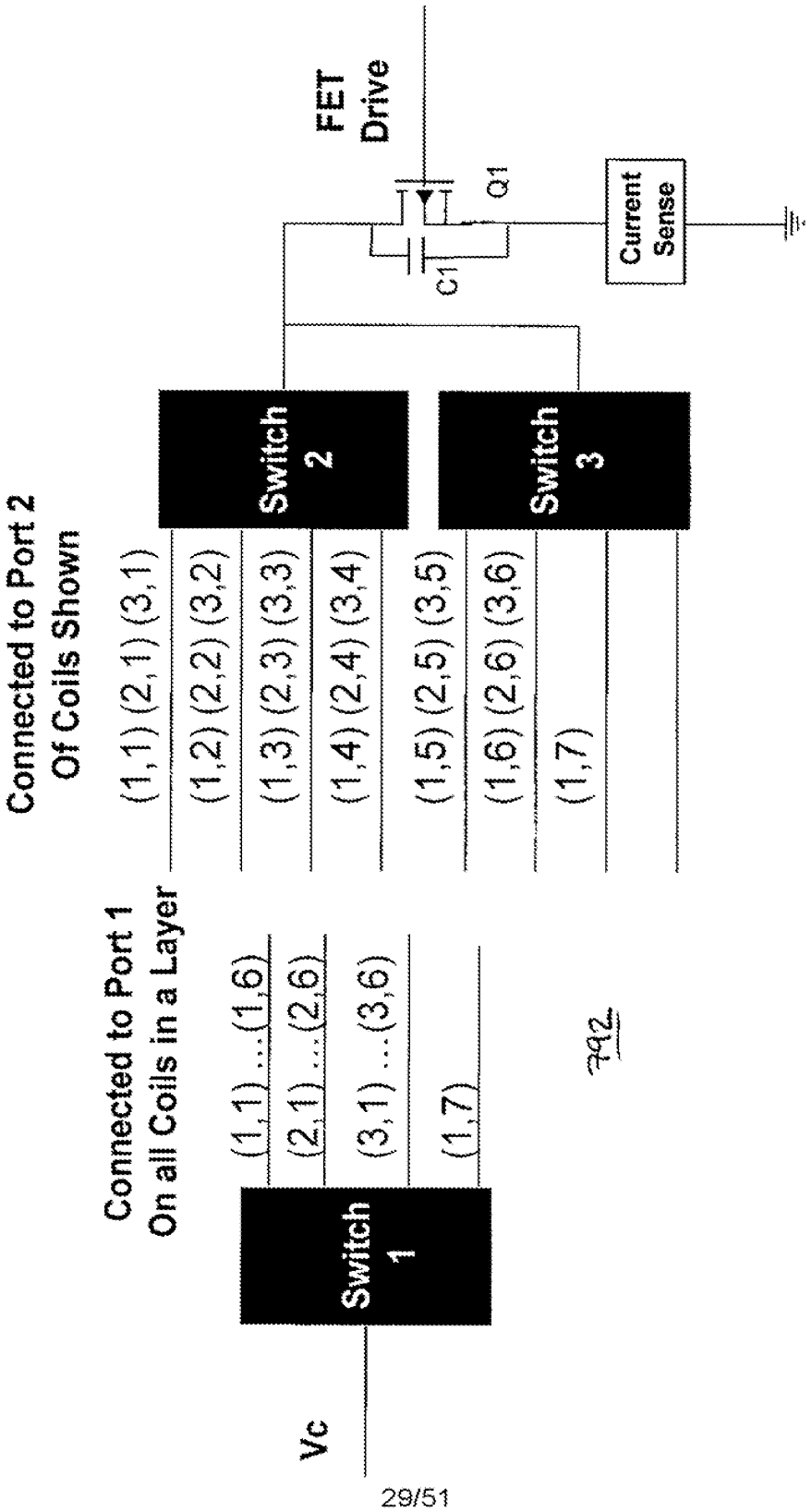

FET Drive
Q1
C1
Current Sense
Switch 2
Switch 3
Switch 1
Vc
Connected to Port 2
Of Coils Shown
(1,1) (2,1) (3,1)
(1,2) (2,2) (3,2)
(1,3) (2,3) (3,3)
(1,4) (2,4) (3,4)
(1,5) (2,5) (3,5)
(1,6) (2,6) (3,6)
(1,7)
Connected to Port 1
On all Coils in a Layer
(1,1) ...(1,6)
(2,1) ...(2,6)
(3,1) ...(3,6)
(1,7)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

Figure 40

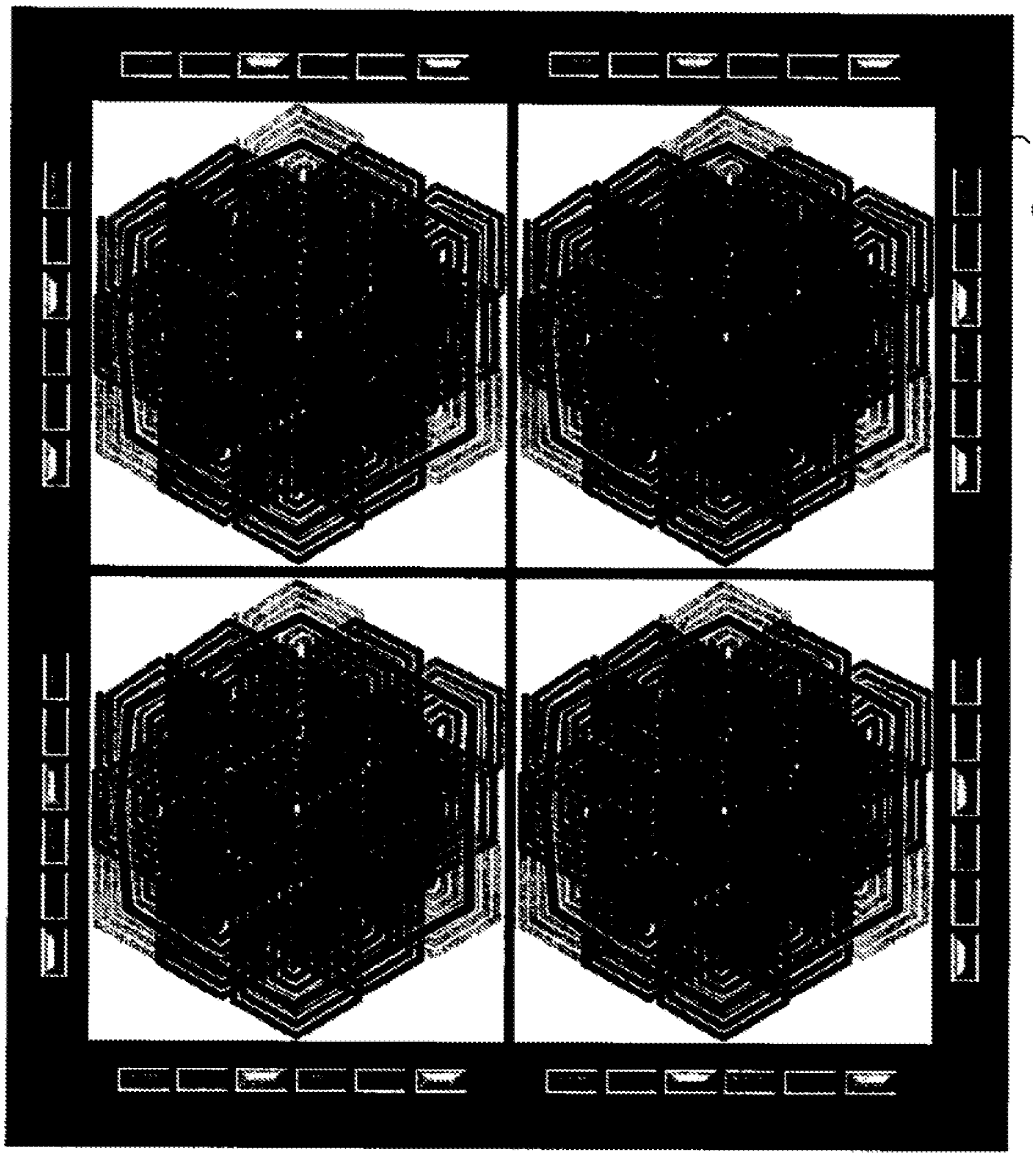


Figure 41

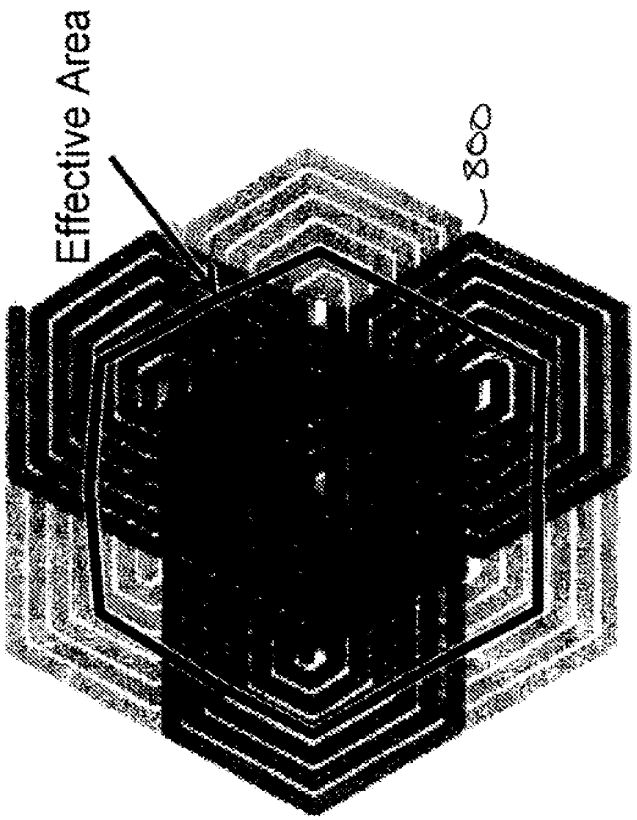


Figure 42

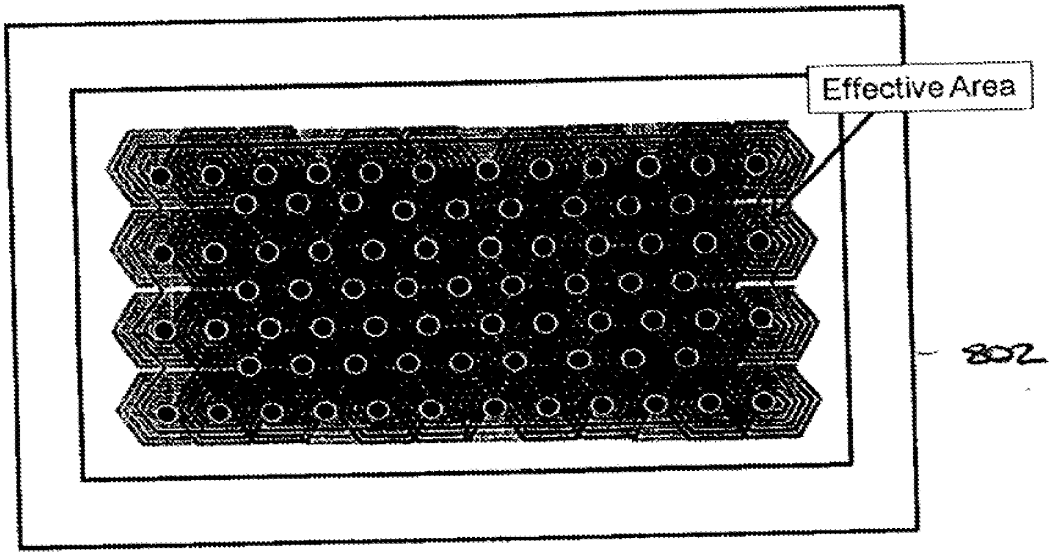

Effective Area
802

FIG. 43

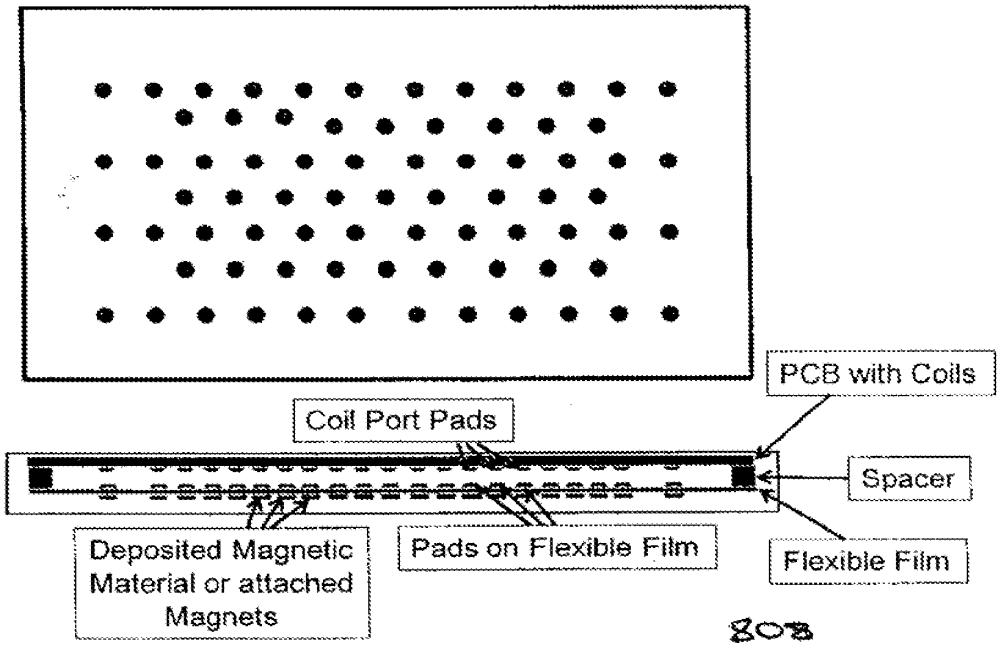

PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film
803

FIG. 44

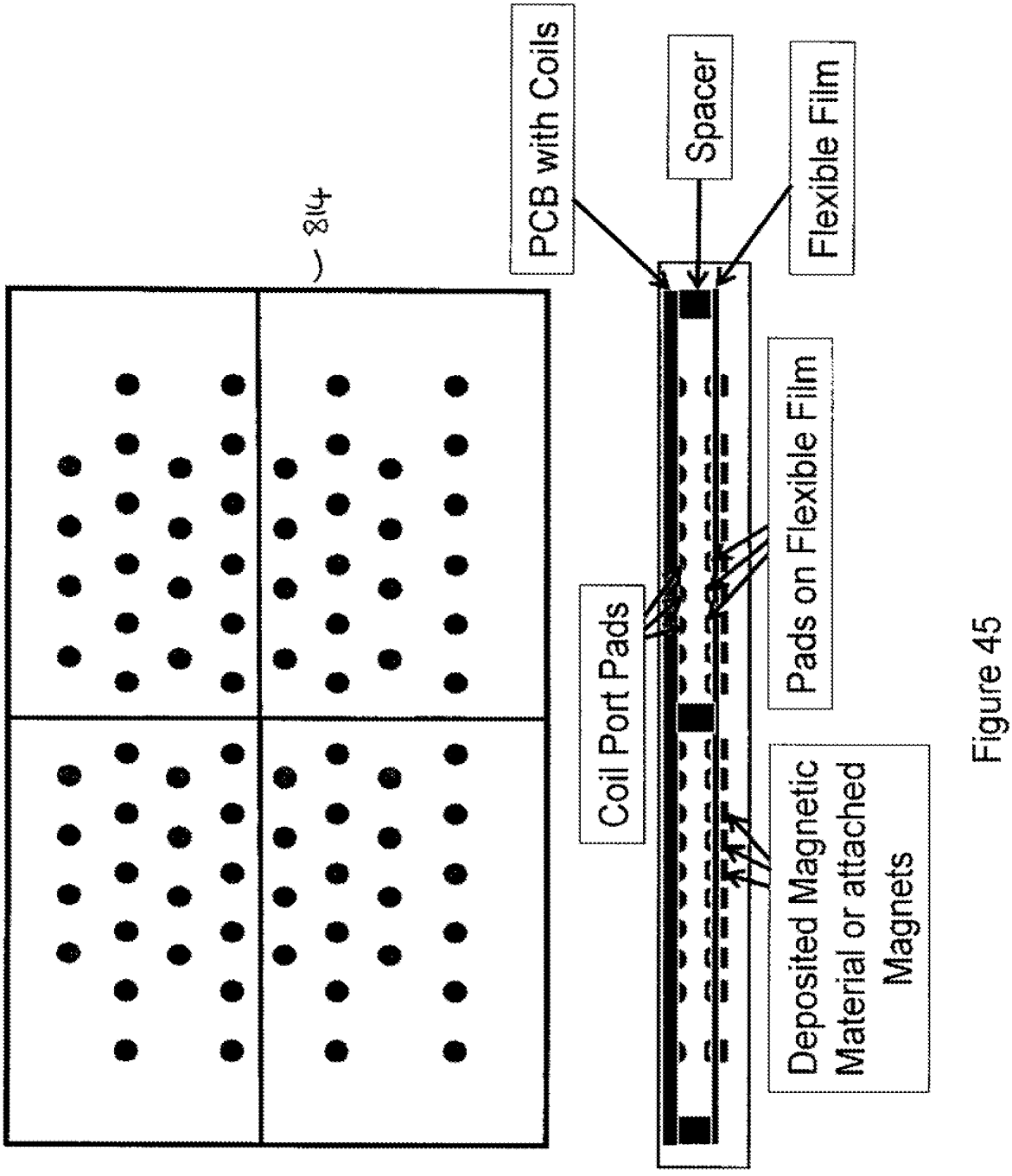
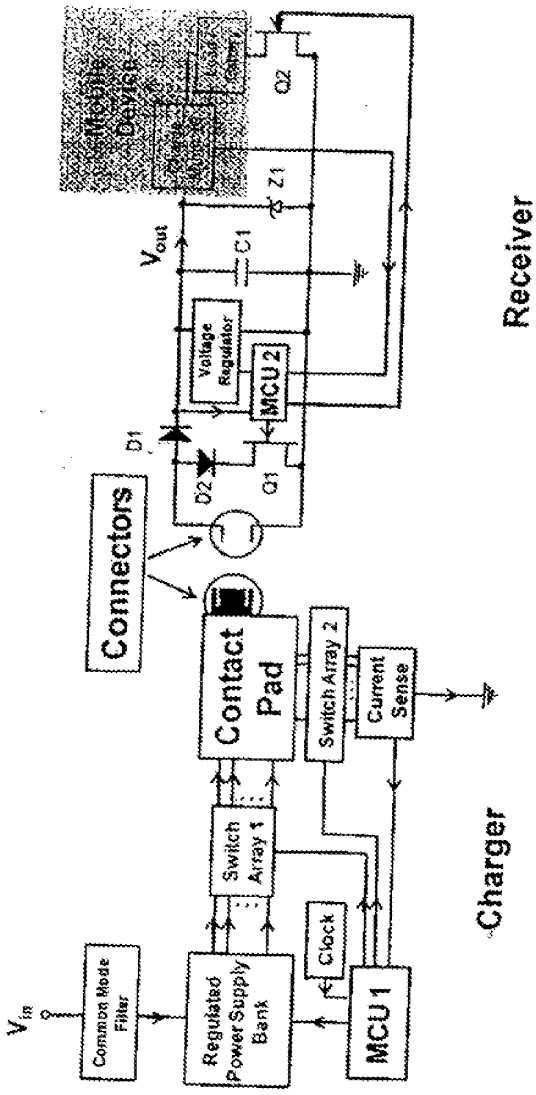

814
PCB with Coils
Spacer
Flexible Film
Coil Port Pads
Pads on Flexible Film
Deposited Magnetic Material or attached Magnets

Figure 45


Mobile Device
Q2
Z1
V_{out}
C1
Voltage Regulator
MCU 2
D1
D2
Q1
Connectors
Contact Pad
Switch Array 2
Current Sense
Switch Array 1
Clock
V_{in}
Common Mode Filter
Regulated Power Supply Bank
MCU 1
Receiver
Charger

820

FIG. 46

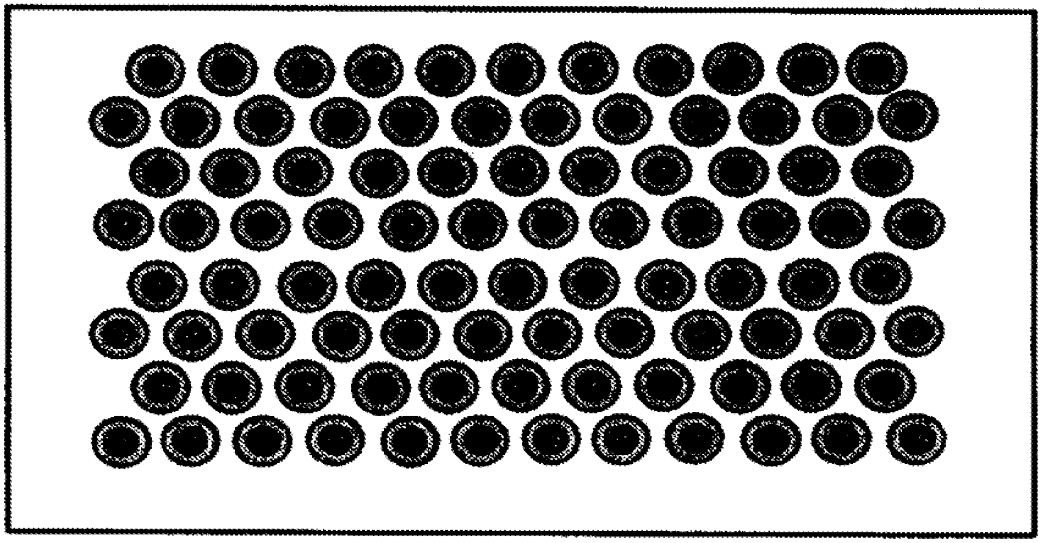


FIG. 47

824

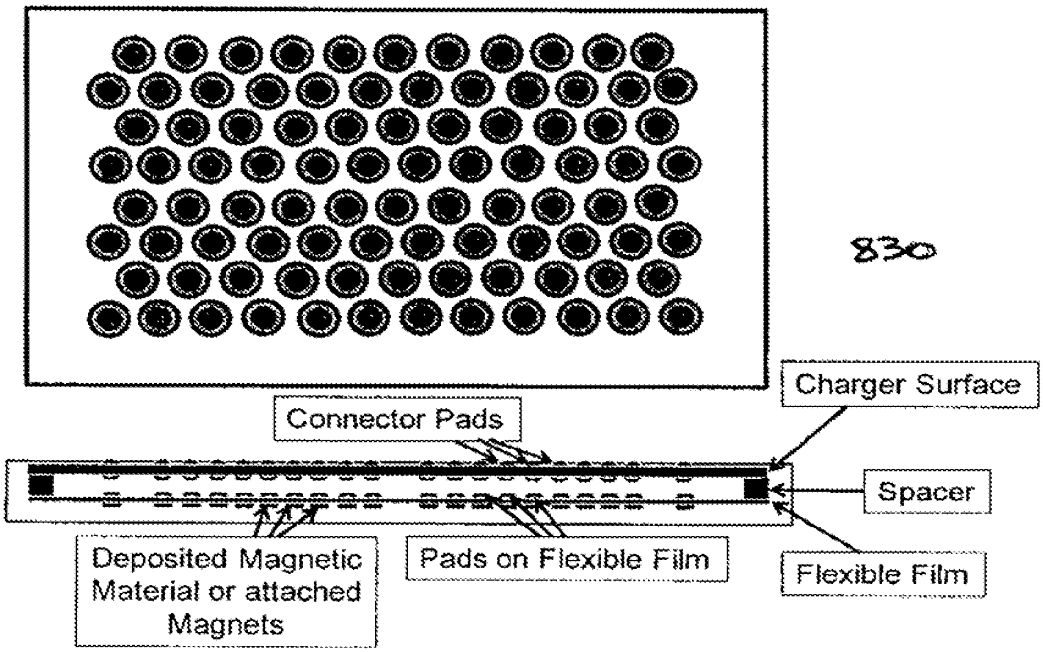


FIG. 48

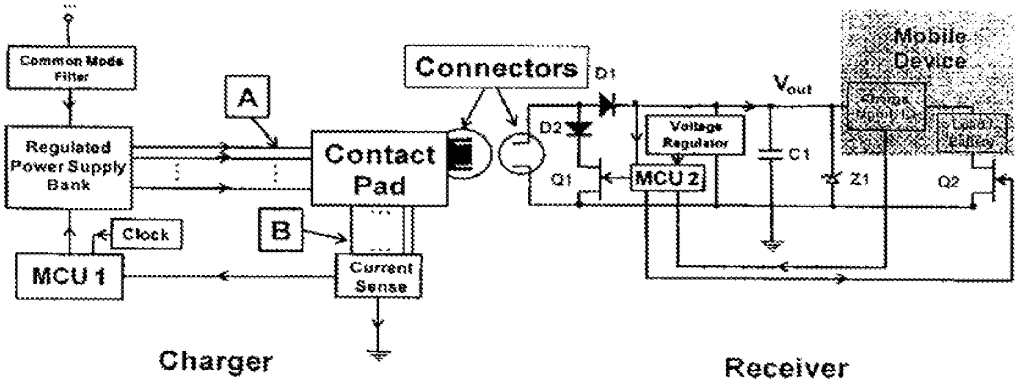


FIG. 49

836

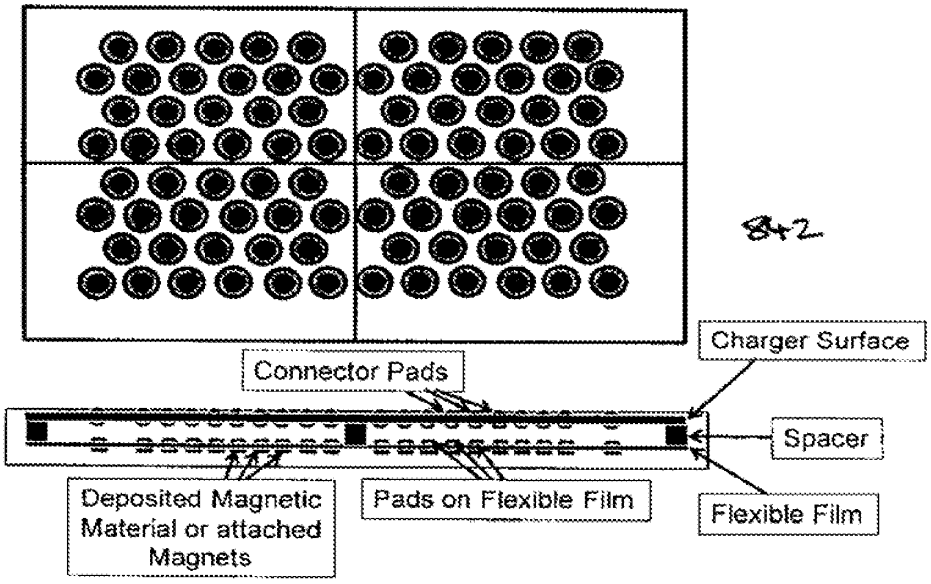
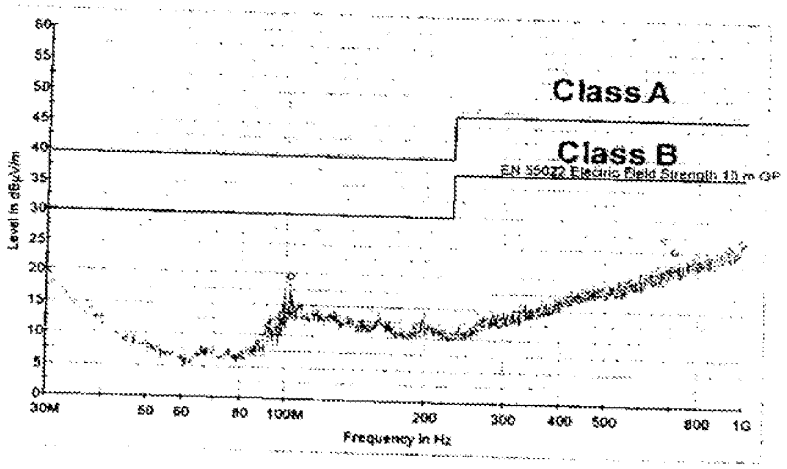
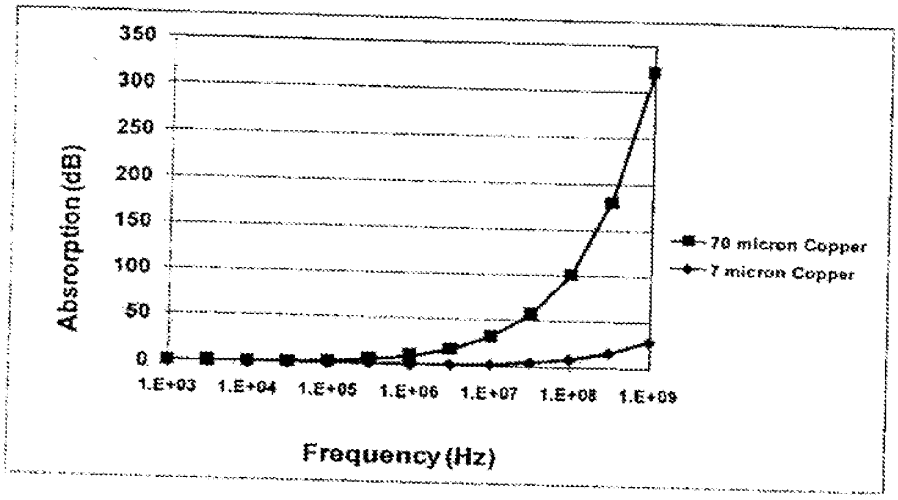


FIG. 50



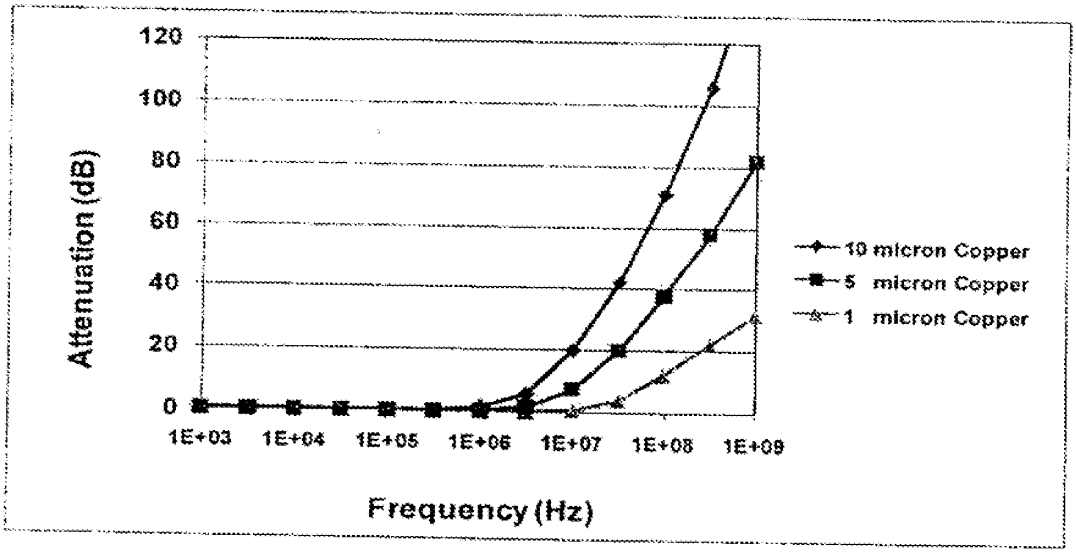
846

FIG. 51

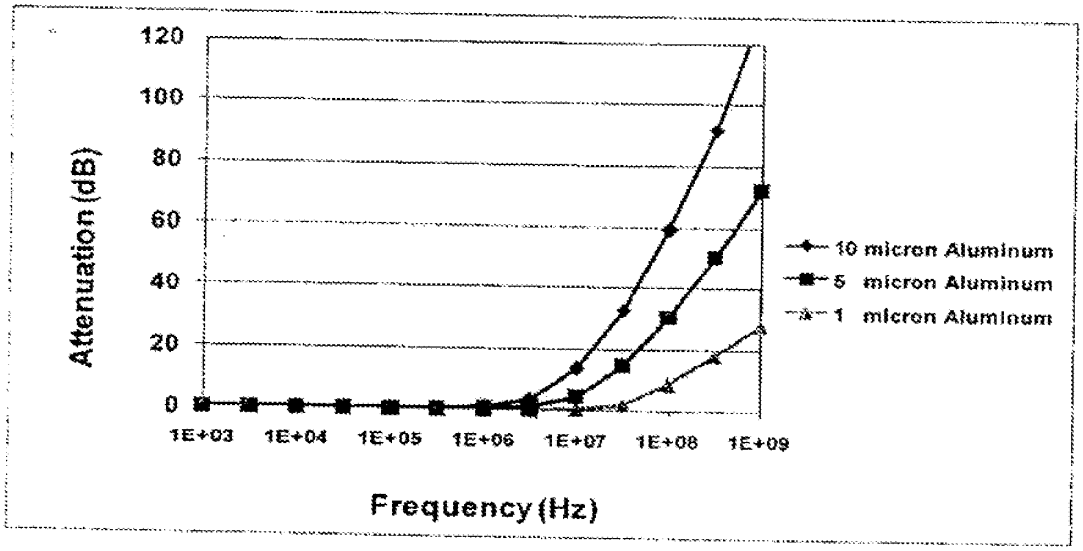


850

FIG. 52



854



856

FIG. 53

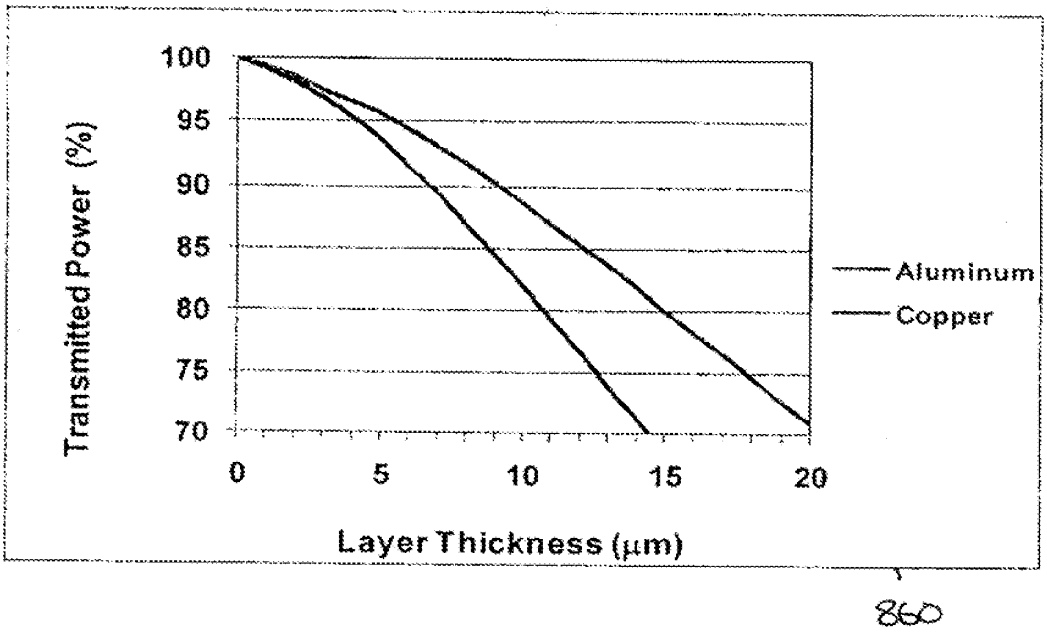

100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper
860

FIG. 54

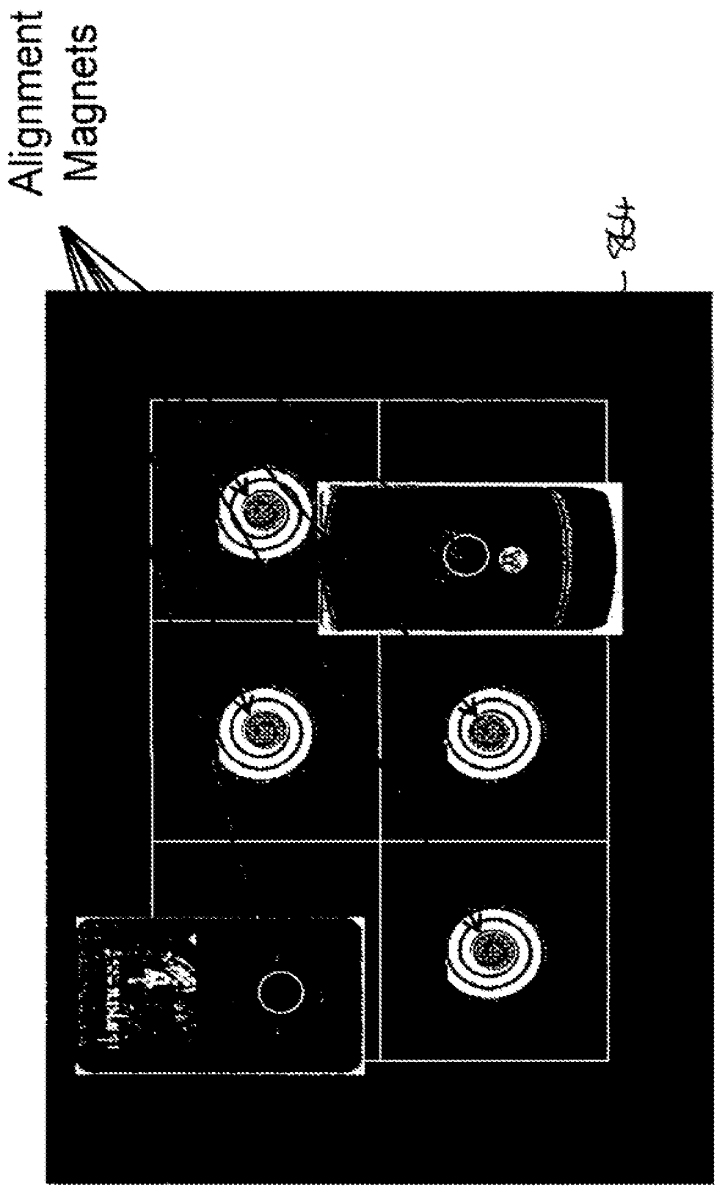


Figure 55

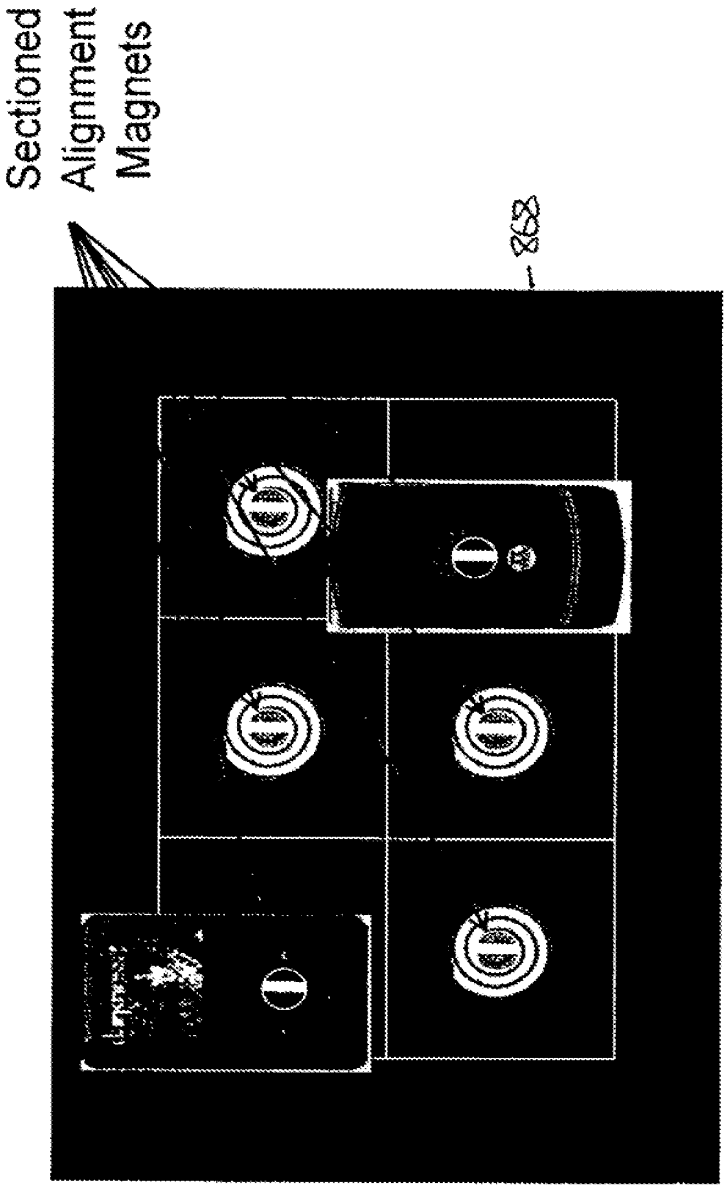


Figure 56

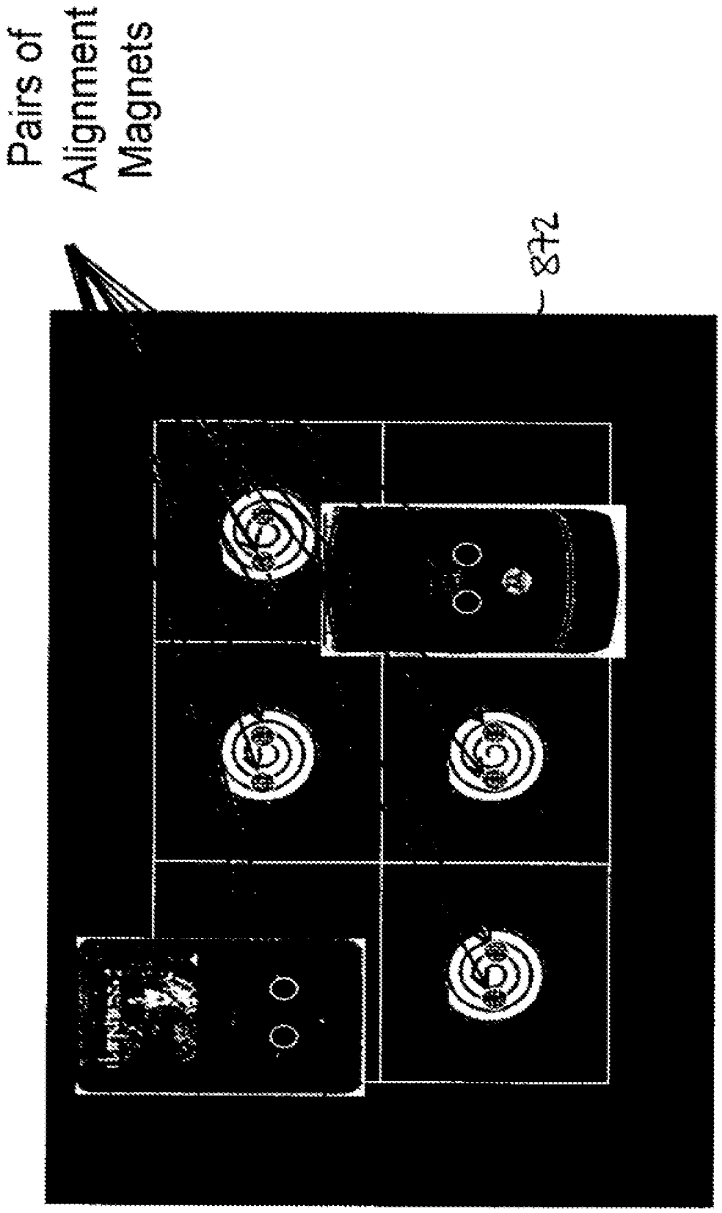


Figure 57

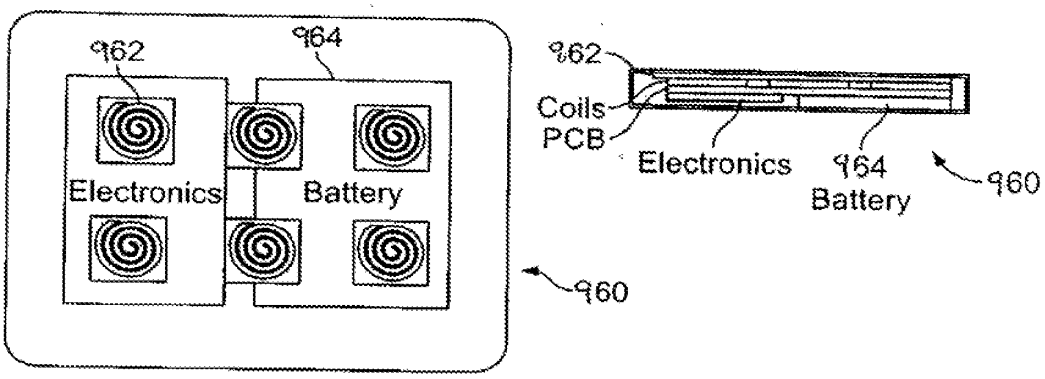

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

FIG. 58

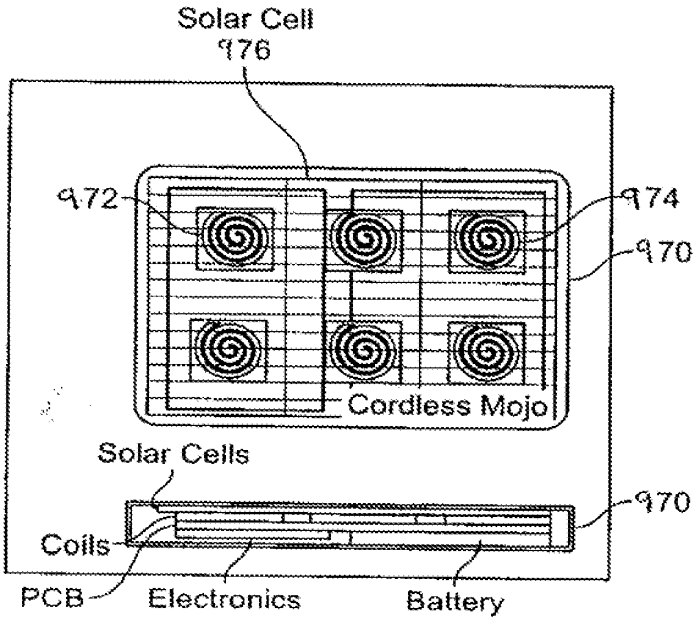

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

FIG. 59

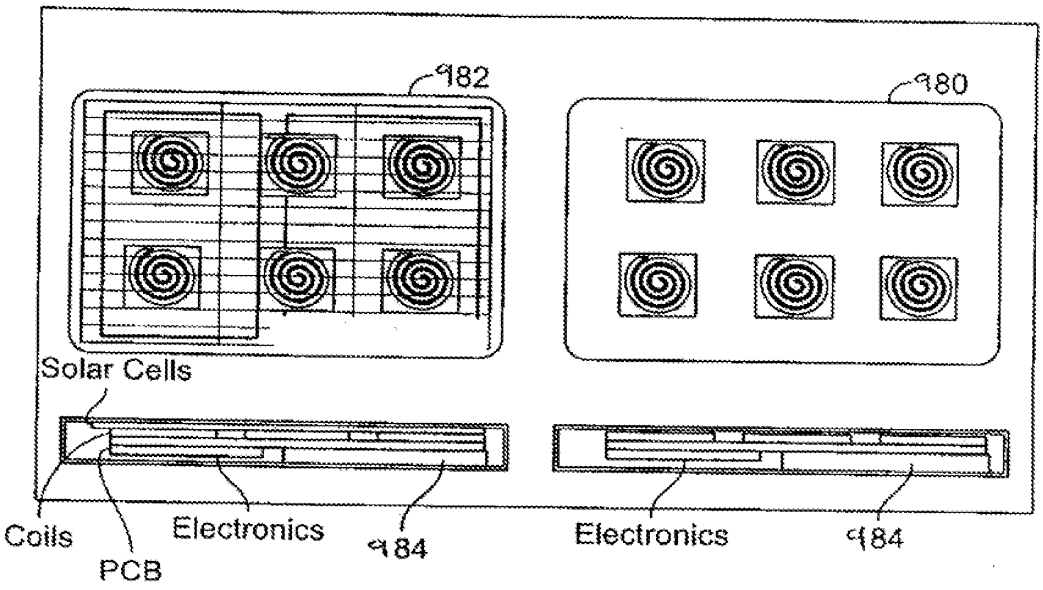

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

FIG. 60

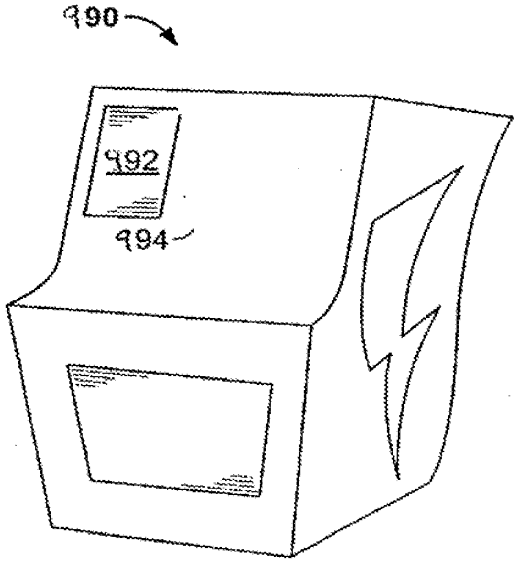

990
992
994

FIG. 61

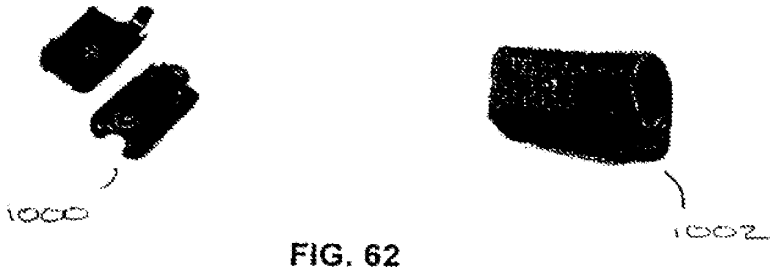


FIG. 62

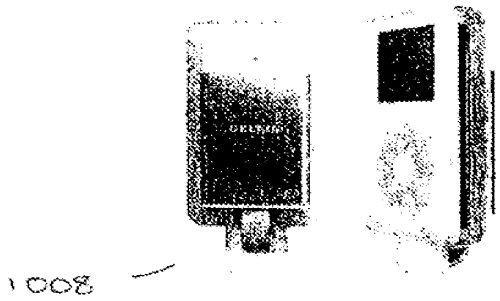


FIG. 63

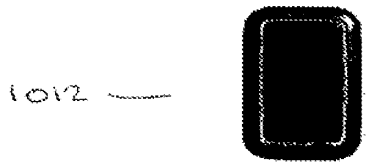


FIG. 64

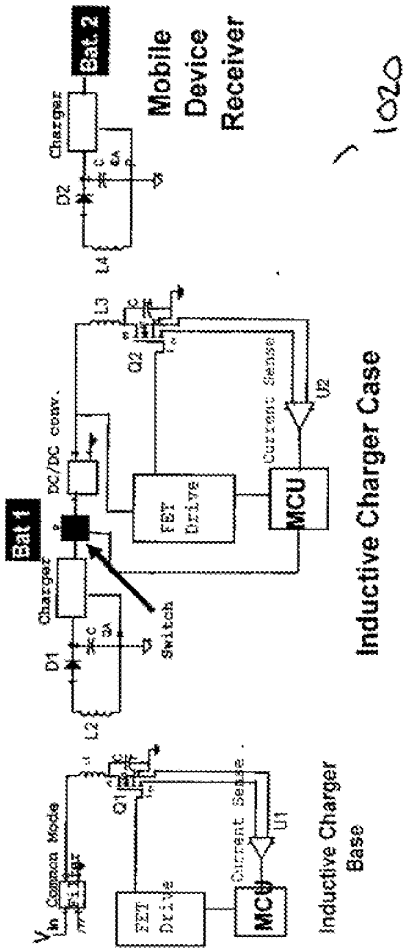

Mobile Device Receiver
1020
Bat 2
Charger
D2
L4
L3
Q2
DC/DC conv.
Current Sense
U2
FET Drive
MCU
Bat 1
Charger
Switch
D1
L2
Inductive Charger Case
Q1
Current Sense
U1
Common Mode Filter
FET Drive
MCU
Inductive Charger Base

Figure 65

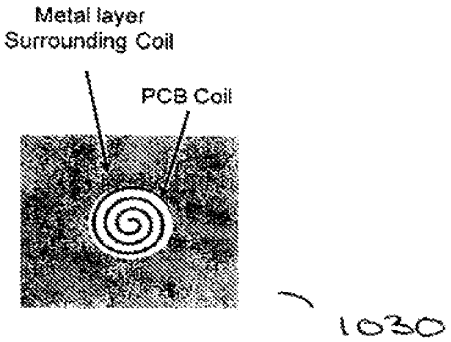


Figure 66

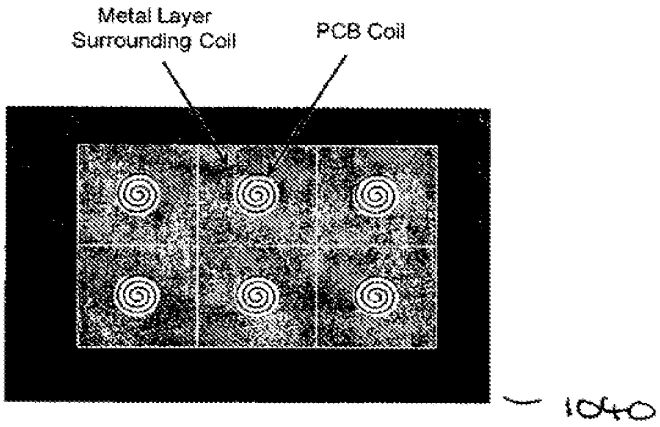


Figure 67

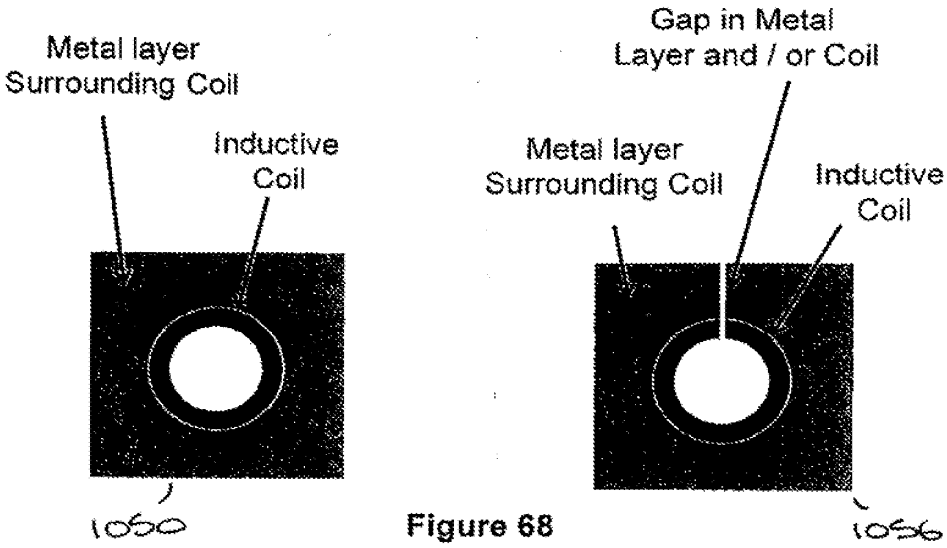


Figure 68

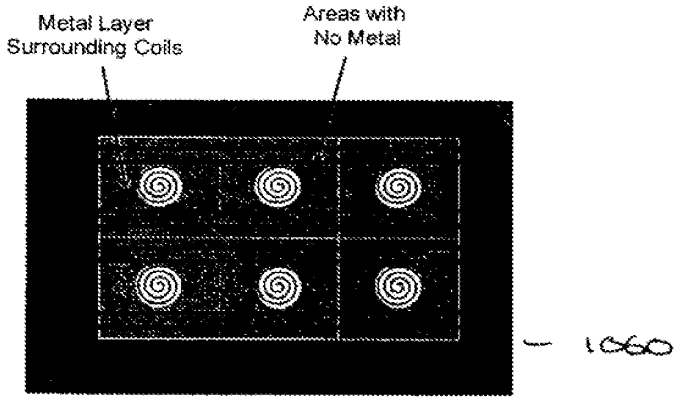
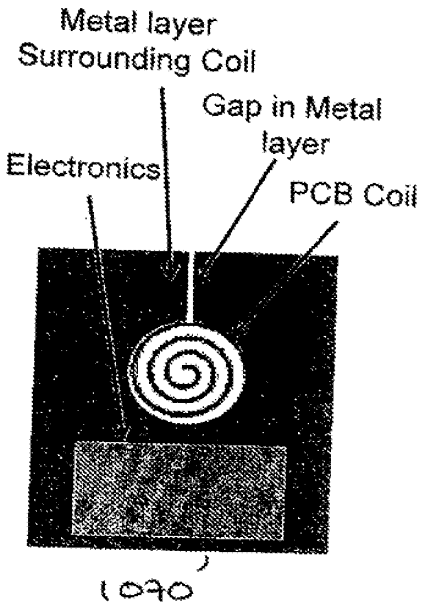


Figure 69



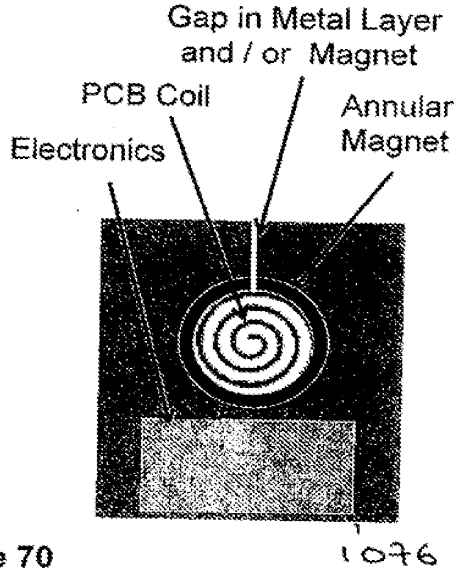


Figure 70

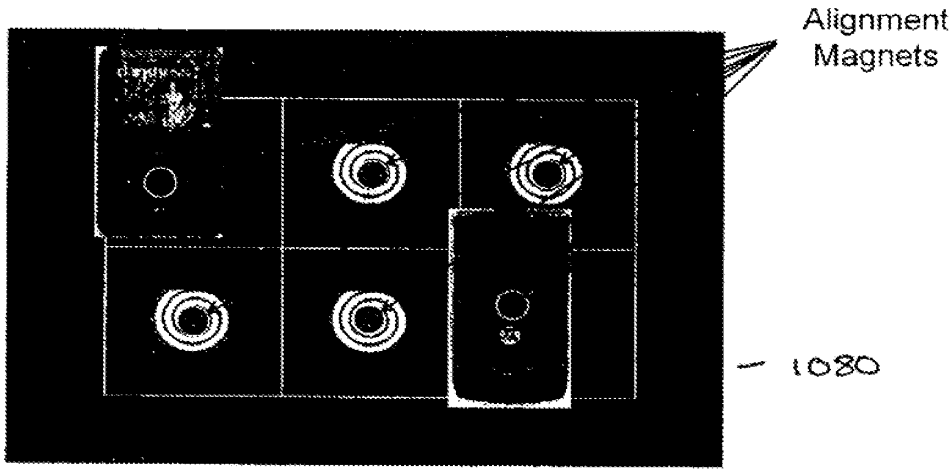


Figure 71

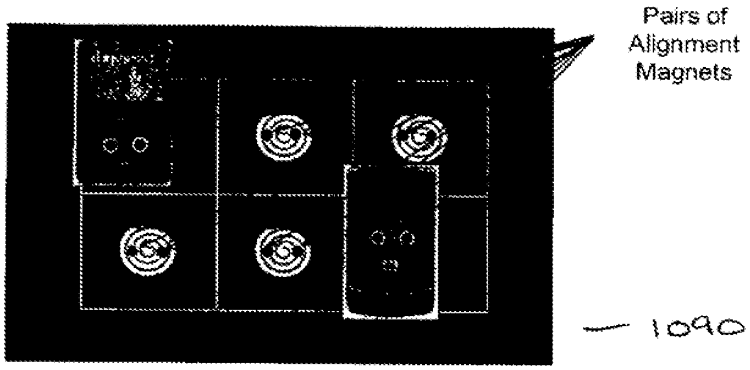


Figure 72

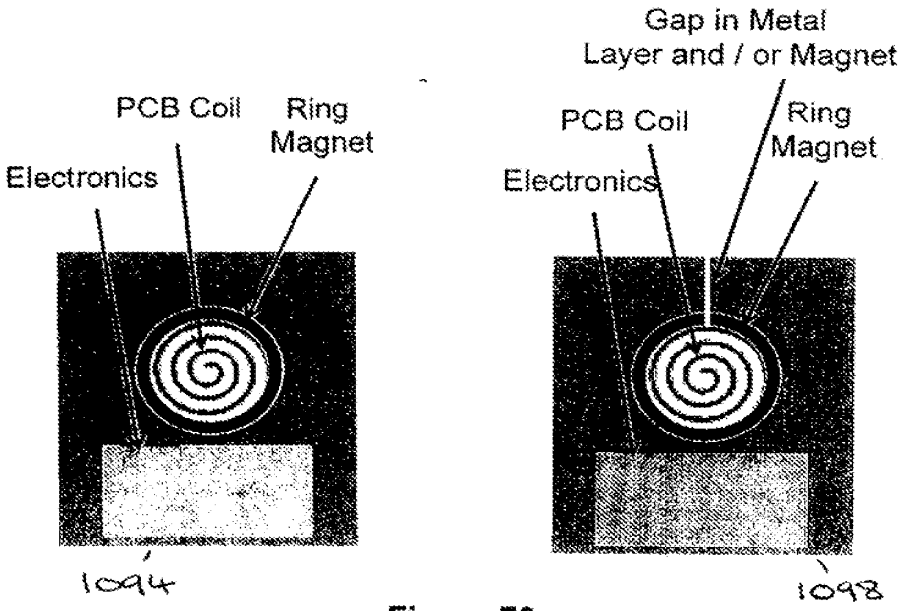


Figure 73

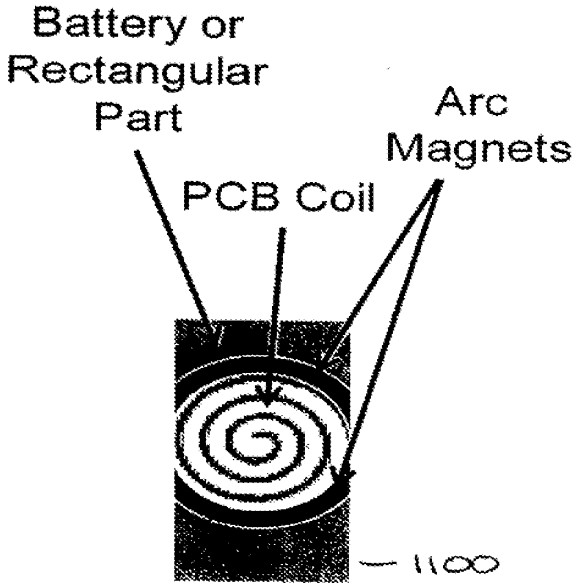


Figure 74

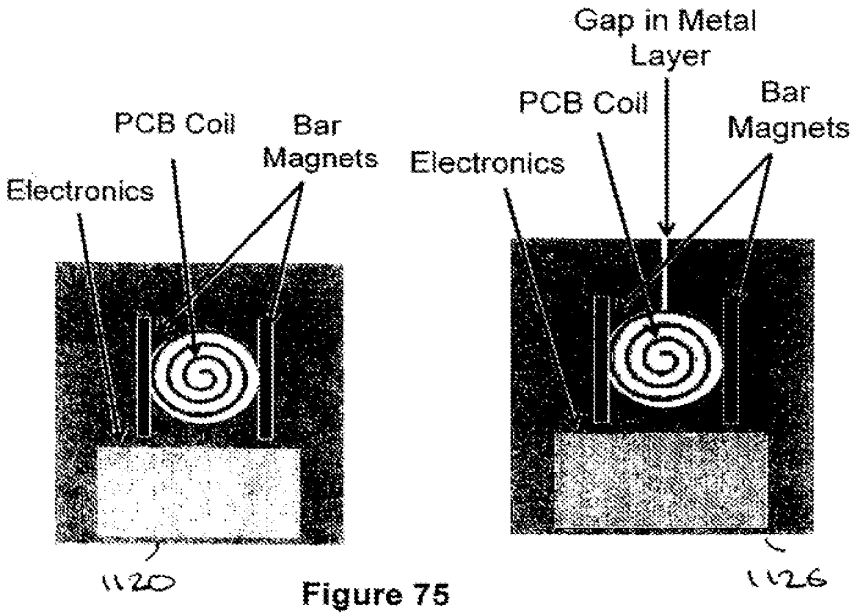


Figure 75

INTERNATIONAL SEARCH REPORT

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USPC - 320/108
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B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC 320/108

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC 320/108 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PUbWEST(USPT PGPB.EPAB.JPAB), Google
Search Terms Inductive, base, receiver coll zener, mosfet, single unit, spiral, non-fernte, charge, primary coil

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X -- Y	US 7,21 1,986 B1 (FLOWERDEW et al) 01 May 2007 (01 05 2007), entire document especially the Abstract, Fig 2, col 4, lns 44-60, col 7, lns 52-61, col 6, lns 14-27	9-14 ---------- 1-8 and 15-20
Y	US 2004/0113589 A1 (CRISP et al) 17 June 2004 (17 06 2004), entire document especially paras [0088], [0136], [0154]	15-16 and 18
Y	US 2003/0094921 A1 (LAU et al) 22 May 2003 (22 05 2003), entire document especially the Abstract	17
Y	US 2003/0103039 A1 (BURR et al) 05 June 2003 (05 06 2003), entire document especially paras [0019], [0023), and [0029]	1-8 and 19-20
Y	US 2005/0127867 A1 (CALHOON et al) 16 June 2005 (16 06 2005), entire document especially para [0050]	2 and 7
Y	US 2005/0189910 A1 (HUI) 01 September 2005 (01 09 2005), entire document especially paras [0014], [0085]	6 and 8

☐ Further documents are listed in the continuation of Box C ☐

* **Special categories of cited documents**
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on pπoπfy claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published pnor to the international filing date but later than the priority dale claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 August 2008 (06 08 2008)	**08 AUG 2008**
Name and mailing address of the ISA/US Mail Stop PCT, Attn ISA/US, Commissioner for Patents P O Box 1450, Alexandna, Virginia 22313-1450 Facsimile No 571-273-3201	Authorized officer Lee W Young PCT Helpd βsk 571-272-4300 PCTOSP 571-272-7774

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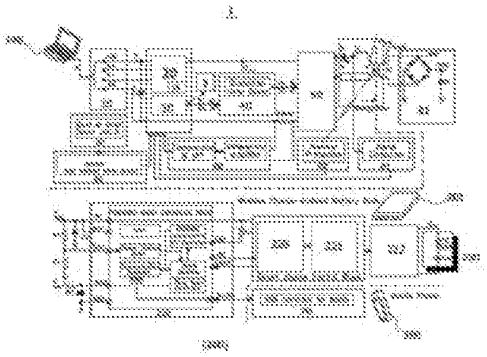
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(54) 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치,충전용 배터리팩 및 무접점 충전장치를 이용한 휴대용단말기

(57) 요 약

본 발명은 무접점 충전장치에 관한 것으로, 보다 상세하게는 컴퓨터 USB 통신 가능하게 구성된 무접점 충전장치(1)와 휴대용 단말기의 충전용 배터리팩 사이에 유도기전력을 이용하여 무선 데이터 통신 및 전력공급이 가능하도록 구성한 것으로써, 데이터 통신 및 전력 공급을 함께 전송하도록 하며, 접촉전송에 다른 접촉불량이 없어 신호 전송이 양호하도록 하는 무접점 충전장치를 제공한다.

대 표 도



특허청구의 범위

청구항 1

합체형상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(10);

상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(20);

상기 USB커넥터(10)와 연결되고, 상기 컴퓨터 또는 노트북으로부터 공급되는 전원을 휴대용 단말기에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(50), 전류센싱블록(60) 및 전원공급용 부재를 제어하는 MPU블록(30); 및

상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70)이 포함되어 구성되고,

상기 직렬공진 컨버터(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기로 공급되는 전원 신호를 변환하도록 구성되며,

상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기측의 2차코일(80)에 의한 부하변조 신호를 감지하여 상기 MPU블록(30)으로 감지된 신호를 전송하도록 구성되어, 상기 MPU 블록(30)에서 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지된 신호를 분석하여 상기 휴대용 단말기를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 2

제 1항에 있어서,

상기 1차코일(70)은,

분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되며,

상기 직렬공진 컨버터(50)는 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터인 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 3

제 1항에 있어서,

상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버를 구비한 게이트 드라이브 블록(40)과,

상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성된 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 4

제 1항에 있어서,

상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와,

상기 1차코일(70)과 직렬로 연결되어, 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도가 과열되면 전류

를 차단하는 바이메탈(71)과,

상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와,

음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)를 더 구비하는 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 5

삭제

청구항 6

제 1항에 있어서,

상기 USB드라이버블록(20)은,

USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고,

상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기와 서로 송수신하는 IrDA 포트(22)를 더 구비하고,

상기 휴대용 단말기의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부를 더 구성하는 것을 특징으로 하는 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치.

청구항 7

제 1항 내지 제 4항 및 제 6항 중 어느 한 항의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고 전력 신호를 전송받기 위한 상기 2차코일(80)이 일측에 구성된 충전체몸체(201),

상기 충전체몸체(201) 내부 일측의 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하고, 상기 1차코일(70)과 송수신되는 데이터 신호를 처리하는 충전체제어부(210),

상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)가 포함되어 구성되며,

상기 충전회로(220)는 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급되도록 구성된 것을 특징으로 하는 충전용 배터리팩.

청구항 8

제 7항에 있어서,

상기 충전체제어부(210)는,

상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부,

상기 충전용 밧데리(230)의 충전정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하는 것을 특징으로 하는 충전용 배터리팩.

청구항 9

제 7항에 있어서,

상기 충전체몸체(201)는,

상기 휴대용 단말기와 분리 및 체결이 가능하도록 별체로 형성되는 분리형팩으로 구성되거나, 또는

상기 휴대용 단말기의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형팩으로 구성되며,

상기 2차코일(60)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되는 것을 특징으로 하는 충전용 배터리팩.

청구항 10

제 9항에 있어서,

상기 분리형팩의 충전체몸체(201)는,

상기 충전제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급하는 터미널 블록(240)을 더 구성한 것을 특징으로 하는 충전용 배터리팩.

청구항 11

제 8항에 있어서,

상기 충전체몸체(201)는,

충전리시버모듈(517)에 권선된 2차코일(516)로부터 유도된 전력이 무선 전력 수신 회로(513)를 통하여 충전하는 배터리셀(512),

상기 배터리셀(512) 저면, 전후좌우 사면을 감싸며, Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 자기장으로부터 상기 배터리셀(512)을 보호하는 차폐판(515)(515-1)(515-2)(515-3)(515-4),

상기 차폐판(515)과 상기 충전리시버모듈(517) 사이에 구비되어 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), Ni - Fe (80 중량부 : 20 중량부), 또는 파인메탈(Finemetal, Fe-Si-Cu-Nb)을 포함하여 구성되어 2차코일(516)에 유도자기장이 잘 유도되도록 하는 자성판(503),

상기 차폐판(515)과 상기 배터리셀(512) 사이에 Ni-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 빨어프릴 수 있는 절연체로 구비되어 상기 차폐판(515)의 열이 배터리셀(512)에 전도되지 않도록 하는 절연판(502),

상기 무선 전력 수신 회로(513)를 감싸며 Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 상기 무선 전력 수신 회로(513)에 자기장을 차폐하는 차폐부재(501)를 포함하여 구성된 것을 특징으로 하는 충전용 배터리팩.

청구항 12

제 7항의 무접점 충전장치(1)로부터 전원을 공급받고 데이터를 송수신하는 것을 특징으로 하는 무접점 충전장치를 이용한 휴대용 단말기.

청구항 13

제 9항의 일체형팩의 충전체몸체(201)를 구비하는 충전용 배터리팩(200)을 내재하여,

IrDA 컨트롤러(302) 및 무접점 충전장치(1)의 IrDA 포트(22)와 데이터 통신을 하는 IrDA 포트를 포함하여 구성된 것을 특징으로 하는 휴대용 단말기.

청구항 14

제 8항의 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접속되어 전원을 공급받는 전력수신터미널블록(310)과,

상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및

상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)를 구성한 것을 특징으로 하는 무접점 충전장치를 이용한 휴대용 단말기.

발 명 의

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

[0019] 본 발명은 무접점 충전장치에 관한 것으로, 보다 상세하게는 컴퓨터 USB 통신 가능하게 구성된 무접점 충전장치와 휴대용 단말기의 충전용 배터리팩 사이에 유도기전력을 이용하여 무선 데이터 통신 및 전력공급이 가능하도록 구성하여, 데이터 통신 및 전력 공급을 함께 전송하도록 하며, 접촉전송에 따른 접촉불량이 없어 신호 전송이 양호하도록 하는 무접점 충전장치를 제공한다.

[0020] 일반적으로 휴대용 단말기는 사용자가 휴대하고 이동하면서 사용하기 편리한 장치로, 핸드폰, PDA, MP3 플레이어 등이 있다.

[0021] 이러한 휴대용 단말기는 충전된 밧데리를 장착하거나 내부에 내재된 밧데리에 충전하면서 일정시간 동안 사용하도록 구성된다. 따라서 필요한 때에 충전을 하고 필요한 데이터를 데스크탑 컴퓨터 또는 노트북으로부터 데이터를 전송받아서 원하는 기능을 작동하여 편리함을 제공하도록 구성된 것이다.

[0022] 이러한 휴대용 단말기용 핸드폰용 충전기는 도 11에 도시된 대한민국 특허 공개번호 제10-2001-0026976호(핸드폰 충전장치)에 의하면, 외부로부터 공급되는 전원선이 본체(600) 일측에 구비되고, 본체(600)의 상부 장착공간(601)에 핸드폰(610)의 저부가 삽입되면서, 핸드폰(610)의 후면 저부의 전원 단자와 본체(600) 장착공간(601)의 내부 단자(602)가 접촉되면서 핸드폰(610)에 전원을 공급하도록 구성된다.

[0023] 이와 같은 종래의 전원공급장치는 전원만 공급할 뿐 데이터를 전송하거나 처리할 수 없어, 별도의 데이터 케이블을 이용하여 컴퓨터와 연결해야만 하는 불편함이 있다. 또한 핸드폰의 단자와 본체의 단자는 접촉방식에 의하기 때문에 다수 회 반복하게 되면, 양측 단자 사이에 순간 전압변화가 발생하여 단자의 전기 접촉성이 불량하게 되고 기기의 안정성이 저하되는 문제점이 있다. 특히 습기가 있거나 먼지가 많이 있는 곳에서는 전기접촉성이 더욱 불량하여 핸드폰 및 전원공급장치가 고장날 우려가 있는 등의 문제점이 있다.

발명이 이루고자 하는 기술적 과제

[0024] 본 발명은 종래 기술의 문제점을 해결하기 위해 제안된 것으로, 본 발명의 목적은 TC, TA, 또는 PC의 USB Port의 출력을 전원 입력으로 하는 유도기전력을 이용한 무접점 전력 전송에 의해 휴대용 단말기(휴대폰, PDA, MP3 player, DAB 또는 DMB 단말기, PMP, 또는 Handheld 단말기 등)와 PC간 무선 데이터 통신과 무선 충전을 동시에 가능하게 하는, 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치 및 이를 이용한 휴대용 단말기를 제공하는 것이다.

[0025] 또한 본 발명의 다른 목적은, 충전하고자 하는 휴대용 단말기의 배터리 팩(2차측 무선충전 모듈이 내장된 팩) 이외의 다른 금속 이물질이 올려졌을 때 이를 감지하여 차단시킬 수 있는 이물질 감지 기능과, 휴대용 단말기의 배터리 팩을 인식하여 충전상태를 인식할 수 있는 식별기능을 가지며, 과부하와 온도 프로텍션 기능을 가지는, 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치 및 이를 이용한 휴대용 단말기를 제공하는 것이다.

발명의 구성 및 작용

[0026] 상기와 같은 목적을 달성하기 위한 본 발명 무선 데이타 통신과 전력 전송이 가능한 무접점 충전장치는, 합체형 상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(10); 상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(20); 상기 USB커넥터(10)와 연결되고, 상기 컴퓨터 또는 노트북으로부터 공급되는 전원을 휴대용 단말기에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(50), 전류센싱블록(60) 및 전원공급용 부재를 제어하는 MPU 블록(30); 및 상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70)이 포함되어 구성된다. 그리고 상기 직렬공진 컨버터(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기로 공급되는 전원 신호를 변환하도록 구성되며, 상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기측의 2차코일(80)에 의한 부하변조 신호를 감지하여 상기 MPU블록(30)으로 감지된 신호를 전송하도록 구성되어, 상기 MPU 블록(30)에서 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지신호를 분석하여 상기 휴대용 단말기를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것을 특징으로 한다.

[0027] 이에 상기 1차코일(70)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되며, 상기 직렬공진 컨버터(50)는 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터로 구비되고, 상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버를 구비한 게이트 드라이브 블록(40)과, 상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성될 수 있다.

[0028] 그리고 상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여, 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와; 상기 1차코일(70)과 직렬로 연결되어, 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도가 과열되면 전류를 차단하는 바이메탈(71)과; 상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와; 음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)가 더 구비된다.

그리고 상기 1차코일(70)에서는 일정한 인터벌의 PWM펄스가 발생되고, 이에 응답하는 상기 2차코일(80)로부터의 신호를 상기 전류센싱블록(60)에서 감지하여 상기 MPU 블록(60)으로 전송하되, 상기 MPU 블록(30)에서는 감지된 신호가 규정된 신호이면 ID를 부여하여 데이터 신호 및 전력신호를 전송하도록 하며, 응답이 없거나 응답신호가 규정된 신호가 아닌 것으로 검출되면 이물질로 판별하여 데이터 신호 및 전력 신호의 전송을 중지하도록 하는 이물질 감지기능을 구비한 것이다.

또한 상기 USB드라이버블록(20)은 USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고, 상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기와 서로 송수신하기 위한 IrDA 포트(22)를 더 구비하고, 상기 휴대용 단말기의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부를 더 구성할 수 있다.

[0029] 본 발명의 다른 실시로, 충전용 배터리팩는 상기의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고 전력 신호를 전송받기 위한 상기 2차코일(80)이 일측에 구성된 충전체몸체(201); 상기 충전체몸체(201) 내부 일측의 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하고, 상기 1차코일(70)과 송수신되는 데이터 신호를 처리하는 충전체제어부(210); 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)가 포함되어 구성되며, 상기 충전회로(220)는 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기로 공급되도록 구성된다.

[0030] 이에 상기 충전체제어부(210)는 상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부, 상기 충전용 밧데리(230)의 충전정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하여 구비되고, 상기 충전체몸체(201)는 상기 휴대용 단말기와 분리 및 체결이 가능하도록 별체로 형성되는 분리형팩으로 구성되거나, 또는 상기 휴대용 단말기의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형팩으로 구성되며, 상기 2차코일(80)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형으로 형성되어 구성할 수 있다.

[0031] 그리고 상기 충전체몸체(201)는 충전리시버모듈(517)에 권선된 2차코일(516)로부터 유도된 전력이 무선 전력 수

신 회로(513)를 통하여 충전하는 배터리셀(512), 상기 배터리셀(512) 저면, 전후좌우 사면을 감싸며, Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 자기장으로부터 상기 배터리셀(512)을 보호하는 차폐판(515)(515-1)(515-2)(515-3)(515-4), 상기 차폐판(515)과 상기 충전리시버모듈(517) 사이에 구비되어 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), Ni - Fe (80 중량부 : 20 중량부), 또는 파인메탈(Finemetal, Fe-Si-Cu-Nb)을 포함하여 구성되어 2차코일(516)에 유도자기장이 잘 유도되도록 하는 자성판(503), 상기 차폐판(515)과 상기 배터리셀(512) 사이에 Ni-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 떨어뜨릴 수 있는 절연체로 구비되어 상기 차폐판(515)의 열이 배터리셀(512)에 전도되지 않도록 하는 절연판(502), 그리고 상기 무선 전력 수신 회로(513)를 감싸며 Al, Cu, 또는 Ni Alloy metal을 포함하여 구성되어 상기 무선 전력 수신 회로(513)에 자기장을 차폐하는 차폐부재(501)를 포함하여 구성될 수 있다.

[0032] 그리고 본 발명의 또 다른 실시인 무접점 충전장치를 이용한 휴대용 단말기는 상기의 무접점 충전장치(1)로부터 전원을 공급받고 데이터를 송수신하도록 구성된다.

[0033] 또한 휴대용 단말기는 상기의 일체형팩의 충전제품체(201)를 구비하는 충전용 배터리팩(200)을 내재하여, IrDA 컨트롤러(302) 및 무접점 충전장치(1)의 IrDA 포트(22)와 데이터 통신을 하는 IrDA 포트를 포함하여 구성될 수 있다.

[0034] 나아가 휴대용 단말기는 상기의 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접속되어 전원을 공급받는 전력수신터미널블록(310)과, 상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및 상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)를 구성할 수 있다.

[0035] 이하 첨부되는 도면을 참조하여 상세히 설명한다.

[0036] 즉 본 발명 무접점 충전장치(1)는 도 1 내지 도 10에서와 같이, 함체형상의 장치몸체(2)의 일측으로 구비되어 컴퓨터 또는 노트북(100)의 USB포트와 착 결합 및 분리가 가능하게 연결되는 USB커넥터(USB Connector)(10); 상기 USB커넥터(10)와 연결되어 상기 컴퓨터 또는 노트북(100)과 데이터를 송수신하도록 USB프로토콜로 에뮬레이션하는 USB드라이버블록(USB Emulation Control Block)(20)이 구비된다. 또한 상기 USB커넥터(10)와 연결되어, 상기 컴퓨터 또는 노트북(100)으로부터 전원을 공급받아 휴대용 단말기(300)에 공급하거나 데이터를 송수신하기 위하여, 직렬공진 컨버터(LLC Full-bridge Serial Resonator Converter)(50), 전류센싱블록(Current sensing Block)(60) 및 전원공급용 부재 등을 제어하는 MPU 블록(Micro Processor Unit Block, MPU Block)(30)이 구비된다. 그리고 상기 직렬공진 컨버터(50)로부터의 데이터 신호 및 전원 신호를 상기 휴대용 단말기(300)에 무선으로 전송하기 위하여 장치몸체(2)의 상부에 형성되는 1차코일(70) 등으로 구성된다.

[0037] 이에 상기 직렬공진 컨버터(Resonator Convertoer)(50)는 상기 USB드라이버블록(20)과 상기 휴대용 단말기(300) 사이에 송수신되는 데이터 신호 및 상기 USB커넥터(10)로부터 상기 휴대용 단말기(300)로 공급되는 전원 신호를 변환하도록 구성된 것이다. 그리고 상기 전류센싱블록(60)은 상기 1차코일(70)과 대응되는 상기 휴대용 단말기(300) 측의 2차코일(80)에 의한 부하변조(Load regulation) 신호를 감지하여 상기 MPU 블록(30)으로 신호를 전송하도록 구성된 것으로, 상기 MPU 블록(30)에서는 1차코일(70) 및 상기 전류센싱블록(60)을 통하여 전송된 상기 2차코일(80)에 대한 감지신호를 분석하여 상기 휴대용 단말기(300)를 인식하고 충전 전압을 안정전압으로 제어하도록 구성된 것이다.

[0038] 그리고 상기 1차코일(70)은 분리형 변압기의 FPCB, PCB, 코일(Coil) 및 페라이트 코어(Ferrite Core) 중 어느 하나로 구성되고, 이를 위한 상기 직렬공진 컨버터(50)는 일반적인 변압기용 공진형 컨버터로 구성될 수 있으며, 특히 반파형 또는 전파형으로 직렬/병렬 공진형 컨버터인 LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)로 구성하여 안정적인 전력 전송이 되도록 구성함이 바람직하다.

[0039] 또한 상기 USB드라이버블록(20) 및 상기 MPU 블록(30)과 상기 직렬공진 컨버터(50) 사이에 구비되어 부스트랩 게이트 드라이버(Bootstrap Gate Driver)를 구비한 게이트 드라이브 블록(FET Gate Drive Block)(40)과, 상기 2차코일(80) 신호 중 배터리 충전상태 신호를 감지하기 위한 상기 1차코일(70)로부터 신호를 전송받아 상기 MPU 블록(30)의 제어에 의해 충전용 밧데리(230)의 충전상태를 표시하는 디스플레이부(3)를 더 포함하여 구성한 것이다.

[0040] 나아가 도 1 및 도 3과 같이 상기 장치몸체(2) 내부의 온도를 감지하고 상기 1차코일(70)의 온도를 측정하여 측정된 온도의 과열 여부, 고온 여부에 따라 회로 차단을 위하여 상기 MPU 블록(30)으로 신호를 전송하는 온도보호회로부(92)와, 상기 1차코일(70)과 직렬로 연결되어 상기 1차코일(70)에 흐르는 전류가 과다하거나 내부온도

가 과열되면 전류를 차단하는 바이메탈(Bimetal)(71)과, 상기 장치몸체(2) 내부의 먼지 및 냄새를 감지하는 먼지냄새 센서(90)와, 음이온을 발생하고 세균 박멸용 항균 스프레이를 분사하는 이온 발생부(91)를 더 구비할 수 있다. 또한 이와 같은 과열 방지용 온도센서를 구비한 온도보호회로부(92), 바이메탈(71), 먼지냄새 센서(90) 및 이온 발생부(91) 등은 무접점 충전장치(1)와 결합 및 작동하는 충전용 배터리팩(200) 및 휴대용 단말기(300) 등에도 적절한 구성으로 구비함이 바람직하다.

[0041] 이와 같이 구비된 본 발명 무접점 충전장치(1)의 구성 및 작동을 살펴보면 다음과 같다. 즉 본 발명은 코어-투-코어(Core-to-Core) 통신 방식을 이용하여, 무접점 충전장치(1)와, 충전용 배터리팩(200) 또는 충전용 배터리팩(200)이 내장된 휴대용 단말기(300) 간에 데이타 통신뿐만 아니라 충전용 전력을 함께 전송하도록 하는 구성이다.

[0042] 이러한 무접점 충전장치(1)는 휴대용 단말기(300), 충전용 배터리팩(200) 및 무접점 충전장치(1) 내부 시스템의 상태를 감시하고 제어할 수 있는 컴퓨터 또는 노트북(100)과 통신하는 통신수단을 수반한다. 이에 본 발명에서는 컴퓨터 또는 노트북(100)과 무접점 충전장치(1) 간에 USB 통신에 의하여 통신함을 예로 하였으며, 이는 USB 통신은 데이터 통신과 함께 충전용 전력을 하나의 회선으로 동시에 공급할 수 있기 때문이다. 그러나 RS-232c, SISC 및 시리얼, 패럴렐 등과 같은 다수의 데이터 전용 통신 방식으로 무접점 충전장치(1)와 컴퓨터 또는 노트북(100) 사이에 데이터 통신 연결이 가능하며, 이러한 경우에는 무접점 충전장치(1)는 별도의 일반적인 방법으로 전원을 공급받을 수 있다. 즉 무접점 충전장치(1)는 컴퓨터 또는 노트북(100)으로부터 통신연결됨과 함께 주변기기인 휴대용 단말기(300)의 충전용 전력을 컴퓨터 또는 노트북(100)으로부터 공급받을 수 있을 뿐만 아니라, 이와 다르게 별도의 일반적인 방법으로 전원 공급을 받을 수 있어, 결국 무접점 충전장치(1)와 휴대용 단말기(300) 사이에 충전 및 데이터 통신이 모두 가능하도록 구비한 것이다.

[0043] 즉 본 발명에서 예시하는 바람직한 실시예는 컴퓨터 또는 노트북(100)과 무접점 충전장치(1) 간에는 USB 통신방식으로 하였으며, 이러한 USB 통신 회선은 네개의 단자 중, 두개의 단자는 전원을 공급하며, 나머지 두 단자는 데이터를 전송하도록 규약되어있다. 따라서 USB 통신방식으로 무접점 충전장치(1)와 전원공급 및 데이터 송수신이 가능한 것이다. 이러한 USB 통신방식에서는 컴퓨터 또는 노트북(100)에 호스트 컨트롤러(Host Controller)가 내재되어 있어, 회선으로 연결되는 기기들을 제어할 수 있는 것이다. 그리고 이에 대응되는 무접점 충전장치(1)의 USB 드라이버블록(20)은 무접점 충전장치(1)의 USB용 컨트롤러가 내재되는 것으로, 무접점 충전장치(1)의 상태 및 무접점 충전장치(1)와 연결되는 충전용 배터리팩(200) 또는 휴대용 단말기(300)와 결합된 경우에 이들의 정보를 컴퓨터 또는 노트북(100)에 USB 방식으로 변환하여 송수신하게 된다.

[0044] 또한 이러한 USB 통신방식으로 통신하는 것은 1차코일(70) 및 2차코일(80)에서 비록 변조된 상태로 송수신된다. 그리고 충전용 배터리팩(200)에도 USB 통신을 위한 컨트롤러가 충전제어부(210)에 내재될 수 있으며, 또한 휴대용 단말기(300)에도 USB 통신을 위한 컨트롤러가 내재될 수 있으며, 이들 통신 신호는 무접점 충전장치(1)의 USB드라이버블록(20)을 거쳐야 하는 것이므로 결국 무접점 충전장치(1)를 허브로 하여 컴퓨터 또는 노트북(100)과 USB 방식의 통신을 하게 된다.

[0045] 따라서 상기 코어-투-코어(Core - to - Core) 통신 방식을 이용한 무접점 충전장치(1)와 휴대용 단말기(300) 간의 데이타 통신 및 전력을 전달하는 무접점 충전장치(1)는, 컴퓨터, 노트북(100)의 USB 포트로 연결하기 위한 USB커넥터(USB Connector)(10); 상기 컴퓨터, 노트북(100)과 USB커넥터(10)와 연결되어, 음악, 동영상, 데이타를 수신받아 USB 프로토콜로 에뮬레이션하는 USB드라이버블록(USB Emulation Control Block)(20); 무접점 충전장치(Wireless Charger)(1)의 내부 소자를 제어하기 위한 MPU블록(30); 부츠트랩 게이트 드라이버(Bootstrap Gate Driver)를 포함하는 게이트 드라이브 블록(Gate Drive Block)(40); LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)인 직렬공진 컨버터(50); FPCB, PCB, 코일, 페라이트 코어로 구성된 분리형 변압기로써, 상기 MPU 블록(30)의 제어에 따라 신호를 무선으로 전송하여 휴대용 단말기(300)에 내장된 배터리 팩의 2차코일(80)로 전송하기 위한 1차코일(70); C-L 공진부에 직렬로 연결되고, 모든 팀의 기능이 마비되었을 때 또는 코어(1차코일(70))가 과열되었을 때 차단할 수 있도록 삽입하여 안전장치를 확보하기 위한 바이메탈(Bimetal)(71); 상기 무접점 충전장치(1)의 먼지 및 냄새를 감지하기 위한 먼지냄새 센서(Dust & Smell Sensor Circuit)(90); 부가적인 음이온 발생기능이나 세균 박멸을 위한 항균 스프레이 분사하기 위한 이온 발생부(Ionizer High voltage drive circuit Control Block)(91); 2차코일(80)과 연결되는 충전용 배터리팩(200) 측의 무선 충전 모듈이 내장된 휴대용 단말기를 부하 변조(Load regulation)를 통하여 1차코일(70)의 충전 모듈의 MPU 블록(30)에서 충전용 배터리팩(200)의 ID를 인식하고, 충전용 배터리팩(200)의 2차정류단의 전압을 항상 정전압으로 제어할 수 있도록 무접점 충전장치(1)의 1차측 주파수 자동 가변 알고리즘을 통하여 전류 피드백에 의한 안정적인 전력 제어하기 위하며, 2차측 신호를 감지하기 위한 전류센싱블록(Current sensing block)(60);

충전 팩의 온도를 감지하기 위한 온도보호회로부(Thermal Protection Safety Block)(82); 충전용 배터리팩(200)인 2차측 신호의 피드백 신호를 감지한 1차코일(70)과 연결되어 2차측 신호를 검출하는 신호검출블록(61) 등을 포함한다.

[0046] 그리하여 휴대용 단말기(300)는 상기 구성의 무접점 충전장치(1)를 USB 통신의 허브로 하여, 컴퓨터(PC) 또는 노트북(100)으로부터 음악, 동영상, 데이터 등을 전송받을 수 있으며, 나아가 컴퓨터 또는 노트북(100)에서 휴대용 단말기(300)를 제어할 수 있는 것이다. 이를 위해 USB커넥터(10)와 연결된 USB드라이버블록(20)은 송수신되는 데이터를 USB 프로토콜로 에뮬레이션하며, USB드라이버블록(20) 및 MPU블록(30)에 의해 1차코일(분리형 변압기: FPCB, PCB, Coil, Ferrite core로 구성된 변압기)(70)에서 신호를 무선으로 휴대용 단말기(300) 또는 충전용 배터리팩(200)에 전송한다. 이에 1차코일(70)과 마찬가지로 충전용 배터리팩(200)의 2차코일(분리형 변압기: FPCB, PCB, Coil, Ferrite core로 구성된 변압기)(80)에서 전송된 데이터 신호를 수신하여, FSK(Frequency Shift Keying, 주파수 편이 방식)를 통하여 신호를 분리하고, 이 데이타를 휴대용 단말기(300)의 저장매체(메모리)에 데이터를 저장하며, 이에 USB 컨트롤러(301)를 구비할 수 있어 이를 통하여 데이터를 저장할 수 있다.

[0047] 이에 더하여 무접점 충전장치(1)가 가동하는 중에, 충전용 배터리팩(200)의 2차측 무선 충전모듈이 내장된 충전용 배터리팩(200) 또는 휴대용 단말기(300)를 상기 무접점 충전장치(1)에 근접시키면, 자동으로 컴퓨터 또는 노트북(100)에서 동기화되어 USB 통신으로 자동 접속되고, 휴대용 단말기(300)의 경우 저장매체 폴더가 맵업되어 음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등을 무선으로 컴퓨터 또는 노트북(100)에서 업로드 및 다운로드 할 수 있다.

[0048] 즉 컴퓨터 또는 노트북(100)과 연결된 무접점 충전장치(1)는 일정한 인터벌을 두고 1차코일(70)로 하여 펄스를 발신하여 충전용 배터리팩(200)의 접속 여부를 감지하게 된다. 그리하여 무접점 충전장치(1)의 1차코일(70)과 충전용 배터리팩(200)의 2차코일(80) 간에 무선 데이터 통신을 할 수 있으며, 이와 별도로 상기 컴퓨터 또는 노트북(100)의 USB 포트의 전원 또는 별도의 공급전원을 충전용 배터리팩(200)에 공급할 수 있다. 이러한 무접점 충전장치(1) 및 배터리팩(200) 그리고 휴대용 단말기 등의 구성은 본 발명의 출원인이 다수 출원한 기술에 의해 실시가 가능한 것이다. 이와 같은 무접점 충전장치(1) 및 배터리팩(200)에 의한 충전 및 데이터 통신 방식에 더하여, 본 발명에서는 무접점 충전장치(1) 및 배터리팩(200) 그리고 휴대용 단말기 등에 전력전송 뿐만 아니라 데이터 통신도 동시에 가능하도록 구비하여, 메인 컴퓨터 또는 노트북 등의 제어장치로부터 데이터 송 수신 및 기능의 제어 그리고 상태 감시 등이 용이하게 할 수 있도록 구비한 것이다.

[0049] 그리고 전류센싱블록(60)에 의하여 감지된 2차코일(80)로부터의 신호가 휴대용 단말기(300)가 구비되지 않는 것으로 판별되거나, 음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등을 수신할 수 있는 메모리가 함께 구비되지 않은 것으로 판별되는 신호로 수신될 경우에는, MPU블록(30)의 제어에 의하여 1차코일(70)로 USB 데이터(음악(MP3 format), 동영상(avi, asf, dat format), 데이터 등)의 전송을 하지 않도록 하기 위하여, USB 데이터전송제어모듈(25)을 USB드라이버블록(USB Emulation Control Block)(20)에 더 구비하며, 이에 의하여 휴대용 단말기가 접속된 것으로 판명되면 다시 데이터를 전송할 수 있다. 그리하여 1차코일(70) 및 2차코일(80)은 전력전송 및 전력전송에 필요한 데이터가 전송되도록 하며, 또한 컴퓨터 또는 노트북에 이에 알맞은 신호를 전송하도록 구비할 수 있다.

[0050] 이에 무접점 충전장치(1)의 MPU블록(30)의 제어에 의하여 직렬공진 컨버터(50) 및 1차코일(70)과 2차코일(80)을 통하여, 무접점 충전장치(1)의 펄스신호에 대한 응답으로 충전용 배터리팩(200) 또는 휴대용 단말기(300)에서는 고유의 ID를 발생하여 다시 무접점 충전장치(1)로 전송하게 된다. 즉 충전용 배터리팩(200) 충전제어부(210)의 2차측 무선 충전 모듈이 내장된 ID칩에서 고유 ID 신호를 2차코일(80)을 통하여 발신하게 되면, 무접점충전장치(1)에서는 1차코일(70), 신호검출블록(61), 전류센싱블록(60)을 통하여, 공급되는 전력신호의 부하변조(Load regulation) 신호를 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID를 인식하게 된다. 이와 같이 인식된 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID를 인식하게 되면, 이러한 충전용 배터리팩(200) 또는 휴대용 단말기(300)에 대한 정보는 컴퓨터 또는 노트북(100)에 전송하게 된다. 즉 상기 무접점 충전용 배터리팩(200)이 상기 무접점 충전장치(1)에 올려지면 충전용 배터리팩(200)에 내장된 ID칩이 동작하여 무부하 상태에서 로드 레귤레이션을 하여 충전 스타트 ID를 무접점 충전장치(1)에 전송하고, 상기 무접점 충전장치(1)는 그 신호를 피드백 받아서 ID가 일치하며 올바른 신호인지를 확인하고 일치하면 풀 파워모드로 전력을 충전용 배터리팩(200)에 공급한다.

[0051] 그리고 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 고유 ID가 인식되면, 1차코일(70) 및 2차코일(80)을 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 2차측 정류단 전압을 항상 정전압 제어를 한다. 이는

무접점 충전장치(1)의 1차 측 주파수 자동 가변 알고리즘을 통하여 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 2차측 충전 전력을 제어한다. 이러한 충전 전력 제어를 보면, 무접점 충전장치(1)의 1차코일(70), 신호검출블록(61), 전류센싱블록(60)에서는 Vdrop(= Vrec - Vbat)에 의한 2차측 소비전력|Pdis=(Vrec-Vbat)*Ichg|을 최소화하도록 구비된다. 이에 Vrec은 2차측 입력전압이 되는 2차측 정류회로(81)의 출력 전압(도 1의 상부 우측에 도시됨)이고, Vbat는 2차측 최종 충전 소비 전압이 되는 2차측 충전용 배터리팩(230)의 배터리 전압(도 1의 하부 우측에 도시됨)이며, Vdrop는 2차측에 있어 입력 전압(즉 Vrec)에 대한 충전 소비 전압(즉 Vbat)의 차이의 전압이 되며, Ichg는 2차측에 인가되는 전류이고, Pdis는 2차측에서 충전에 소비되는 전력이다. 이와 같은 정보는 2차측 배터리팩에서 1차측 무접점충전장치(1)로 신호전송되어 전력제어하게 되는 것이다. 따라서 충전용 배터리팩(200) 또는 휴대용 단말기(300)에서 별도의 2차측 충전모듈의 부재를 줄일 수 있고, 기타 충전칩들의 온도 상승을 억제하며, 이로써 복잡하고 가격이 비싼 스위칭 충전용 IC를 사용하지 않고 리니어 충전용 IC를 사용할 수 있으며, 또한 배터리 팩의 내부 공간을 확보할 수 있다.

[0052] 다음으로 살펴볼 수 있는 것은 충전모듈을 구비하지 아니한 이종의 금속체가 무접점 충전장치(1) 위에 올려졌을 때, 유도기전력에 의하여 이러한 이종의 금속체가 와전류에 의한 순실이 열로 발생하여 과열이 되어, 무접점 충전장치(1)가 손상되는 현상이 발생될 우려가 있다. 이러한 현상은 유도기전력을 이용한 무접점 충전장치(1)의 안정성에 가장 큰 영향을 미치는 문제이다. 그러므로 동전, 금속펜, 가위, 등 생활 속의 금속체 등, 충전모듈이 구비되지 아니한 이종의 금속체를 인식하고 전력을 차단하여 과열의 위험으로부터 안전하도록 하는 안전장치를 반드시 구비하여야만 한다.

[0053] 이를 위한 구성을 살펴보면, 1차코일(70)에서 2차코일(80)에 전력을 전달시키는 수단은 반파 또는 전파형 직렬/병렬 공진형 컨버터를 사용하여 LC공진을 시켜 전류를 정현파로 만들어 유도결합에 의해 2차 측에 전력을 전달하는 것이다. 이때 스위칭 주파수는 공진주파수 보다 높게 설정하여 소프트 스위칭이 되도록 한다. 1차코일(70)에서 일정한 인터벌(interval)을 두고 아주 짧은 시간 동안 PWM펄스를 인가하여, 이종의 이물질이 올려져 있는지 여부를 감지하여 판별하는 메카니즘을 구성한 것이다. 무부하시 스위칭 주파수와 전류의 위상이 항상 90도를 이루는데, 이물질이 근접되면 자기 인덕턴스의 변화에 의해 전류의 위상이 변화되고, 이 위상차의 레벨에 따라 이물질의 정도를 인식하도록 하였다. 즉 물체 근접이 감지되면 전력을 인가하는 일정시간 동안 ID 체크 신호를 발신하며, 제한된 고유 ID 신호가 감지되지 않거나 또는 상이한 ID가 인식이 되면, 이물질로 인식하여 무접점 충전장치(1)의 충전 시스템을 shut-down 시켜 충전 전력을 1차코일(70)로 공급되지 않도록 하여, 충전용 배터리팩(200) 또는 휴대용 단말기(300)의 충전회로의 안정성을 확보한 것이다.

[0054] 즉 무접점 충전장치(1)에서는 상기 1차코일(70)에서 일정한 인터벌의 PWM펄스를 발생하고, 이에 응답하는 상기 2차코일(80)로부터의 신호를 상기 전류센싱블록(60)에서 감지함에, 감지된 신호가 규정된 신호이면 ID를 부여하여 데이터 신호 및 전력신호를 전송하며, 응답이 없거나 응답신호가 규정된 신호가 아니면 이물질로 감지하여 데이터 신호 및 전력 신호의 전송을 중지하는 이물질 감지기능을 더 포함하여 구성한 것이다.

[0055] 또한 이러한 이물질 감지기능에 의한 충전 중 이물질 감지는 복잡한 기술이 요구되는데 충전이 되면서 전력은 점점 떨어지도록 구비할 수 있다. 이 전력 곡선에 히스테리시스를 두어 이물질이 올려졌을 때, 히스테리시스 구간을 넘어가면 이물질로 인식하여 shut-down시키는 알고리즘이 사용하여 구현할 수 있다.

[0056] 본 발명은 상기 무접점 충전장치(1)의 안전장치와 무선충전용 모듈이 내장된 충전용 배터리팩(200)의 안전성 및 배터리 상태 감시기능을 갖춘 무선 충전 솔루션을 제공할 수 있다.

[0057] 그리고 상기 무접점 충전장치(1)는 기본적으로 온도보호회로부(82)에 의하여 1차코일(70)과 구성된 여러 칩의 온도를 검출하거나 장치몸체(2) 내부의 온도를 감시하여, 상시 온도가 45℃ 이상일 경우, Shut-down시키는 기능과, 과전류, 과전압에 대한 보호 기능을 칩에 내장하고, 또한 퓨즈(Fuse)를 내장하여 과전류를 차단한다. 그리고 상기 무접점 충전장치(1)의 구성 칩의 기능이 마비되어 이상신호가 검출되면 회로를 차단하며, 1차코일(70)과 연결된 C-L 공진부에 직렬로 바이메탈(Bimetal)(71)을 구성하여 1차코일(70)이 과열되었을 때 회로를 차단할 수 있도록 하는 등, 안전장치를 구성하였다.

[0058] 그리고 부가적으로 움이온 발생기능이나 세균 박멸을 위한 항균 스프레이가 분사되고, LCD 디스플레이부(3) 또는 컴퓨터, 노트북(100) 등에 충전이 되는 상태를 표시한다. 이에 더하여 충전용 밧데리(230)가 만충전되면, 충전용 IC에서 출력된 만충전 신호를 ID칩에서 받아서 만충전 상태를 충전제어부(210)의 제어에 의해 상기 무접점 충전장치(1)에 로드 레귤레이션을 통하여 전송하고, 이 신호를 피드백 받아 충전용 배터리팩(200)이 충전 완료 상태인 것을 디스플레이부(3), 컴퓨터 또는 노트북(100) 등에 표시한다.

[0059] 이러한 본 발명 무접점 충전장치(1)는 또한 도 4와 같이, 상기에 기술된 바와 같이 컴퓨터 또는 노트북 등으로부터 USB 포트를 이용하여 전력을 충전할 수 있으며, 또한 컴퓨터 또는 노트북과 근접되지 않는 상황, 즉 여행을 하는 등과 같은 상황에서 다양한 방법으로 충전할 수 있도록 부가된 구성을 할 수 있다. 즉 충전기, 어댑터, USB 포트 등을 입력으로 하는 24핀 커넥터를 사용할 수 있으며, 그 일 실시예로 24핀 표준 커넥터를 사용하여 여행용 충전기가 꽂일 경우, 1번 핀에 할당된 특정 ID저항을 통해 항상 4.2V를 21, 22번 핀을 통해 입력받고, 어댑터가 꽂일 경우 4, 5번 핀을 통해 전원을 입력받고, USB 포트에 꽂일 경우 16번 핀을 통해 전원을 입력 받을 수 있으며, 상기 무접점 충전장치(1)는 입력전원이 4V에서 5.5V에서 동작 가능하도록 구비할 수 있다.

[0060] 그리고 상기 24핀 표준 커넥터를 사용하는 어댑터를 사용하여 2개의 휴대용 단말기를 동시에 충전시킬 수 있는 도킹 스테이션을 구성하여 상기 무접점 충전기를 2개 연결하여 각각 휴대용 단말기 2대를 동시에 충전시킬 수도 있다.

[0061] 상기와 같이 구성된 본 발명의 다른 실시를 살펴보면 다음과 같다.

[0062] 즉 컴퓨터 또는 노트북(100)과 USB 통신하는 상기 USB드라이버블록(20)을 USB에 대한 컨트롤러 기능뿐만 아니라, IrDA 신호로 변환하는 기능을 부가한 것이다.

[0063] 따라서 이러한 USB드라이버블록(20)은 USB프로토콜 및 IrDA로 서로 변환하는 IrDA 신호변환부(21)를 더 구비하고, 상기 IrDA 신호변환기(21)에 의해 IrDA로 변환된 데이터 신호를 상기 MPU 블록(30)의 제어에 의해 상기 휴대용 단말기(300)과 서로 송수신하는 IrDA 포트(22)를 더 구비하고, 휴대용 단말기(300)의 IrDA 컨트롤블록(302)으로부터 발신되어 IrDA 포트(22)에서 수신된 상기 휴대용 단말기(300)의 고유ID를 감지하여 구별하는 휴대용단말기ID 감별부(미도시됨)를 더 구성하였다.

[0064] 이에 도 2 및 도 3은 본 발명에 따른 IrDA 송수신 모듈이 내장된 무접점 충전장치(1)를 나타낸 도면이다.

[0065] 이를 참조하면, 상기 무접점 충전장치(1)는 전원입력으로 컴퓨터나 노트북(100)의 USB포트에 연결하면, 상기 무접점 충전장치(1)에 내장된 IrDA 신호변환부(21)에 의해 USB 통신프로토콜 및 IrDA 등의 데이터를 상호 변환하고, IrDA 트랜시버를 통하여 PC 또는 노트북으로부터 저장된 음악, 동영상, 데이터 등을 연동하여 휴대용 단말기(300)(휴대폰, PDA, PMP, DMB단말기, MP3 등)와 데이터를 무선으로 상호 교환할 수 있다. 또한 전원 공급용 전력의 전송을 1차코일(70) 및 2차코일(80)에 의한 비접촉 분리형 변압기를 이용하여 상기 휴대용 단말기(300)로 에너지를 전달하여 배터리를 충전한다.

[0066] 상기 무접점 충전장치(1)에 내장된 IrDA 포트(22)와 상기 휴대용 단말기(300)의 IrDA포트를 일치시켜 2차측 무선 충전모듈이 내장된 휴대용 단말기(300)를 상기 무접점 충전장치(1)에 근접시키면, 상기 무접점 충전장치(1)는 상기에 언급된 바와 같은 기술의 1차코일(70) 및 2차코일(80)에 의해 자동으로 컴퓨터 본체와 동기화되며, 이에 무접점 충전장치(1)와 휴대용 단말기(300) 간에 쌍방이 적외선 통신이 가능하도록 컴퓨터 또는 노트북(100)에 USB가 자동으로 접속되며, 따라서 휴대용 단말기(300)의 저장매체 폴더가 팝업되고 음악(MP3 format), 동영상(avi, asf, dat format) 등 데이터를 무선 다운로드할 수 있으며, 기타 데이터 처리를 함께 할 수 있는 것이다.

[0067] 이에 도 3은 이러한 무접점 충전장치(1) 및 휴대용 단말기(300) 간에 각각 내장된 IrDA 포트에 의한 적외선 통신 방식과 전력을 전달하는 무접점 충전장치(1)에 대한 구성도를 도시한 것이다.

[0068] 즉 도 3의 상기 무접점 충전장치(1)는 USB 커넥터(USB Connector)(10), USB-to-IrDA로 신호변환하는 IrDA 신호변환부(21)가 내재된 USB드라이버블록(20), MPU 블록(30), 부트스트랩 게이트 드라이버(Bootstrap Gate Driver)를 포함하는 게이트 드라이브 블록(Gate Drive Block)(40), LLC 풀브릿지 직렬 공진 컨버터(LLC Full-bridge Serial Resonator Converter)의 직렬공진 컨버터(50), 1차코일(70), 2차코일(80), 바이메탈(Bimetal)(71), 먼지냄새 센서(Dust & Smell Sensor Circuit)(90), 이온 발생부(Ionizer High voltage drive circuit Control Block)(91), 전류센싱블록(Current sensing block)(60), 온도보호회로부(Thermal Protection Safety Block)(92), 및 2차측 신호를 검출하는 신호검출블록(61) 등을 포함한다.

[0069] 그리고 휴대용 단말기(300)에는 IrDA 컨트롤러(302) 및 IrDA 포트 등이 구비된다. 그리하여 휴대용 단말기(300)와 무접점 충전장치(1) 사이에 각각의 IrDA 포트를 이용하여 데이터 통신을 하도록 구비할 수 있다.

[0070] 상기와 같이 구성된 본 발명의 무접점 충전장치(1)와 결합되어 무접점 충전장치(1)와 서로 데이터를 무선으로 송수신하며, 전원용 전력을 무선으로 공급받는 충전용 배터리팩(200)을 구성한 것이다.

[0071] 즉 상기의 무접점 충전장치(1)의 장치몸체(2) 일측과 서로 접촉가능하도록 하며, 상기 1차코일(70)과 비접촉 상태에서 자기장에 의해 데이터 신호를 송수신하고, 전력 신호를 전송받는 상기 2차코일(80)이 일측에 구성된 충전체몸체(201), 상기 충전체몸체(201) 내부 일측에 상기 2차코일(80)과 연결되어 상기 1차코일(70)로부터 전송되는 전력 신호를 처리하여 충전용 밧데리(230)에 전송하며, 상기 1차코일(70)과 송수신하는 데이터 신호를 처리하는 충전체제어부(210), 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)에 충전용 전력을 전송하도록 하는 충전회로(220)를 포함하며, 상기 충전회로(220)은 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기(300)로 공급되도록 구성한 것이다.

[0072] 이에 상기 충전체제어부(210)는 상기 무접점 충전장치(1)로부터 최초 연결된 것을 감지하면 고유ID를 상기 2차코일(80) 및 상기 1차코일(70)을 통하여 상기 무접점 충전장치(1)로 전송하도록 하는 고유ID부(고유 ID 칩), 상기 충전용 밧데리(230)의 충전 정도를 감지하여 상기 무접점 충전장치(1)로 전송하는 충전감지부를 포함하여 구성한 것이다.

[0073] 그리고 상기 충전체몸체(201)는 상기 휴대용 단말기(300)와 분리 및 체결이 가능하도록 별체로 형성되는 분리형태으로 구성될 수 있다. 또한 상기 휴대용 단말기(300)의 본체 케이스 내부에 내재되어 일체로 형성되는 일체형태으로도 구성될 수 있다.

[0074] 이에 분리형태으로 구비된 충전체몸체(201)는 상기 충전체제어부(210)의 제어에 의하여 상기 충전용 밧데리(230)의 전원을 상기 휴대용 단말기(300)로 공급하는 터미널 블록(240)을 더 구성하였다.

[0075] 이를 도 1 및 도 3으로 하여 설명하면, 상기 충전용 배터리팩(200)의 2차코일(80)은 휴대용 단말기의 풀브릿지 정류회로(Rectification Block)(81)와 연결된다. 그리고 정류회로(81)와 연결된 충전체제어부(210)는 상기 휴대용 단말기(300) 또는 충전용 배터리팩(Wireless charge-enabled Battery Pack)(200)의 고유 ID를 송출하여 무접점 충전장치(1)에서 이물질 감지가능이 수행되도록 하고, 충전 상태 피드백 충전 회로를 on-off하고 이를 무접점 충전장치(1)로 송출하며, 신호-to-USB 변환 기능이 가능하도록 구비될 수 있다. 그리고 충전을 위한 충전회로(Charse Manasement Block)(220), 배터리 용량 체크 회로(Fuel Gause Control Block)(221), 배터리 보호회로(Prototection Control Block)(222), PTC와 충전용 밧데리(230), 및 휴대용 단말기(300)에 내장된 USB 컨트롤러(301) 또는 IrDA 컨트롤블록(302) 등을 함께 구비할 수 있다.

[0076] 그리고 상기에 기술된 무접점 충전회로(1)의 안전장치와 같이, 충전용 배터리팩(200)에도 다수의 안전장치를 구비한다.

[0077] 즉 충전용 배터리팩(200)의 안전장치는 충전회로에 내장된 온도센서가 있어서 외부에 연결된 NTC가 온도변화에 따라 저항값이 변동되어 분배된 전압을 피드백 받아, 기 설정된 온도 이상이 되면 충전을 차단하는 기능을 내장할 수 있다. 또한 PCM이라는 보호회로에 의해 과전류, 과전압, 과방전, 단락 등으로부터 배터리를 보호하고 PTC 또는 바이메탈(Bimetal)을 사용하여 과전류와 온도에 의해 차단되어 충전용 배터리팩(200) 및 충전용 밧데리(230) 및 이들의 회로를 보호한다. 그리고 충전용 배터리팩(200)에 내장된 ID 칩 및 다수의 칩 등에 대해, 충전 중 내부의 오동작이 발생했을 경우, 상기 무접점 충전장치(1)에 로드 레귤레이션을 통해 이러한 오작동 신호를 전송하고, 상기 무접점 충전장치(1)에서 ESR를 통해 신호를 받아서 스위칭을 차단하여 전력공급을 중단하는 메커니즘을 구비할 수 있다.

[0078] 그리고 이러한 충전용 배터리팩(200)은 도 5 내지 도 9도와 같이, 휴대용 단말기(300) 내부에 함께 내재하여 일체로 구비할 수 있으며 또한 별체로 분리 및 결합이 용이하게 구비할 수 있다. 따라서 이러한 휴대용 단말기(300)는 충전용 배터리팩(200)의 터미널 블록(240)과 전기적으로 접촉되어 전원을 공급받는 전력수신터미널블록(310)과, 상기 전력수신터미널블록(310)과 연결되어 전력을 변환하는 DC/DC 컨버터(320) 및 상기 DC/DC 컨버터(320)에서 변환된 전력을 충전하는 충전블록(330)을 구성할 수 있다.

[0079] 이와 같은 본 발명은 일반적으로 비접촉 변압기의 경우 접촉형인 일반 변압기와 달리 큰 공극을 갖기 때문에 자화인덕턴스는 일반 변압기에 비해 상대적으로 작고, 누설인덕턴스는 상대적으로 크기 때문에 기존 곡렬 공진형 컨버터를 그대로 사용하면 부하 변화에 대한 많은 순환전류가 흐르는 단점을 가지게 된다. 뿐만 아니라 2차측 정류다이오드의 연속적인 전류에 의해 다이오드의 역 회복 특성에 따른 스위칭 손실이 발생할 우려가 있다. 그

러나 본 발명에서는 이러한 문제점을 개선하기 위해 비접촉 변압기용 풀브릿지 LLC 직렬 공진형 컨버터(50)를 적용하여 스위칭 주파수는 공진주파수보다 낮은 주파수에서 동작하여 기존 직렬 공진형 컨버터를 사용한 경우보다 순환전류를 많이 줄일 수 있고, 2차측 정류다이오드에 불연속 전류가 흐르기 때문에 다이오드의 스위칭 손실을 줄일 수 있는 장점을 가진다.

[0080] 또한 1차코일(70) 및 2차코일(80)은 분리형 변압기의 FPCB, PCB, 코일 및 페라이트 코어 중 어느 하나로 구성되고, 원형, 사각형 또는 다각형의 평판 또는 통형상의 코일형태로 형성되도록 하여 서로 신호 전송이 원활하도록 구비한 것이다.

[0081] 이러한 본 발명에 따른 무접점 충전용 배터리팩(200)의 제조 구성의 예를 도 5 내지 도 9를 참조하여 기술하면 다음과 같다. 즉 도 5는 출인원 하드팩으로 된 충전용 배터리팩(200)에 대한 것이고, 도 6은 휴대용 단말기(300)에 내장되는 실시예에 대한 회로도이다.

[0082] 즉 출인원 하드팩의 충전용 배터리팩(200)은 2차코일과 자기장 차폐 쉴드, 정류회로, 충전회로(스위칭 또는 리니어 충전 회로), 무선 통신 ID 인식 회로, 보호회로, 배터리로 구성된다. 즉 2차코일(코일 또는 코어방식 포함)(80), 정류회로(Rectification Block)(81), LDO+IIC(TX, RX통신)+FET 드라이브+배터리 충전 상태 입력(Empty, Full 신호) 기능+오실레이터+충전회로 enable 또는 disable할 수 있는 포트를 내장한 어댑터 제어 블록(Adaptor Control Block)인 충전체제어부(210), 배터리 보호회로(PCM)(222), PTC와 충전용 밧데리(230), 충전회로(220), 휴대폰과 연결되는 단자인 터미널 블록(240) 등으로 구성된다.

[0083] 그리고 내장형 충전용 배터리팩(200)의 경우에는 상기 휴대용 단말기(300)의 케이스 커버에 2차코일과 자기장 차폐 쉴드를 내장하고(코일을 커버에 사출 성형하거나 보호 케이스를 만들어서 초음파 융착하는 방법 사용), 휴대용 단말기(300)와 연결될 수 있는 단자를 만들어 이 단자를 통하여 연결된 휴대용 단말기(300)의 내장 회로에 정류회로, 무선 ID 인식회로를 부가하고, 상기 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320)와 충전블록(330)을 그대로 사용하여 내장된 배터리팩과 연결된 단자를 통하여 충전한다.

[0084] 또한 상기 휴대용 단말기(300)에 내장된 충전용 배터리팩(200)의 또 다른 구성은, 2차코일과 자기장 차폐 쉴드, 정류회로, 무선 통신 ID인식회로, 보호회로, 배터리 등을 휴대용 단말기(300) 케이스 커버에 융착하지 않고 내부에 내장하며, 상기 휴대용 단말기(300)와 정류회로 출력, 접지, 배터리 양극, 충전상태 핀 등의 연결 단자를 만들고 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320)와 충전블록(330)를 그대로 사용하여 배터리와 연결된 단자를 통하여 충전하도록 구성할 수있다.

[0085] 이러한 내장형 충전용 배터리팩(200)에 대한 회로는 도 6에 도시된 바와 같이, 휴대용 단말기(300)에 적용 가능한 무접점 충전용 세미 이너팩으로, 2차코일(코일 또는 코어방식 포함)(80), 정류회로(Rectification Block)(81), LDO+IIC(TX, RX통신)+FET 드라이브+배터리 충전 상태 입력(Empty, Full 신호) 기능+오실레이터+충전회로 enable 또는 disable할 수 있는 포트를 내장한 어댑터 제어 블록(Adapter Control Block)인 충전체제어부(210), 배터리 보호회로(PCM)(222), PTC와 충전용 밧데리(230), GSM 휴대폰인 휴대용 단말기(300)에 내장된 DC/DC 컨버터(320), 및 GSM휴대폰인 휴대용 단말기(300)에 내장된 충전블록(330)을 포함하여 구성될 수 있다. 이때 GSM휴대폰인 휴대용 단말기(300)는 단말기에 DC/DC컨버터(320)와 충전블록(330)이 내장된 휴대용 단말기(예:GSM 휴대폰)를 말한다.

[0086] 이에 무접점 충전장치(1)에 무접점 충전용 세미 이너팩, 즉 충전용 배터리팩(200)을 내장한 GSM 휴대폰인 휴대용 단말기(300)를 올려놓으면 무접점 충전장치(1)에서 전력을 발생시켜서 2차코일(80)을 통해 충전용 배터리팩(200)으로 전력을 전송한다.

[0087] 그리하여 충전용 배터리팩(200)인 2차 측에서는 2차코일(80)에서 AC 전력을 받아서 정류회로(81)에서 정류를 하여 DC로 만들고, 충전체제어부(210)에서 RX핀을 통해 전압이 안정전압 이상(예 : 5.5V 이상)이면 TX핀을 통해 상기 무접점 충전장치(1)에 전력을 줄이기 위한 Power save 코드를 발생시켜 전달하여, 2차 측 전력이 안정전압(예 :5V 정도)으로 파라미터(주파수)를 조절한다. 이 경우를 반복하여 충전용 배터리팩(200)인 2차 측이 최적의 전압 조건인 안정전압(예 : 5V)이 되면 이에 대한 ID를 발생시키고, 무접점 충전장치(1)의 ID와 일치하면 상기 무접점 충전장치(1)에서 전력을 발생시킨다. 그렇지 않으면 무접점 충전장치(1)에서는 전력 공급을 차단하고 절전 모드로 들어가거나 이물질이 올려졌을 경우 고유ID에 대한 수신정보가 없기 때문에 에러를 발생시켜 전력 공급을 차단한다.

[0088] 도 7 내지 도 9는 이러한 충전용 배터리팩(200)의 다수 실시예에 따른 분해 사시도를 도시한 것이다.

[0089] 우선 충전용 배터리팩(200)의 제1실시예를 도시한 도 7의 구성을 살펴보면, A/S 라벨(411), 상부 케이스(Top case)(412), 무접점 충전용 PCB 보드(413), (-)Ni-Plate(414), PTC 또는 바이메탈(415), 리드선(416), (+)Ni-Plate(417), 보조 케이스(418), Nomax 테이프(419), 정류부 보드(420), 배터리셀(421), 2차측 코일(422), 하부 케이스(Bottom case)(423), 및 라벨(424)을 구비한다. 즉 정류부 보드(420)를 탑면에 배치한 실시예인 것이다.

[0090] 다음으로 도 8은 제2 실시예에 따른 무접점 충전용 내장형 배터리 팩 조립도(회로기판 탑면 배치)로, A/S 라벨(431), 상부 케이스(Top case)(432), 무접점 충전용 PCB 보드(433), (-)Ni-Plate(434), PTC 또는 바이메탈(435), 리드선(436), (+)Ni-Plate(437), 보조 케이스(hot melt 방식으로 충진할 수 있음)(438), Nomax 테이프(439), 연결 보드(440), 배터리셀(441), 2차측 코일(442), 하부 케이스(Bottom case)(443), 및 라벨(444)을 구비한다.

[0091] 그리고 도 9는 제3 실시예에 따른 무접점 충전용 내장형 배터리 팩 조립도(회로기판 측면 배치)로, A/S 라벨(451), 상부 케이스(Top case)(452), 무접점 충전용 PCB 보드(453), (-)Ni-Plate(454), PTC 또는 바이메탈(455), 리드선(456), (+)Ni-Plate(457), 보조 케이스(hot melt 방식으로 충진할 수 있음)(458), Nomax 테이프(459), 연결 보드(460), 배터리셀(461), 2차측 코일(462), 하부 케이스(Bottom case)(463), 및 라벨(464)을 구비한다.

[0092] 상기와 같이 구비되는 배터리팩은 도 10과 같은 개략적인 구조의 자기장을 막는 차폐용 부재를 구비한다. 이와 같은 차폐용 부재에 의하여 배터리 셀 및 충전용 회로들의 오작동을 방지하고 과열되는 것을 방지한다. 즉 도 7 내지 도 9의 배터리셀(421)(441)(461)은 도 10에 개략적으로 도시된 차폐용 부재가 구비된 배터리셀(512)의 구성과 같이 구성할 수 있다.

[0093] 즉 도 10은 무선 전력 수신 모듈을 가진 충전용 배터리팩(200)의 구성도로, 코일, 파인메탈, 박막알루미늄(호일 등), 리튬이온 또는 리튬폴리머로 된 배터리팩은 자기장을 100% 차단하기 위해 박막알루미늄을 넣어서 셀에 영향이 없도록 하여 셀의 사이클이 500회까지 충방전 가능하도록 구비한 것이다. 여기서 코일의 형상은 모든 형태의 코일을 포함한다. 즉 사각형상, 원형상 또는 타원 형상 등으로 다양하게 구비할 수 있다. 그리하여 무선 전력 수신 모듈을 가진 충전용 배터리팩(200)은 배터리셀(512)의 일측에 수직 또는 수평 방향으로 무선 전력 수신 회로(Wireless Power Receiver Circuits)를 구비하고, 상기 무선 전력 수신 회로(513)는 감싸는 자기장을 막는 차폐부재(501)를 포함하여 구성할 수 있다.

[0094] 그리고 코일, 파일메탈, 박막알루미늄(호일 등), 리튬이온 또는 리튬폴리머로 된 충전용 배터리팩(200)은 자기장을 100% 차단하기 위해 차폐판(515)를 구비하였다. 상기 차폐부재(501) 및 차폐판(515)는 Al, Cu, Ni alloy metal 등을 포함하여 얇은 판으로 형성된다. 또한 상기 차폐판(515)과 동일한 구성으로 배터리셀(512)을 중심으로 하여, 전후좌우면에도 각각 차폐판(515-1)(515-2)(515-3)(515-4)를 구비하여, 자기장으로부터 배터리셀(512)을 보호하도록 구성한 것이다. 이러한 차폐판(515)과 2차코일(516)이 권선된 충전리시버모듈(517) 사이에는 자성판(503)을 구비하여, 코일에 1차코일로부터 유도된 자기장이 2차코일(516)에 잘 유도될 수 있도록 투자율이 높은 자성체로 구비한 것이다. 이러한 자성판(503)은 페라이트 계열, Mn - Zn (50 중량부 : 50 중량부), 또는 Ni - Fe (80 중량부 : 20 중량부)로 구비되거나, 파일메탈(Finemetal, Fe-Si-Cu-Nb)로 Fe를 주성분으로, 이에 Si과 B 및 미량의 Cu와 Nb를 고온 상태에서 첨가하여 100℃ 이하로 급냉하여 고체화하여 제조한 것이다.

[0095] 그리고 차폐판(515)과 배터리셀(512) 사이에는 절연체인 절연판(502)을 구비한 것으로, 특히 Ni-Cu로 된 Mesh 또는 방열할 수 있으며 열전도를 빨어드릴 수 있는 절연체로 구비하여, 배터리셀(512)의 온도 상승을 방지하여 과열되지 않도록 하였다. 따라서 온도와 자기장의 영향이 배터리셀(512)에 미치지 않도록 하여, 충전리시버모듈(517)과 연결되어 배터리셀의 사이클이 500회까지 충방전 가능하도록 구비하였고, 이때 코일의 형상은 모든 가능한 형태의 형상으로 하여 구성할 수 있다. 미도시된 기호 511은 (-)터미널이고, 514는 (+)터미널이며 516은 코일을 도시한 것이다.

[0096] 상기의 충전용 배터리팩(200)의 예에 따른 무접점 충전장치(1)는 또한 함체 형상으로 형성된 장치몸체(2)의 상부면에 1차코일(70)을 형성한 것으로, 소용돌이 형상의 원형, 사각형 또는 다각형 형상으로 코일 또는 코어의 형태로 1차코일(70)을 구성할 수 있다. 그리고 이와 같이 1차코일(70)이 구성된 무접점 충전장치(1)의 상부로 충전용 배터리팩(200) 또는 충전용 배터리팩(200)이 내재된 휴대용 단말기(300)를 올려 놓으면, 컴퓨터 또는 노트북과 연결된 상태에서 송수신용 데이터 및 전원용 전력을 공급되도록 구성한 것이다.

[0097] 상술한 바와 같이, 본 발명의 바람직한 실시예를 참조하여 설명하였지만, 해당 기술 분야의 숙련된 당업자는 하기의 특허청구범위에 기재된 본 발명의 사상 및 영역으로부터 벗어나지 않는 범위 내에서 본 발명을 다양하게 수정 또는 변형하여 실시할 수 있다.

발명의 효과

[0098] 상기와 같은 구성된 본 발명에 따른 무선 데이타 통신과 전력 전송이 가능한 무접점 충전기 및 이를 이용한 휴대용 단말기는 TC, TA, PC의 USB Port의 출력을 전원 입력으로 하는 유도기전력을 이용한 무접점 전력 전송에 의해 휴대용 단말기(휴대폰, PDA, MP3 player, DAB 또는 DMB 단말기, PMP(Portable Music Player), Handheld 단말기 등)와 컴퓨터(PC)간 무선 데이터 통신과 무선 충전을 동시에 가능하여 전송시 에러가 발생되지않고 안정적으로 데이터를 송수신하면서 전력을 함께 공급할 수 있는 효과가 있다.

[0099] 또한 본 발명에 따른 무접점 충전기는 충전하고자 하는 휴대용 단말기의 배터리 팩(2차측 무선충전 모듈이 내장된 팩) 이외의 다른 금속 이물질이 올려졌을 때, 이를 감지하여 차단시킬 수 있는 이물질 감지 기능과, 휴대용 단말기의 배터리 팩을 인식하여 충전상태를 인식할 수 있는 식별기능을 가지며, 과부하와 온도 프로텍션 기능을 제공하여, 기기의 손상을 방지하며 최적의 충전 효율 상태를 유지하도록 하는 효과가 있다.

도면의 간단한 설명

[0001] 도 1은 본 발명에 따른 무접점 충전장치의 회로도이다.

[0002] 도 2는 본 발명에 따른 무접점 충전장치의 IrDA 통신이 적용된 실시예의 사시도이다.

[0003] 도 3은 본 발명에 따른 무접점 충전장치에 IrDA 통신이 적용된 실시예의 회로도이다.

[0004] 도 4는 본 발명에 따른 무접점 충전기에서 24핀 커넥터를 사용하는 충전기, 어댑터, USB 포트를 입력으로 사용하는 실시예를 도시한 예시도이다.

[0005] 도 5는 본 발명에 따른 충전용 배터리팩의 회로도이다.

[0006] 도 6은 본 발명에 따른 충전용 배터리팩에 대한 다른 실시예의 회로도이다.

[0007] 도 7은 본 발명에 따른 충전용 배터리팩의 제1실시예에 따른 분해사시도이다.

[0008] 도 8은 본 발명에 따른 충전용 배터리팩의 제2실시예에 따른 분해사시도이다.

[0009] 도 9는 본 발명에 따른 충전용 배터리팩의 제3실시예에 따른 분해사시도이다.

[0010] 도 10은 본 발명에 따른 충전용 배터리팩의 무선 전력 수신 모듈을 가진 배터리 팩에 대한 분해사시도이다.

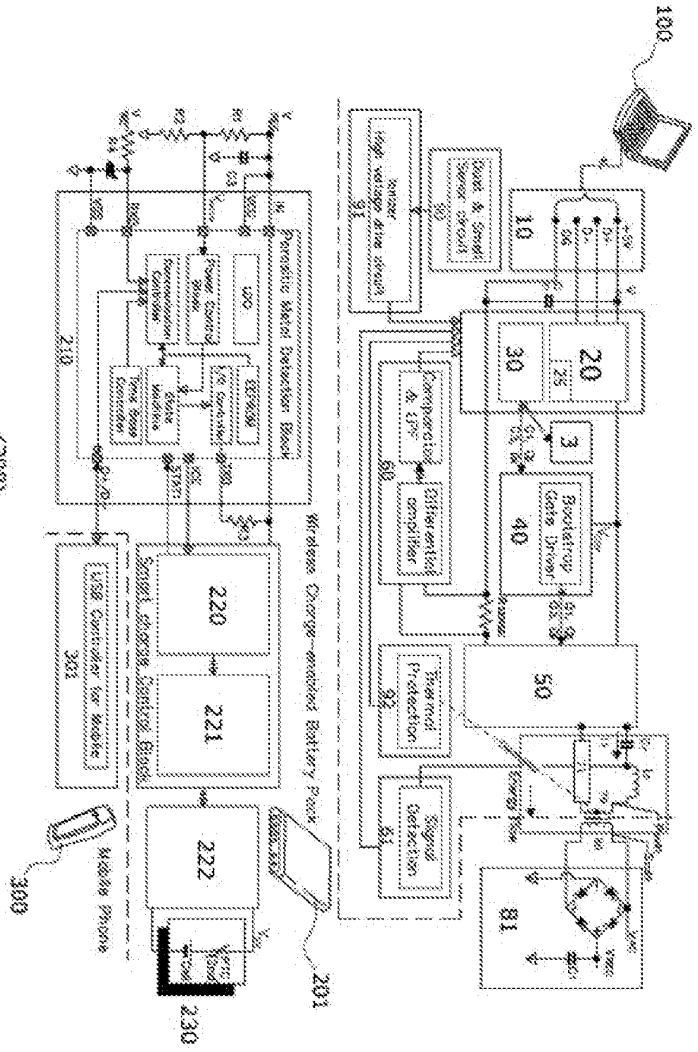
[0011] 도 11은 종래 기술에 따른 핸드폰용 충전장치에 대한 사용상태도이다.

[0012] <도면의 주요 부분에 대한 부호의 설명>

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

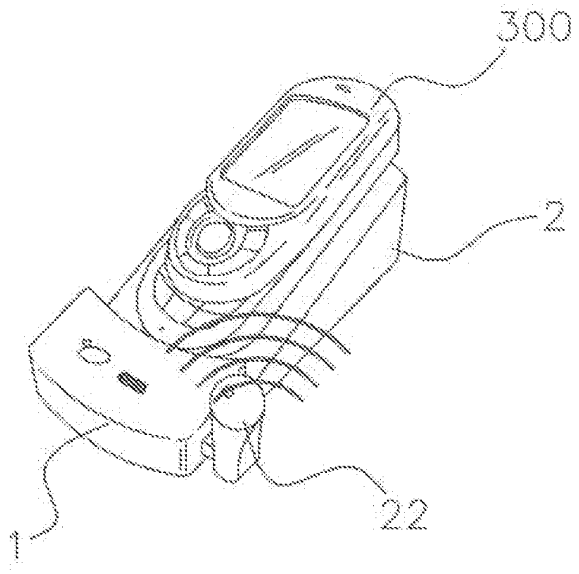
도면

도면1

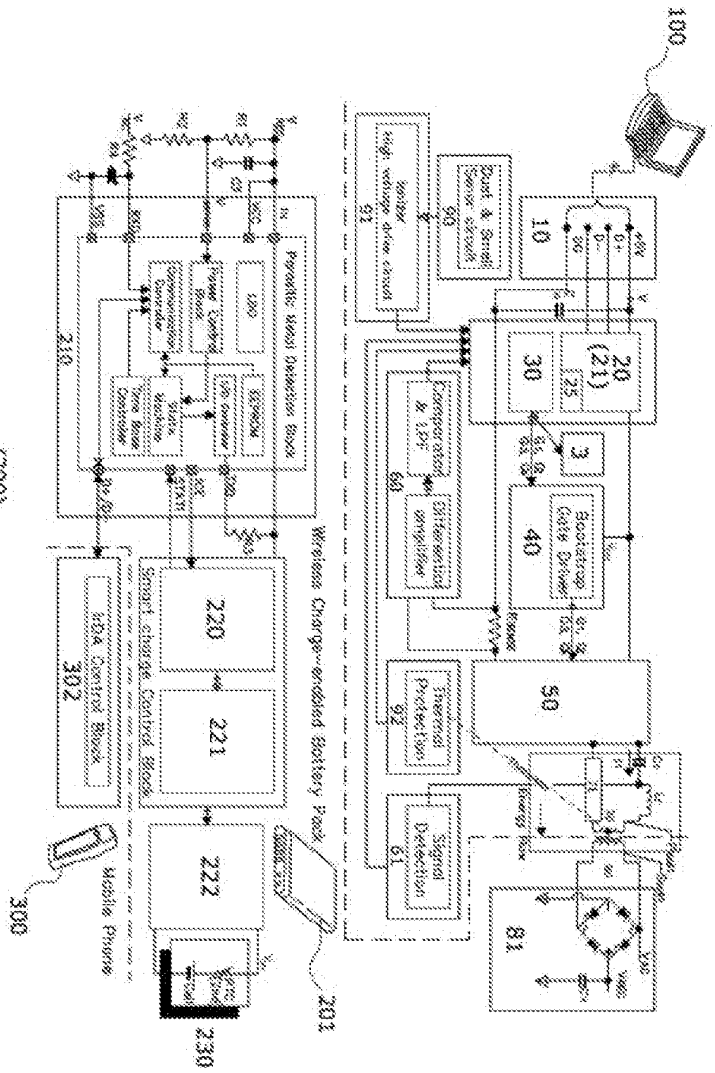

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81
91
92
3
Inverter High voltage drive circuit
Over & Short Detect circuit
Temperature & Life
Differential amplifier
Bootstrap Gate Driver
Thermal Protection
Signal Detection
Wireless Charge-enabled Battery Pack
(200)
Portable Metal Detection Block
Power Control
LED
Smart Charge Control Block
220
221
222
230
201
300
Mobile Phone
USB Controller for Mobile
302
210

도면2

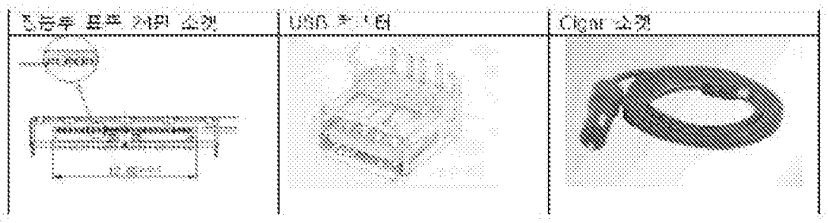
도면2



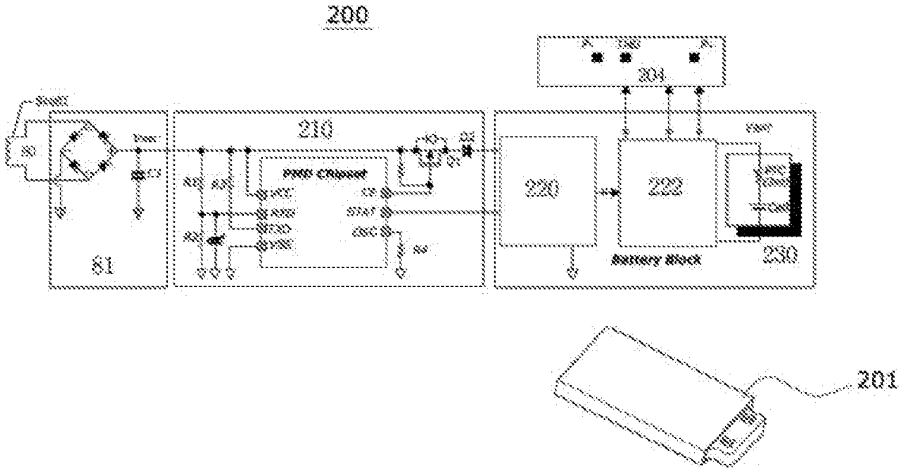
도면3


100
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(21)
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201
210
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221
222
230
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302
(200)
Wireless Charge-enabled Battery Pack
Smart charge Control Block
Portable Metal Detection Block
Mobile Phone
Temperature & Volt
Differential amplifier
Thermal Protection
Signal Detection
Switching Unit
Power Relay
Power Control
Charge Control
Data Memory
EEPROM
LED
Data Communication
Data Control
Data Interface
Protection Circuit
Switching Control
Switching Transformer
Rectifier
Smoothing
Feedback
Photo Coupler
Primary Side Controller
Secondary Side Rectifier
Secondary Side Smoothing
Secondary Side Feedback
Secondary Side Controller
Secondary Side Protection
Secondary Side Auxiliary Power
Secondary Side Output
Secondary Side Ground
Secondary Side Voltage
Secondary Side Current
Secondary Side Temperature
Secondary Side Pressure
Secondary Side Humidity
Secondary Side Light
Secondary Side Sound
Secondary Side Vibration
Secondary Side Motion
Secondary Side Proximity
Secondary Side Touch
Secondary Side Gesture
Secondary Side Voice
Secondary Side Image
Secondary Side Video
Secondary Side Audio
Secondary Side Data
Secondary Side Communication
Secondary Side Control
Secondary Side Power
Secondary Side Battery
Secondary Side Charger
Secondary Side Discharger
Secondary Side Balancer
Secondary Side Monitor
Secondary Side Protector
Secondary Side Switch
Secondary Side Relay
Secondary Side Fuse
Secondary Side Breaker
Secondary Side Contactor
Secondary Side Transformer
Secondary Side Inductor
Secondary Side Capacitor
Secondary Side Resistor
Secondary Side Diode
Secondary Side Transistor
Secondary Side IC
Secondary Side Module
Secondary Side Board
Secondary Side Wire
Secondary Side Connector
Secondary Side Terminal
Secondary Side Pin
Secondary Side Socket
Secondary Side Plug
Secondary Side Cable
Secondary Side Harness
Secondary Side Assembly
Secondary Side Unit
Secondary Side System
Secondary Side Network
Secondary Side Server
Secondary Side Client
Secondary Side Protocol
Secondary Side Interface
Secondary Side Software
Secondary Side Hardware
Secondary Side Firmware
Secondary Side Application
Secondary Side Program
Secondary Side Code
Secondary Side Data
Secondary Side Information
Secondary Side Knowledge
Secondary Side Intelligence
Secondary Side Wisdom
Secondary Side Experience
Secondary Side Skill
Secondary Side Ability
Secondary Side Talent
Secondary Side Gift
Secondary Side Blessing
Secondary Side Luck
Secondary Side Fortune
Secondary Side Destiny
Secondary Side Fate
Secondary Side Karma
Secondary Side Reincarnation
Secondary Side Heaven
Secondary Side Hell
Secondary Side God
Secondary Side Devil
Secondary Side Angel
Secondary Side Demon
Secondary Side Spirit
Secondary Side Soul
Secondary Side Body
Secondary Side Mind
Secondary Side Heart
Secondary Side Brain
Secondary Side Eye
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Secondary Side Nose
Secondary Side Mouth
Secondary Side Hand
Secondary Side Foot
Secondary Side Leg
Secondary Side Arm
Secondary Side Head
Secondary Side Face
Secondary Side Hair
Secondary Side Skin
Secondary Side Bone
Secondary Side Muscle
Secondary Side Blood
Secondary Side Vein
Secondary Side Artery
Secondary Side Nerve
Secondary Side Cell
Secondary Side Tissue
Secondary Side Organ
Secondary Side System
Secondary Side Body
Secondary Side Life
Secondary Side Death
Secondary Side Birth
Secondary Side Growth
Secondary Side Development
Secondary Side Evolution
Secondary Side Change
Secondary Side Transformation
Secondary Side Metamorphosis
Secondary Side Reproduction
Secondary Side Generation
Secondary Side Family
Secondary Side Relationship
Secondary Side Love
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Secondary Side Emotion
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Secondary Side Mood
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Secondary Side Behavior
Secondary Side Action
Secondary Side Reaction
Secondary Side Response
Secondary Side Stimulus
Secondary Side Input
Secondary Side Output
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Secondary Side Function
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Secondary Side Goal
Secondary Side Objective
Secondary Side Mission
Secondary Side Vision
Secondary Side Dream
Secondary Side Hope
Secondary Side Wish
Secondary Side Desire
Secondary Side Need
Secondary Side Want
Secondary Side Demand
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Secondary Side Competition
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Secondary Side Information
Secondary Side Data
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Secondary Side Art
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Secondary Side Past
Secondary Side Time
Secondary Side Space
Secondary Side Universe
Secondary Side Earth
Secondary Side Nature
Secondary Side Environment
Secondary Side Ecology
Secondary Side Pollution
Secondary Side Disaster
Secondary Side Safety
Secondary Side Security
Secondary Side Health
Secondary Side Medicine
Secondary Side Hospital
Secondary Side Doctor
Secondary Side Patient
Secondary Side Disease
Secondary Side Cure
Secondary Side Prevention
Secondary Side Life
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Secondary Side Reward
Secondary Side Education
Secondary Side Learning
Secondary Side Teaching
Secondary Side Knowledge
Secondary Side Information
Secondary Side Data
Secondary Side Technology
Secondary Side Science
Secondary Side Art
Secondary Side Culture
Secondary Side History
Secondary Side Future
Secondary Side Present
Secondary Side Past
Secondary Side Time
Secondary Side Space
Secondary Side Universe
Secondary Side Earth
Secondary Side Nature
Secondary Side Environment
Secondary Side Ecology
Secondary Side Pollution
Secondary Side Disaster
Secondary Side Safety
Secondary Side Security
Secondary Side Health
Secondary Side Medicine
Secondary Side Hospital
Secondary Side Doctor
Secondary Side Patient
Secondary Side Disease
Secondary Side Cure
Secondary Side Prevention

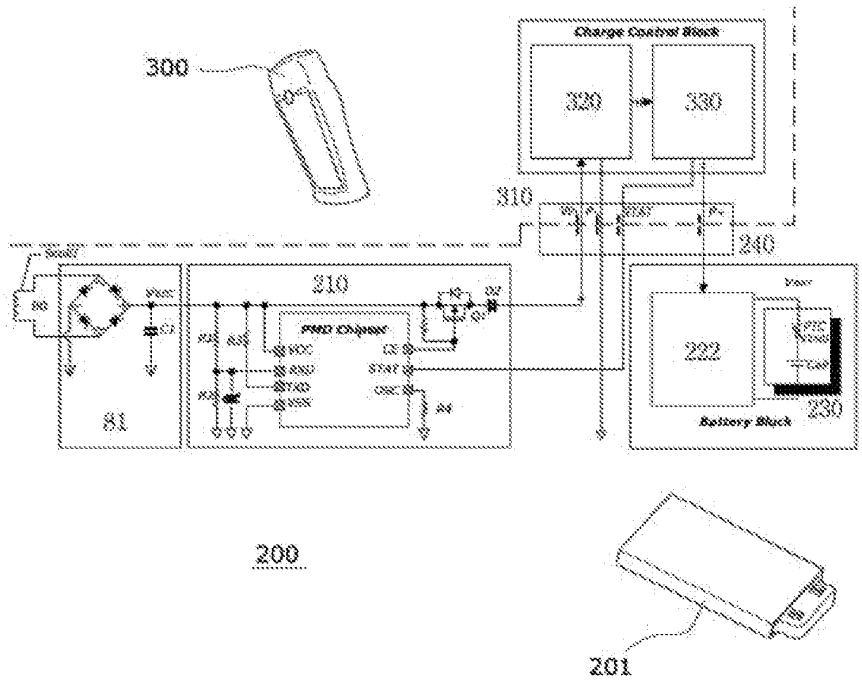
도면4


도등록 트로 가변 소켓
USB 케이블
Clear 소켓

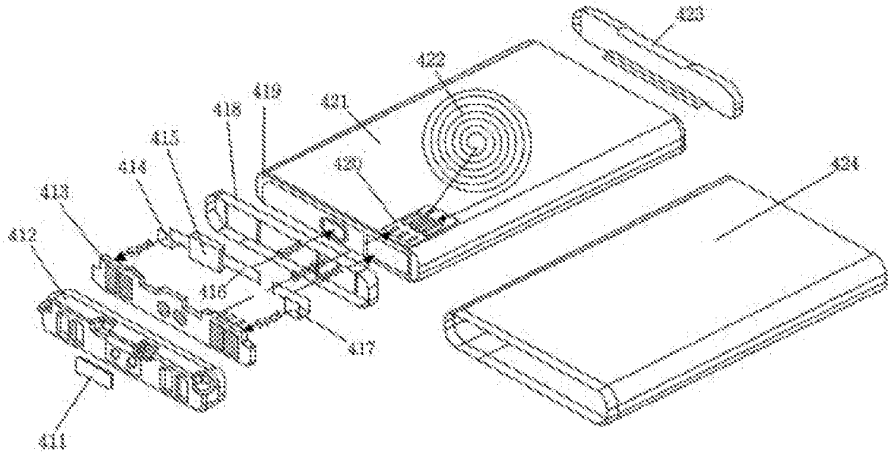
도면5


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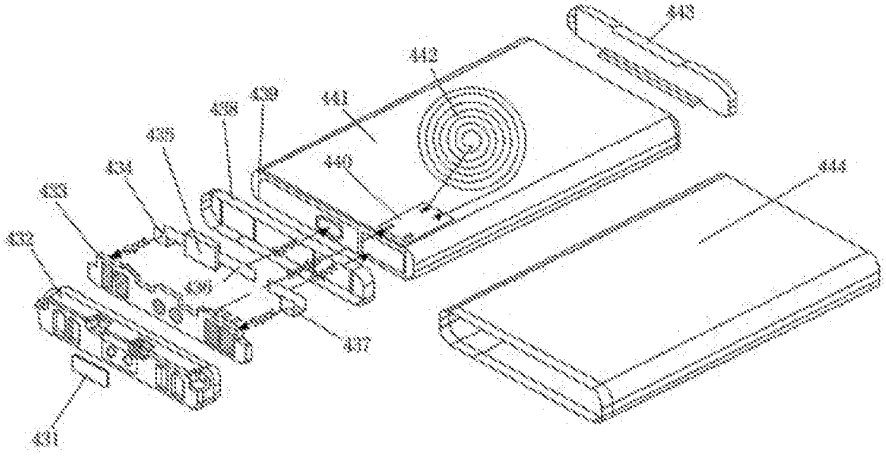
도면6


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Charge Control Block
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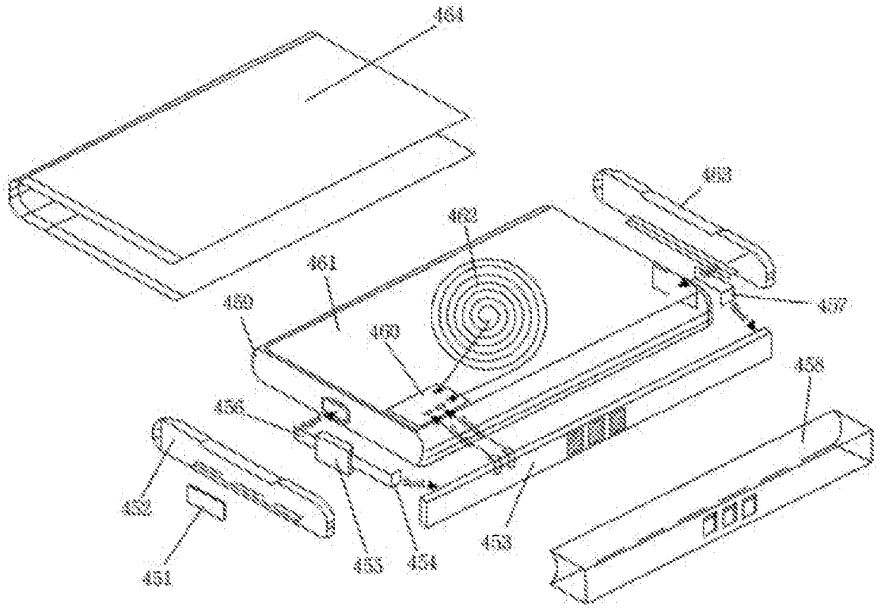
도면7


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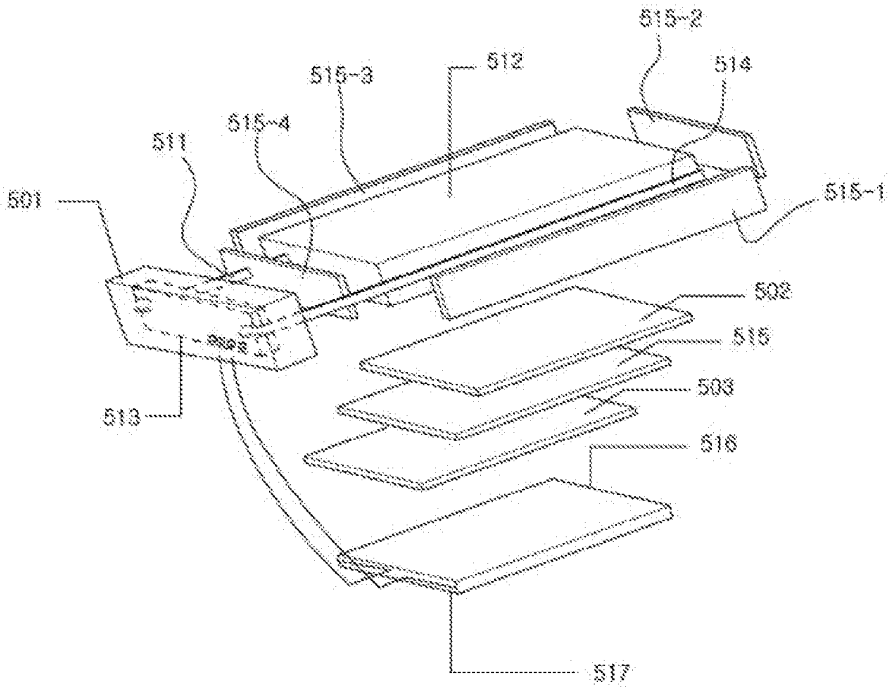
도면8


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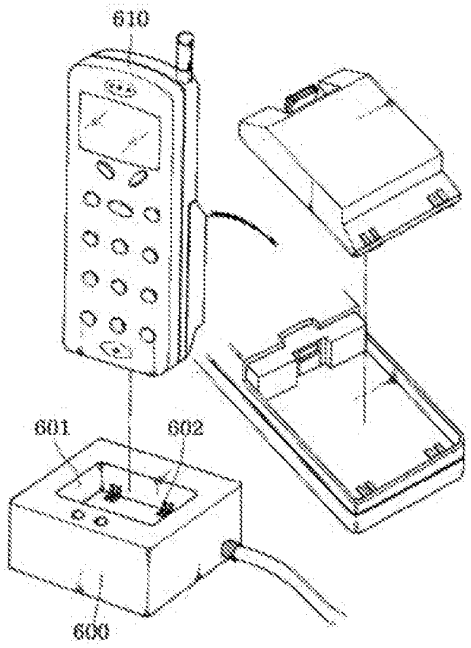
도면9


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도면10


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도면11



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審査請求　未請求　請求項の数７　ＯＬ　（全　７　頁）

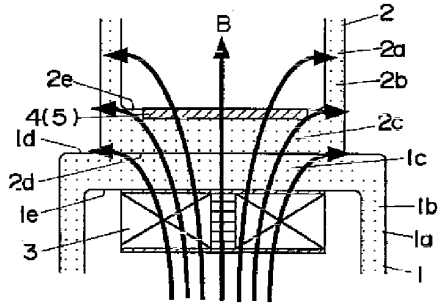
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(54)【発明の名称】　非接触電力伝達装置、及びその製造方法

(57)【要約】
【課題】　一次側コイルと二次側コイル間のギャップを極端に小さくすることができ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる非接触電力伝達装置を提供する。
【解決手段】　電力供給装置１側に一次側コイル３を、負荷機器２側に二次側コイル４を配設し、一次側コイル３から二次側コイル４への電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル３又は二次側コイル４を平面コイル５に形成し、該平面コイル５を電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設する。



１　電力供給装置
１ａ　相互接続部
１ｃ　接触壁
１ｄ　外面
１ｅ　内面
２　負荷機器
２ａ　相互接続部
２ｃ　接触壁
２ｄ　外面
２ｅ　内面
３　一次側コイル
４　二次側コイル
Ｂ　磁束

【特許請求の範囲】
【請求項１】　電力供給装置側に一次側コイルを、負荷機器側に二次側コイルを配設し、一次側コイルから二次側コイルへの電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル又は二次側コイルを平面コイルに形成し、該平面コイルを電力供給装置又は負荷機器の相互接続部の接触壁に配設することを特徴とする非接触電力伝達装置。
【請求項２】　平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面に配設することを特徴とする請求項１記載の非接触電力伝達装置。
【請求項３】　平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設し、且つ外面と内面の両面に配設した両コイルを電気的に接続することを特徴とする請求項１記載の非接触電力伝達装置。
【請求項４】　平面コイルを保護するための防護シールで平面コイルの露出部を覆うことを特徴とする請求項２又は３のいずれかに記載の非接触電力伝達装置。
【請求項５】　前記防護シールの中心部に磁気部を設けたことを特徴とする請求項４記載の非接触電力伝達装置。
【請求項６】　一次側コイルから発生する磁束と交差する場所に二次側コイルを複数配設したことを特徴とする請求項１乃至４のいずれかに記載の非接触電力伝達装置。
【請求項７】　上記平面コイルをホットスタンピングによって電力供給装置又は負荷機器の相互接続部の接触壁に配設することを特徴とする非接触電力伝達装置の製造方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、非接触電力伝達装置、及びその製造方法に関するものである。
【０００２】
【従来の技術】図９は従来の非接触電力伝達装置の電力伝達部を示すものである。この装置の電力伝達部の主要部は、電力供給装置１の相互接続部１ａ内に配設される一次側コイル３と、負荷機器２の相互接続部２ａ内に配設される二次側コイル４とで構成され、一次側コイル３から二次側コイル４への電磁誘導により非接触で電力伝達を行うものである（図中Ｂは磁束を表す）。尚、一次側コイル３は、電力供給装置１の相互接続部１ａのハウジング１ｂの接触壁１ｃの内面１ｅに、二次側コイル４は、負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの内面２ｅに、夫々密着して配設してある。
【０００３】ところで、一次側コイル３から二次側コイル４へ伝達される電力を増加させる方法としては、一次側コイル３又は二次側コイル４のインダクタを増やす、或いはコア挿入によって伝達効率を向上させる等が考えられる。まず一次側コイル３又は二次側コイル４のインダクタを増やす方法の場合、インダクタを増大させるために、コイルの巻数を増やすので、コイルが大きくなり、装置の小型化を妨げる。またコア挿入によって伝達効率を向上させる方法の場合も、先の方法と同じく、コア挿入によって装置の小型化を妨げることになる他、コストアップにもつながる。
【０００４】そこで、上記以外の方法として、一次側コイル３と二次側コイル４間のギャップをできるだけ小さくする方法が考えられる。即ち、これは、一次側コイル３が配設される電力供給装置１の相互接続部１ａのハウジング１ｂの接触壁１ｃの肉厚と、二次側コイル４が配設される負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの肉厚をできるだけ薄くして、一次側コイル３と二次側コイル４間の距離を可能な限り小さくする方法である。しかし、この方法では、ハウジング強度、ハウジング成型条件、及び絶縁距離等の制限により、ハウジング１ｂ、及びハウジング２ｂの接触壁１ｃ，２ｃの肉厚を薄くするにも限界がある。また、この方法の場合、図１０に示すように商品のデザインによっては、曲面部１４に一次側コイル３、及び二次側コイル４を配設しなければならないこともある。この場合、一次側コイル３と二次側コイル４間のギャップが大きくなってしまい、一次側コイル３から二次側コイル４へ伝達される電力を確保するのが困難になる。
【０００５】
【発明が解決しようとする課題】本発明は上記の点に鑑みて為されたものであり、一次側コイルと二次側コイル間のギャップを極端に小さくすることができ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる非接触電力伝達装置を提供することを目的としている。
【０００６】
【課題を解決するための手段】本発明の請求項１に係る非接触電力伝達装置は、電力供給装置１側に一次側コイル３を、負荷機器２側に二次側コイル４を配設し、一次側コイル３から二次側コイル４への電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル３又は二次側コイル４を平面コイル５に形成し、該平面コイル５を電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設することを特徴とするものである。
【０００７】また本発明の請求項２に係る非接触電力伝達装置は、請求項１の構成に加えて、平面コイル５に形成した一次側コイル３又は二次側コイル４のいずれかを電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）の外面１ｄ（２ｄ）に配設することを特徴とするものである。

【０００８】また本発明の請求項３に係る非接触電力伝達装置は、請求項１の構成に加えて、平面コイル５に形成した一次側コイル３又は二次側コイル４のいずれかを電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）の外面１ｄ（２ｄ）と内面１ｅ（２ｅ）の両面に配設し、且つ外面１ｄ（２ｄ）と内面１ｅ（２ｅ）の両面に配設した両コイル３，３（４，４）を電気的に接続することを特徴とするものである。

【０００９】また本発明の請求項４に係る非接触電力伝達装置は、請求項２又は３のいずれかの構成に加えて、平面コイル５を保護するための防護シール６で平面コイル５の露出部５ａを覆うことを特徴とするものである。

【００１０】また本発明の請求項５に係る非接触電力伝達装置は、請求項４の構成に加えて、前記防護シール６の中心部に磁気部７を設けたことを特徴とするものである。

【００１１】また本発明の請求項６に係る非接触電力伝達装置は、請求項１乃至４のいずれかの構成に加えて、一次側コイル３から発生する磁束Ｂと交差する場所に二次側コイル４を複数配設したことを特徴とするものである。

【００１２】また本発明の請求項７に係る非接触電力伝達装置の製造方法は、上記平面コイル５をホットスタンピングによって電力供給装置１又は負荷機器２の相互接続部１ａ（２ａ）の接触壁１ｃ（２ｃ）に配設することを特徴とするものである。

【００１３】

【発明の実施の形態】本発明の実施の形態を図１乃至図８に基づいて説明する。

【００１４】本発明の実施の形態の一例を図１乃至図３に示す。図１は本発明の非接触電力伝達装置の電力伝達部を示すものである。非接触電力伝達装置の電力伝達部は、電力供給装置１の相互接続部１ａと負荷機器２の相互接続部２ａから構成される。電力供給装置１の相互接続部１ａと、負荷機器２の相互接続部２ａは夫々、有底筒状のハウジング１ｂとハウジング２ｂで外殻が形成され、ハウジング１ｂの接触壁１ｃの内面１ｅには一次側コイル３が、ハウジング２ｂの接触壁２ｃの内面２ｅには二次側コイル４が、夫々ハウジング１ｂ、ハウジング２ｂの中心軸にコイルの巻き軸が一致するように配設される。尚、この例では、一次側コイル３には一般に使用される筒状コイルを用い、一方の二次側コイル４には図２に示すような銅箔を渦巻き状に形成した平面コイル５を用いる。またこの平面コイル５の形成、並びにハウジング２ｂの接触壁２ｃの内面２ｅへの配設はホットスタンピングによって行う。

【００１５】次に本発明の非接触電力伝達装置の動作説明をする。図３はこの非接触電力伝達装置の回路図を示すものであり、図３（ａ）が電力供給装置１の回路図、図３（ｂ）が負荷機器２の回路図である。まず電力供給装置１において、交流電源８から供給される交流電流を高周波発生回路９によって高周波電流に変換し、ハウジング１ｂの接触壁１ｃの内面１ｅに配設した一次側コイル３に高周波電流を流し、図１に示すような磁束Ｂを発生させる。次に負荷機器２において、ハウジング２ｂの接触壁２ｃの内面２ｅに配設した平面コイル５である二次側コイル４に前記磁束Ｂが交差することによって、電磁誘導により二次側コイル４に起電力が発生し、整流ダイオード１０により整流した後、電池１１に電流を供給し、充電を行う。こうして電力を供給された負荷機器２は負荷機器２に配設した電源スイッチ１３をオンにすることによって負荷１２を駆動させることができる。

【００１６】上記のように本発明の非接触電力伝達装置は、二次側コイル４を平面コイル５に形成し、平面コイル５を負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃの内面２ｅに配設することで、平面コイル５である二次側コイル４の全部分と相手側コイルである一次側コイル３間の距離が短くなり、一次側コイル３から発生する磁束Ｂのうち二次側コイル４に交差する磁束Ｂの数を多くすることができるので、大きな起電力が得られ、一次側コイル３から二次側コイル４へ伝達される電力を増大させることができる。また逆に負荷機器２側に一定の電力を得ようとする場合、従来のものと比べて、一次側コイル３又は二次側コイル４のインダクタが小さくて済むため、部品の小型化、及びコストダウンを図ることができる。また平面コイル５であるため、縦方向のスペースを取らないので、装置を小型化、及び薄型化できる。また上記平面コイル５をホットスタンピングによって負荷機器２の相互接続部２ａのハウジング２ｂの接触壁２ｃに配設することで、非接触電力伝達装置の電力伝達部を低コストで製造することが可能となる。またホットスタンピングにより、ハウジングの曲面部にも平面コイル５を配設できるため、商品のハウジング形状の自由度が増す。

【００１７】次に本発明の実施の形態の他の例を図４に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は前記例と同じであり、この例では二次側コイル４をハウジング２ｂの接触壁２ｃに外面２ｄと面一となるように埋設する。このような構成とすることで、一次側コイル３と二次側コイル４間のギャップが、ハウジング１ｂの接触壁１ｃの厚みのみとなり、短くなるため、一次側コイル３から二次側コイル４へ伝達される電力をより増大させることができる。

【００１８】次に本発明の実施の形態の他の例を図５に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は第１の例と同じであり、この例では二次側コイル４として２つの平面コイル５，５をハウジング２ｂの接触壁２ｃの外面２ｄと内面２ｅの両面に配設し、且つ外面２ｄと内面２ｅの両

面に配設した両コイル５，５を電気的接続部材１５を介して接続する。尚、外面２ｄと内面２ｅの両面に配設した両コイル５，５は夫々、接触壁２ｃの外面２ｄ、及び内面２ｅと面一になるように埋設する。このような構成とすることで、一次側コイル３と二次側コイル４間のギャップが、ハウジング１ｂの接触壁１ｃの厚みのみとなり、短くなるため、一次側コイル３から二次側コイル４へ伝達される電力を増大させることができ、加えてハウジング２ｂの接触壁２ｃの外面２ｄと内面２ｅの両面に配設した両コイル５，５を接続することにより、コイルの巻数が増え、インダクタが増大するため、一次側コイル３から二次側コイル４へ伝達される電力をさらに増大させることができる。

【００１９】次に本発明の実施の形態の他の例を図６に示す。この非接触電力伝達装置は、第２の例の構成において、ハウジング２ｂの接触壁２ｃの外面２ｄに面一に埋設した平面コイル５を保護するために、防護シール６で平面コイル５の露出部５ａを覆ったものである。このような構成とすることで、負荷機器２の落下、転倒、及び電力供給装置１との着脱による二次側コイル４のコイルの断線又は劣化を防止することができる。

【００２０】次に本発明の実施の形態の他の例を図７に示す。この非接触電力伝達装置は、前記例の構成において、防護シール６の中心部に磁気部７を設けたものである。尚、磁気部７の中心は一次側コイル３と、二次側コイル４の巻き軸と同一直線上に位置する。このような構成とすることで、磁束Ｂが防護シール６の中心部の磁気部７に集束され、二次側コイル４を交差する磁束Ｂの数が増加するため、一次側コイル３から二次側コイル４へ伝達される電力の伝達効率を上げることができる。

【００２１】次に本発明の実施の形態の他の例を図８に示す。この非接触電力伝達装置は、平面コイル５である二次側コイル４の配設を除く他の構成は第２の例と同じであり、この例では一次側コイル３から発生する磁束Ｂと交差する場所に二次側コイル４を複数配設する。このように１つの二次側コイル４の場合では交差しない磁束Ｂも二次側コイル４を前記磁束Ｂと交差するように複数設けることにより、二次側コイル４に交差する磁束Ｂの数を増やすことができるので、大きな起電力が得られ、一次側コイル３から二次側コイル４へ伝達される電力をより増大させることができる。

【００２２】

【発明の効果】本発明の請求項１記載の発明にあっては、電力供給装置側に一次側コイルを、負荷機器側に二次側コイルを配設し、一次側コイルから二次側コイルへの電磁誘導により電力伝達する非接触電力伝達装置において、一次側コイル又は二次側コイルを平面コイルに形成し、該平面コイルを電力供給装置又は負荷機器の相互接続部の接触壁に配設することで、一次側コイル又は二次側コイルが平面コイルとなっているため、該平面コイルの全部分と相手側コイル間の距離が短くなり、一次側コイルから発生する磁束のうち二次側コイルに交差する磁束の数を多くすることができるので、大きな起電力が得られ、一次側コイルから二次側コイルへ伝達される電力を増大させることができる。また逆に負荷機器側に一定の電力を得ようとする場合、従来のものと比べて、一次側コイル又は二次側コイルのインダクタが小さくて済むため、部品の小型化、及びコストダウンを図ることができる。また平面コイルであるため、縦方向のスペースを取らないので、装置を小型化、及び薄型化できる。

【００２３】また本発明の請求項２記載の発明にあっては、請求項１記載の発明の効果に加えて、平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面に配設することで、一次側コイルと二次側コイル間のギャップが、電力供給装置又は負荷機器のいずれかの相互接続部の接触壁の厚みのみとなり、短くなるため、一次側コイルから二次側コイルへ伝達される電力をより増大させることができる。

【００２４】また本発明の請求項３記載の発明にあっては、請求項１記載の発明の効果に加えて、平面コイルに形成した一次側コイル又は二次側コイルのいずれかを電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設し、且つ外面と内面の両面に配設した両コイルを電気的に接続することで、一次側コイルと二次側コイル間のギャップが、電力供給装置又は負荷機器のいずれかの相互接続部の接触壁の厚みのみとなり、短くなるため、一次側コイルから二次側コイルへ伝達される電力を増大させることができ、加えて電力供給装置又は負荷機器の相互接続部の接触壁の外面と内面の両面に配設した両コイルを接続することにより、コイルの巻数が増え、インダクタが増大するため、一次側コイルから二次側コイルへ伝達される電力をさらに増大させることができる。

【００２５】また本発明の請求項４記載の発明にあっては、請求項２又は３のいずれかに記載の発明の効果に加えて、平面コイルを保護するための防護シールで平面コイルの露出部を覆うことで、負荷機器の落下、転倒、及び電力供給装置との着脱による一次側コイル又は二次側コイルのいずれかのコイルの断線又は劣化を防止することができる。

【００２６】また本発明の請求項５記載の発明にあっては、請求項４記載の発明の効果に加えて、前記防護シールの中心部に磁気部を設けたことで、磁束が防護シールの中心部の磁気部に集束され、二次側コイルを交差する磁束の数が増加するため、一次側コイルから二次側コイルへ伝達される電力の伝達効率を上げることができる。

【００２７】また本発明の請求項６記載の発明にあっては、請求項１乃至４のいずれかに記載の発明の効果に加えて、一次側コイルから発生する磁束と交差する場所に

二次側コイルを複数配設したことで、１つの二次側コイルの場合では交差しない磁束も二次側コイルを前記磁束と交差するように複数設けることにより、二次側コイルに交差する磁束の数を増やすことができるので、大きな起電力が得られ、一次側コイルから二次側コイルへ伝達される電力をより増大させることができる。

【００２８】また本発明の請求項７記載の発明にあっては、上記平面コイルをホットスタンピングによって電力供給装置又は負荷機器の相互接続部の接触壁に配設することで、非接触電力伝達装置の電力伝達部を低コストで製造することが可能となる。またホットスタンピングにより、ハウジングの曲面部にも平面コイルを配設できるため、商品のハウジング形状の自由度が増す。

【図面の簡単な説明】

【図１】本発明の実施の形態の一例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図２】同上の（ａ）は負荷機器の相互接続部の接触壁近傍の上面図、（ｂ）はＡ－Ａ線断面図である。

【図３】同上の（ａ）は電力供給装置の回路図、（ｂ）は負荷機器の回路図である。

【図４】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図５】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図６】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図７】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図８】本発明の実施の形態の他の例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

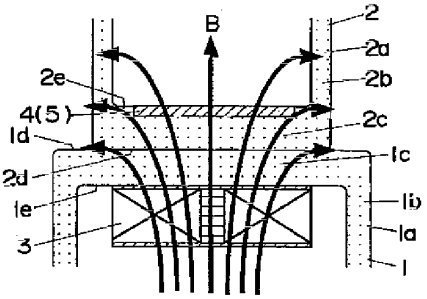
【図９】従来例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【図１０】従来例を示すものであり、非接触電力伝達装置の電力伝達部の断面図である。

【符号の説明】

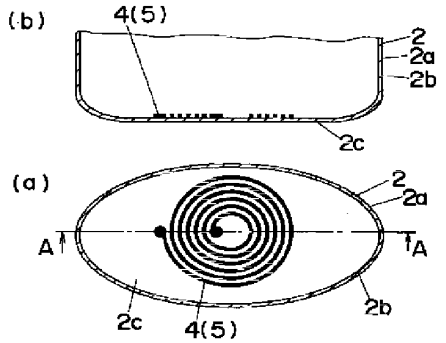
１　電力供給装置
１ａ　相互接続部
１ｃ　接触壁
１ｄ　外面
１ｅ　内面
２　負荷機器
２ａ　相互接続部
２ｃ　接触壁
２ｄ　外面
２ｅ　内面
３　一次側コイル
４　二次側コイル
５　平面コイル
５ａ　露出部
６　防護シール
７　磁気部
Ｂ　磁束

【図１】

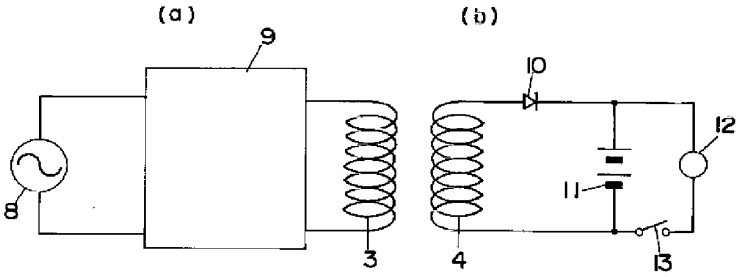


１　電力供給装置
１ａ　相互接続部
１ｃ　接触壁
１ｄ　外面
１ｅ　内面
２　負荷機器
２ａ　相互接続部
２ｃ　接触壁
２ｄ　外面
２ｅ　内面
３　一次側コイル
４　二次側コイル
Ｂ　磁束

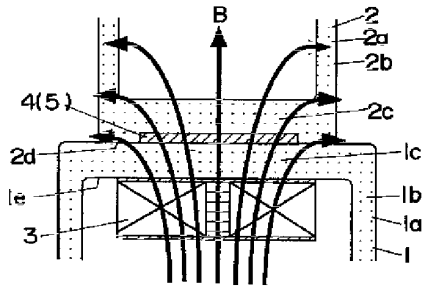
【図２】



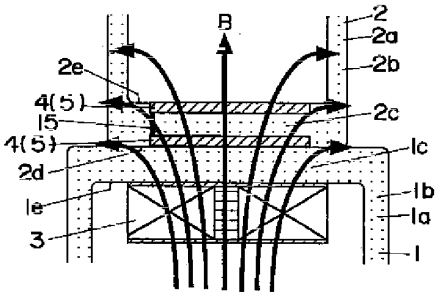
【図3】



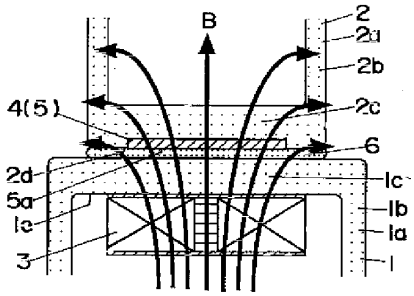
【図4】



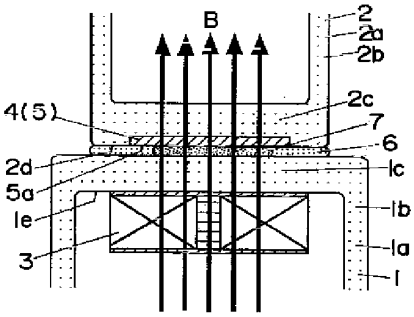
【図5】



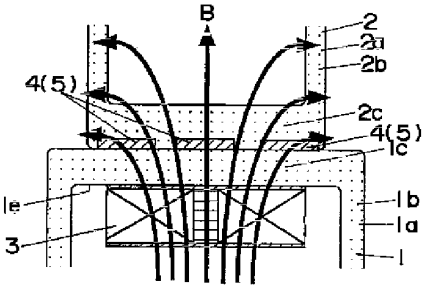
【図6】



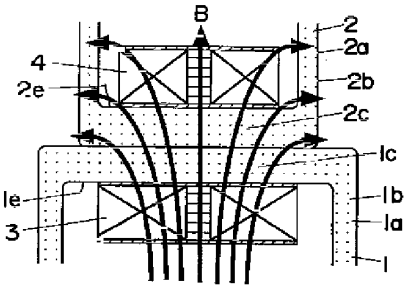
【図7】



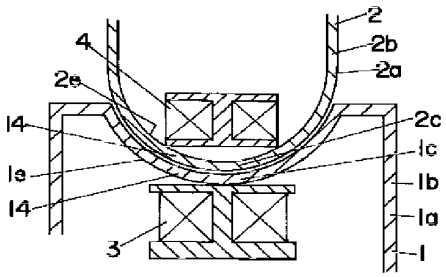
【図8】



【図9】



【図１０】



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特開2003－45731
（P2003－45731A）
(43)公開日　平成15年２月14日(2003.2.14)

(51)Int.Cl.[7]	識別記号	Ｆ Ｉ		ﾃｰﾏｺｰﾄﾞ(参考)
Ｈ０１Ｆ　38/14		Ｈ０２Ｊ　17/00		Ｂ
Ｈ０２Ｊ　17/00		Ｈ０１Ｆ　23/00		Ｂ

審査請求　未請求　請求項の数１　ＯＬ　（全　３　頁）

(21)出願番号　特願2001－230023(P2001－230023)

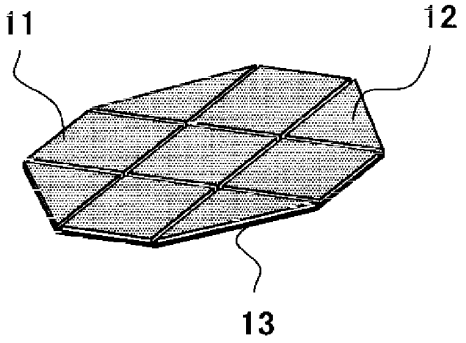
(22)出願日　平成13年７月30日(2001.7.30)

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(54)【発明の名称】　非接触電力伝送装置

(57)【要約】
【課題】　伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与した非接触電力伝送装置を提供すること。
【解決手段】　本発明の非接触電力伝送装置は、空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置であって、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着して構成される。



【特許請求の範囲】
【請求項１】　空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置において、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着したことを特徴とする非接触電力伝送装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、コイル間に生じる電磁誘導作用により、空間を介して電力を伝送する非接触電力伝送装置に関する。
【０００２】
【従来の技術】従来、空隙を介して対向させたコイル間に生じる電磁誘導作用を利用して非接触に電力を伝送する方式は、コードレス・パワー・ステーションと呼ばれ、１９９３年度刊行の日本応用磁気学会誌［１７，４８５－４８８］に開示されており、その利用例としては、非接触な電力伝送を行い得ることから、例えば、１９９１年度刊行の電気学会論文誌［Ａ，１１１－Ａ，８０７］に開示されているように、人工心臓の駆動装置への有効な電力供給手段として挙げられている。
【０００３】因みに、完全埋込型の人工心臓用トランスには、一対のコイルが使用され、そのトランスには、薄型化が要求されている。人工心臓の駆動装置のエネルギー伝送用の磁性材料としてアモルファス磁性材料を用いたトランスでは、その厚さが３ｍｍ程度になっているが、フェライトを用いたポットコアタイプのものでは、トランスの厚さが１５ｍｍ程度になっている。また、本発明者らはフェライト板を用いたトランスでトランスの薄型化を実現している。
【０００４】このようなコードレス・パワー・ステーションは、人工心臓の駆動装置への電力供給手段以外にも、携帯用家電製品等への電力供給やバッテリ充電にも応用可能である。
【０００５】
【発明が解決しようとする課題】しかしながら、上述したアモルファス磁性材料を用いて形成したトランスでは、薄型化を実現しているが、電力伝送時にはアモルファス磁性材では、高周波磁界による発熱が生じ、長時間使用の場合、人体での低温火傷を生ずるまでに昇温するという欠点を有している。
【０００６】また、人体等に使用する場合においては、コイル形状がある程度の曲率をもって形成される方が好都合となる場合も多い。従って、磁性体と配置したコイルがある程度の可撓性を有することは、実用上、有益となる。
【０００７】前述のアモルファス磁性材を装着したコイルにおいては、良好な可撓性が得られている。
【０００８】一方、フェライト板を装着したコイルにおいては、電力伝送時におけるフェライト部での発熱は殆ど生じず、生体への火傷などの問題は発生しない。一方、フェライト板は硬く、脆いので、フェライト板を装着したコイルの可撓性はない。
【０００９】本発明は、かかる問題点を解決すべくなされたもので、その技術的課題は、伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与することにある。
【００１０】
【課題を解決するための手段】本発明によれば、空隙を介して対向するコイルにおける電磁誘導作用を利用して、非接触に電力を伝送する装置において、前記対向するコイルの外側部に軟磁性フェライト板を複数個敷設してなるフェライトシートを装着した非接触電力伝送装置が得られる。
【００１１】
【作用】本発明においては、対向した平面渦巻型コイルの外側部に、軟磁性フェライトチップを敷くように設けたフェライトシートを配置することにより、非接触電力伝送が良好で、発熱が殆どなく、可撓性を有するトランス部が実現できる。
【００１２】非接触電力伝送が良好となるのは、フェライトシート部において、磁束の捕捉及び１次側と２次側の磁束結合が向上するからである。また、発熱が殆ど生じないのは、フェライトの電気抵抗が高いので、電磁誘導作用による渦電流発熱が極めて少ないためである。また、フェライト部の可撓性は、フェライトチップをプラスチックシート等に貼り付けて、フェライトシート状に形成することによって、ある程度の変形が可能となることで、付与している。
【００１３】
【実施例】以下、実施例について説明する。
【００１４】（実施例１）図１は、本発明の実施例１で用いるフェライトシートを示す斜視図である。
【００１５】まず、透磁率が約２５００で、飽和磁化が約０.５Ｔ（５０００Ｇ）のＭｎ-Ｚｎ系スピネルフェライト焼結体を使用して、厚さ１ｍｍからなる辺長１１ｍｍの正方形状角板１１と、これを対角方向に切断して、二等辺長各１０ｍｍとなる二等辺三角形板１２を作製した。
【００１６】平面渦巻コイルとして、直径１００μｍの銅線を１００本束ねたものを５ターン巻線し、外径３０ｍｍ、内径１５ｍｍ、厚さ１.５ｍｍに作製し、これらを対向させて、電源に接続される方を１次側（入力側）、電磁誘導で出力が発生する方を２次側（出力側）とした。
【００１７】次に、これら平面渦巻コイルを１ｍｍの空隙を持たせて対向させ、１対の平面渦巻コイルを構成し、周波数１００ｋＨｚ、１次側電圧、４Ｖの条件下で、２次側出力（最大伝送電力）P_2及び変換効率ηを求めた。但し、η＝（出力電力／入力電力）×１００

（％）である。

【００１８】測定における電磁誘導部の構成を、（１）対向するコイルのみの場合と、（２）上述したＭｎ－Ｚｎ系スピネルフェライト焼結体の正方形状角板１１を５枚とＭｎ－Ｚｎ系スピネルフェライト焼結体の二等辺三角形板１２の４枚を約０．５ｍｍの隙間を空けてポリエステルフィルム１３に貼り付け、正八角形状に作製したフェライトシートを対向するコイルの両外側部に装着した場合の２種類について測定している。その結果を表１に示す。

【００１９】

【表１】

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

【００２０】フェライトシートを装着することにより、２次側出力P_2及び変換効率ηが著しく向上することが判る。

【００２１】また、フェライトシートを装着したコイル部は可撓性を保有し、曲率半径５０ｍｍ程度までは容易に到達できた。

【００２２】（実施例２）図２は、本発明の実施例２で用いるフェライトシートを示す斜視図である。

【００２３】まず、透磁率が約８００で、飽和磁化が約０．３５Ｔ（３５００Ｇ）のＮｉ-Ｃｕ-Ｚｎ系スピネルフェライト焼結体を使用して、厚さ０．５ｍｍから成る辺長５ｍｍの正方形状角板２１と、これを対角方向に切断して二等辺長各４ｍｍとなる二等辺三角形板２２を作製した。

【００２４】これら四角形板２４枚と三角形板８枚を約０．５ｍｍの隙間を空けて、シリコンゴムシート２３に貼り付け、正八角形状にフェライトシートを作製した。

【００２５】これを使用した効果について、実施例１と同様にして測定した。その結果を表２に示す。

【００２６】

【表２】

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

【００２７】フェライトシートを装着することにより、２次側出力P_2及び変換効率ηが著しく向上することが判る。

【００２８】また、フェライトシートを装着したコイル部は可撓性を保有し、曲率半径３０ｍｍ程度までは容易に到達できた。

【００２９】

【発明の効果】本発明は、以上説明したように構成されているので、本発明によれば、伝送電力の増大と変換効率の向上を十分に図り得た状態で、フェライト板を装着したコイルに可撓性を付与した非接触電力伝送装置を提供することができる。

【図面の簡単な説明】

【図１】本発明の実施例１で用いるフェライトシートを示す斜視図。

【図２】本発明の実施例２で用いるフェライトシートを示す斜視図。

【符号の説明】

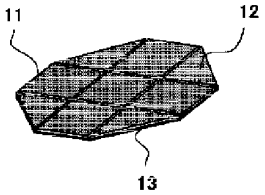
１１，２１　　軟磁性フェライト焼結体の正方形状角板

１２，２２　　軟磁性フェライト焼結体の二等辺三角形板

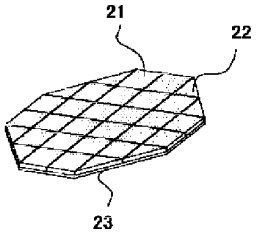
１３　　ポリエステルフィルム

２３　　シリコンゴムシート

【図１】



【図２】



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Application Number	13115811
Filing Date	2011-05-25
First Named Inventor	Partovi, Afshin
Art Unit	2859
Examiner Name	Berhanu, Samuel
Attorney Docket Number	AFPA-01007US1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13115811
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	First Named Inventor	Partovi, Afshin
	Art Unit	2859
	Examiner Name	Berhanu, Samuel
	Attorney Docket Number	AFPA-01007US1

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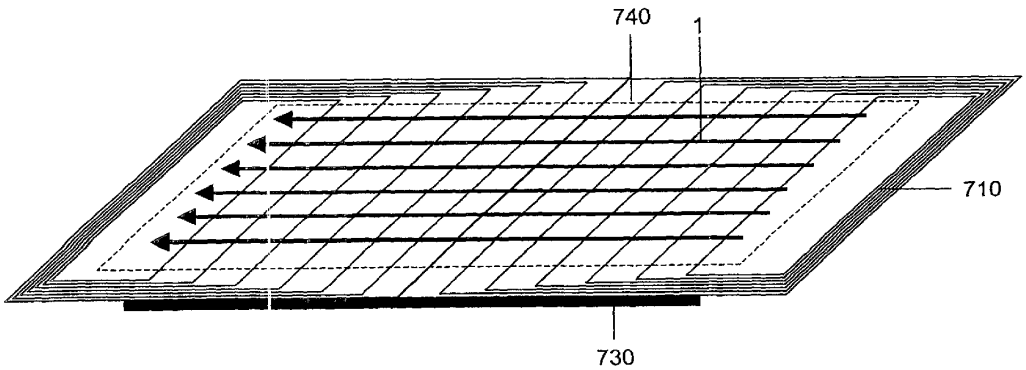
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(54) Title: IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER



(57) Abstract: There is disclosed a system and method for transferring power without requiring direct electrical conductive contacts. There is provided a primary unit having a power supply and a substantially laminar charging surface having at least one conductor that generates an electromagnetic field when a current flows therethrough and having an charging area defined within a perimeter of the surface, the at least one conductor being arranged such that electromagnetic field lines generated by the at least one conductor are substantially parallel to the plane of the surface or at least subtend an angle of 45° or less to the surface within the charging area; and at least one secondary device including at least one conductor that may be wound about a core. Because the electromagnetic field is spread over the charging area and is generally parallel or near-parallel thereto, coupling with flat secondary devices such as mobile telephones and the like is significantly improved in various orientations thereof.

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IMPROVEMENTS RELATING TO CONTACT-LESS POWER TRANSFER

The present application claims priority from UK patent applications nos 0210886.8 of 13th May 2002, 0213024.3 of 7th June 2002, 0225006.6 of 28th October 2002 and 0228425.5 of 6th December 2002, as well as from US patent application no 10/326,571 of 20th December 2002. The full contents of all of these prior patent applications is hereby incorporated into the present application by reference.

This invention relates to a new apparatus and method for transferring power in a contact-less fashion.

Many of today's portable devices incorporate "secondary" power cells which can be recharged, saving the user the cost and inconvenience of regularly having to purchase new cells. Example devices include cellular telephones, laptop computers, the Palm 500 series of Personal Digital Assistants, electric shavers and electric toothbrushes. In some of these devices, the cells are recharged via inductive coupling rather than direct electrical connection. Examples include the Braun Oral B Plak Control power toothbrush, the Panasonic Digital Cordless Phone Solution KX-PH15AL and the Panasonic multi-head men's shavers ES70/40 series.

Each of these devices typically has an adaptor or charger which takes power from mains electricity, a car cigarette lighter or other sources of power and converts it into a form suitable for charging the secondary cells. There are a number of problems associated with conventional means of powering or charging these devices:

- Both the characteristics of the cells within each device and the means of connecting to them vary considerably from manufacturer to manufacturer, and from device to device. Therefore users who own several such devices must also own several different adaptors. If users are going away on travel, they will have to bring their collection of chargers if they expect to use their devices during this time.

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- These adaptors and chargers often require users to plug a small connector into the device or to place the device with accurate alignment into a stand causing inconvenience. If users fail to plug or place their device into a charger and it runs out of power, the device becomes useless and important data stored locally in the device might even be lost.

- In addition, most adaptors and chargers have to be plugged into mains sockets and hence if several are used together, they take up space in plug strips and create a messy and confusing tangle of wires.

- Besides the above problems with conventional methods of recharging devices, there are also practical problems associated with devices having an open electrical contact. For example, devices cannot be used in wet environments due to the possibility of corroding or shorting out the contacts and also they cannot be used in flammable gaseous environments due to the possibility of creating electrical sparks.

Chargers which use inductive charging remove the need to have open electrical contacts hence allowing the adaptor and device to be sealed and used in wet environments (for example the electric toothbrush as mentioned above is designed to be used in a bathroom). However such chargers still suffer from all other problems as described above. For example, the devices still need to be placed accurately into a charger such that the device and the charger are in a predefined relative position (See Figures 1a and 1b). The adaptors are still only designed specifically for a certain make and model of device and are still only capable of charging one device at a time. As a result, users still need to possess and manage a collection of different adaptors.

Universal chargers (such as the Maha MH-C777 Plus Universal charger) also exist such that battery packs of different shapes and characteristics can be removed from the device and charged using a single device. Whilst these universal chargers eliminate the need for having different chargers for different devices, they create even more inconvenience for the user in the sense that the battery packs first need to

be removed, then the charger needs to be adjusted and the battery pack needs to be accurately positioned in or relative to the charger. In addition, time must be spent to determine the correct pair of battery pack metal contacts which the charger must use.

It is known from US 3,938,018 "Induction charging system" to provide a means for non-contact battery charging whereby an inductive coil on the primary side aligns with a horizontal inductive coil on a secondary device when the device is placed into a cavity on the primary side. The cavity ensures the relatively precise alignment which is necessary with this design to ensure that good coupling is achieved between the primary and secondary coils.

It is also known from US 5,959,433 "Universal Inductive Battery Charger System" to provide a non-contact battery charging system. The battery charger described includes a single charging coil which creates magnetic flux lines which will induce an electrical current in a battery pack which may belong to cellular phones or laptop computers.

It is also known from US 4,873,677 "Charging Apparatus for an Electronic Device" to provide an apparatus for charging an electronic device which includes a pair of coils. This pair of coils is designed to operate in anti-phase such that magnetic flux lines are coupled from one coil to the other. An electronic device such as a watch can be placed on these two coils to receive power.

It is also known from US 5,952,814 "Induction charging apparatus and an electronic device" to provide an induction charger for charging a rechargeable battery. The shape of the external casing of the electronic device matches the internal shape of the charger thus allowing for accurate alignment of the primary and secondary coils.

It is also known from US 6,208,115 "Battery substitute pack" to provide a substitute battery pack which may be inductively recharged.

It is known from WO 00/61400 "Device for Inductively Transmitting Electrical Power" to provide a means of transferring power inductively to conveyors.

It is known from WO 95/11545 "Inductive power pick-up coils" to provide a system for inductive powering of electric vehicles from a series of in-road flat primaries.

To overcome the limitations of inductive power transfer systems which require that secondary devices be axially aligned with the primary unit, one might propose that an obvious solution is to use a simple inductive power transfer system whereby the primary unit is capable of emitting an electromagnetic field over a large area (See Figure 2a). Users can simply place one or more devices to be recharged within range of the primary unit, with no requirement to place them accurately. For example this primary unit may consist of a coil encircling a large area. When a current flows through the coil, an electromagnetic field extending over a large area is created and devices can be placed anywhere within this area. Although theoretically feasible, this method suffers from a number of drawbacks. Firstly, the intensity of electromagnetic emissions is governed by regulatory limits. This means that this method can only support power transfer at a limited rate. In addition, there are many objects that can be affected by the presence of an intense magnetic field. For example, data stored on credit cards maybe destroyed and objects made of metal will have induced therein eddy currents generating undesired heating effects. In addition, if a secondary device comprising a conventional coil (see Figure 2a) is placed against a metallic plate such as a copper plane in a printed circuit board or metallic can of a cell, coupling is likely to be significantly reduced.

To avoid the generation of large magnetic fields, one might suggest using an array of coils (See Figure 3) whereby only the coils needed are activated. This method is described in a paper published in the Journal of the Magnetics Society of Japan titled "Coil Shape in a Desk-type Contactless Power Station System" (29th Nov 2001). In an embodiment of the multiple-coil concept, a sensing mechanism senses the relative location of the secondary device relative to the primary unit. A control system then activates the appropriate coils to deliver power to the secondary device in a localised

fashion. Although this method provides a solution to the problems previously listed, it does so in a complicated and costly way. The degree to which the primary field can be localised is limited by the number of coils and hence the number of driving circuits used (i.e. the "resolution" of the primary unit). The cost associated with a multiple-coil system would severely limit the commercial applications of this concept. Non-uniform field distribution is also a drawback. When all the coils are activated in the primary unit, they sum to an equivalent of a large coil, the magnetic field distribution of which is seen to exhibit a minimum at the centre of the coil.

Another scheme is outlined in US 5,519,262 "Near Field Power Coupling System", whereby a primary unit has a number of narrow inductive coils (or alternatively capacitive plates) arranged from one end to the other of a flat plate, creating a number of vertical fields which are driven in a phase-shifted manner so that a sinusoidal wave of activity moves across the plate. A receiving device has two vertical field pickups arranged so that regardless of its position on the plate it can always collect power from at least one pickup. While this scheme also offers freedom of movement of the device, it has the disadvantages of needing a complex secondary device, having a fixed resolution, and having poor coupling because the return flux path is through air.

None of the prior art solutions can satisfactorily address all of the problems that have been described. It would be convenient to have a solution which is capable of transferring power to portable devices with all of the following features and is cost effective to implement:

- Universality: a single primary unit which can supply power to different secondary devices with different power requirements thereby eliminating the need for a collection of different adaptors and chargers;
- Convenience: a single primary unit which allows secondary devices to be placed anywhere within an active vicinity thereby eliminating the need for plugging-in or placing secondary devices accurately relative to an adaptor or charger;

- Multiple-load: a single primary unit that can supply power to a number of secondary different devices with different power requirements at the same time;
- Flexibility for use in different environments: a single primary unit that can supply power to secondary devices such that no direct electrical contact is required thereby allowing for secondary devices and the primary unit itself to be used in wet, gaseous, clean and other atypical environments;
- Low electromagnetic emissions: a primary unit that can deliver power in a manner that will minimize the intensity and size of the magnetic field generated.

It is further to be appreciated that portable appliances are proliferating and they all need batteries to power them. Primary cells, or batteries of them, must be disposed of once used, which is expensive and environmentally unfriendly. Secondary cells or batteries can be recharged and used again and again.

Many portable devices have receptacles for cells of an industry-standard size and voltage, such as AA, AAA, C, D and PP3. This leaves the user free to choose whether to use primary or secondary cells, and of various types. Once depleted, secondary cells must typically be removed from the device and placed into a separate recharging unit. Alternatively, some portable devices do have recharging circuitry built-in, allowing cells to be recharged in-situ once the device is plugged-in to an external source of power.

It is inconvenient for the user to have to either remove cells from the device for recharging, or to have to plug the device into an external power source for recharging in-situ. It would be far preferable to be able to recharge the cells without doing either, by some non-contact means.

Some portable devices are capable of receiving power coupled inductively from a recharger, for example the Braun Oral B Plak Control toothbrush. Such portable devices typically have a custom, dedicated power-receiving module built-in to the

device, which then interfaces with an internal standard cell or battery (which may or may not be removable).

However it would be convenient if the user could transform any portable device which accepts industry-standard cell sizes into an inductively-rechargeable device, simply by fitting inductively-rechargeable cells or batteries, which could then be recharged in-situ by placing the device onto an inductive recharger.

Examples of prior art include US 6,208,115, which discloses a substitute battery pack which may be inductively recharged.

According to a first aspect of the present invention, there is provided a system for transferring power without requiring direct electrical conductive contacts, the system comprising:

i) a primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area; and

ii) at least one secondary device including at least one electrical conductor;

wherein, when the at least one secondary device is placed on or in proximity to a charging area of the primary unit, the electromagnetic field lines couple with the at least one conductor of the at least one secondary device and induce a current to flow therein.

According to a second aspect of the present invention, there is provided a primary unit for transferring power without requiring direct electrical conductive contacts, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area.

According to a third aspect of the present invention, there is provided a method of transferring power in a non-conductive manner from a primary unit to a secondary device, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, the means having a height measured substantially perpendicular to the charging area that is less than either of the width or the length of

the charging area, and the secondary device having at least one electrical conductor; wherein:

i) an electromagnetic field, generated by the means when energised with a predetermined current and measured when the primary unit is effectively in electromagnetic isolation, has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions over the at least one charging area when averaged thereover; and

ii) the electromagnetic field links with the conductor of the secondary device when this is placed on or in proximity to the charging area.

According to a fourth aspect of the present invention, there is provided a secondary device for use with the system, unit or method of the first, second or third aspects, the secondary device including at least one electrical conductor and having a substantially laminar form factor.

In the context of the present application, the word "laminar" defines a geometry in the form of a thin sheet or lamina. The thin sheet or lamina may be substantially flat, or may be curved.

The primary unit may include an integral power supply for the at least one means for generating an electromagnetic field, or may be provided with connectors or the like enabling the at least one means to be connected to an external power supply.

In some embodiments, the means for generating the electromagnetic field have a height that is no more than half the width or half the length of the charging area; in some embodiments, the height may be no more than 1/5 of the width or 1/5 of the length of the charging area.

The at least one electrical conductor in the secondary device may be wound about a core that serves to concentrate flux therein. In particular, the core (where provided) may offer a path of least resistance to flux lines of the electromagnetic field generated by the primary unit. The core may be amorphous magnetically permeable material. In some embodiments, there is no need for an amorphous core.

Where an amorphous core is provided, it is preferred that the amorphous magnetic material is a non-annealed or substantially as-cast state. The material may be at least 70% non-annealed, or preferably at least 90% non-annealed. This is because annealing tends to make amorphous magnetic materials brittle, which is disadvantageous when contained in a device, such as a mobile phone, which may be subjected to rough treatment, for example by being accidentally dropped. In a particularly preferred embodiment, the amorphous magnetic material is provided in the form of a flexible ribbon, which may comprise one or more layers of one or more of the same or different amorphous magnetic materials. Suitable materials include alloys which may contain iron, boron and silicon or other suitable materials. The alloy is melted and then cooled so rapidly ("quenched") that there is no time for it to crystallise as it solidifies, thus leaving the alloy in a glass-like amorphous state. Suitable materials include Metglas® 2714A and like materials. Permalloy or mumetal or the like may also be used.

The core in the secondary device, where provided, is preferably a high magnetic permeability core. The relative permeability of this core is preferably at least 100, even more preferably at least 500, and most preferably at least 1000, with magnitudes of at least 10,000 or 100,000 being particularly advantageous.

The at least one means for generating an electromagnetic field may be a coil, for example in the form of a length of wire or a printed strip, or may be in the form of a conductive plate of appropriate configuration, or may comprise any appropriate arrangement of conductors. A preferred material is copper, although other conductive materials, generally metals, may be used as appropriate. It is to be understood that the term "coil" is here intended to encompass any appropriate

electrical conductor forming an electrical circuit through which current may flow and thus generate an electromagnetic field. In particular, the "coil" need not be wound about a core or former or the like, but may be a simple or complex loop or equivalent structure.

Preferably, the charging area of the primary unit is large enough to accommodate the conductor and/or core of the secondary device in a plurality of orientations thereof. In a particularly preferred embodiment, the charging area is large enough to accommodate the conductor and/or core of the secondary device in any orientation thereof. In this way, power transfer from the primary unit to the secondary device may be achieved without having to align the conductor and/or core of the secondary device in any particular direction when placing the secondary device on the charging surface of the primary unit.

The substantially laminar charging surface of the primary unit may be substantially planar, or may be curved or otherwise configured to fit into a predetermined space, such as a glove compartment of a car dashboard or the like. It is particularly preferred that the means for generating an electromagnetic field does not project or protrude above or beyond the charging surface.

A key feature of the means for generating an electromagnetic field in the primary unit is that electromagnetic field lines generated by the means, measured when the primary unit is effectively in magnetic isolation (i.e. when no secondary device is present on or in proximity to the charging surface), are distributed in two dimensions over the at least one charging area and subtend an angle of 45° or less to the charging area in proximity thereto (for example, less than the height or width of the charging area) and over any quarter length part of the charging area measured in a direction generally parallel to that of the field lines. The measurement of the field lines in this connection is to be understood as a measurement of the field lines when averaged over the quarter length of the charging area, rather than an instantaneous point measurement. In some embodiments, the field lines subtend an angle of 30° or less, and in some embodiments are substantially parallel to at least a central part of the

charging area in question. This is in stark contrast to prior art systems, where the field lines tend to be substantially perpendicular to a surface of a primary unit. By generating electromagnetic fields that are more or less parallel to or at least have a significant resolved component parallel to the charging area, it is possible to control the field so as to cause angular variations thereof, in or parallel to the plane of the charging area, that help to avoid any stationary nulls in the electromagnetic field that would otherwise reduce charging efficiency in particular orientations of the secondary device on the charging surface. The direction of the field lines may be rotated through a complete or partial circle, in one or both directions. Alternatively, the direction may be caused to "wobble" or fluctuate, or may be switched between two or more directions. In more complex configurations, the direction of the field lines may vary as a Lissajous pattern or the like.

In some embodiments, the field lines may be substantially parallel to each other over any given charging area, or at least have resolved components in or parallel to the plane of the charging area that are substantially parallel to each other at any given moment in time.

It is to be appreciated that one means for generating an electromagnetic field may serve to provide a field for more than one charging area; also that more than one means may serve to provide a field for just one charging area. In other words, there need not be a one-to-one correspondence of means for generating electromagnetic fields and charging areas.

The secondary device may adopt a substantially flat form factor with a core thickness of 2mm or less. Using a material such as one or more amorphous metal sheets, it is possible to have core thickness down to 1mm or less for applications where size and weight is important. See Figure 7a.

In a preferred embodiment, the primary unit may include a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending

generally parallel to or subtending an angle of 45° or less to the plane of the windings but substantially at right angles to the parallel sections.

The windings in this embodiment may be formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

Advantageously, the primary unit may include first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

According to a fifth aspect of the present invention, there is provided a system for transferring power in a contact-less manner consisting of:

- a primary unit consisting of at least one electrical coil whereby each coil features at least one active area whereby two or more conductors are substantially distributed over this area in such a fashion that it is possible for a secondary device to be placed in proximity to a part of this active area where the net instantaneous current flow in a particular direction is substantially non-zero;
- at least one secondary device consisting of conductors wound around a high permeability core in such a fashion that it is possible for it to be placed in proximity to an area of the surface of the primary unit where the net instantaneous current flow is substantially non-zero;

whereby the at least one secondary device is capable of receiving power by means of electromagnetic induction when the central axis of the winding is in proximity to the active area of the primary unit, is substantially not perpendicular to the plane of the active area of primary unit and is substantially not parallel to the conductors in the active area of at least one of the coils of the primary unit.

Where the secondary device comprises an inductively rechargeable battery or cell, the battery or cell may have a primary axis and be capable of being recharged by an alternating field flowing in the primary axis of the battery or cell, the battery or cell consisting of:

- an enclosure and external electrical connections similar in dimensions to industry-standard batteries or cells
- an energy-storage means
- an optional flux-concentrating means
- a power-receiving means
- a means of converting the received power to a form suitable for delivery to outside the cell through the external electrical connections, or to recharge the energy storage means, or both.

The proposed invention is a significant departure from the design of conventional inductive power transfer systems. The difference between conventional systems and the proposed system is best illustrated by looking at their respective magnetic flux line patterns. (See Figure 2a and 4)

- Conventional System: In a conventional system (See Figure 2a), there is typically a planar primary coil which generates a magnetic field with flux lines coming out of the plane in a perpendicular fashion. The secondary device has typically a round or square coil that encircles some or all of these flux lines.

- Proposed system: In the proposed system, the magnetic field travels substantially horizontally across the surface of the plane (see Figure 4) instead of directly out of the plane as illustrated in Figure 2a. The secondary device hence may have an elongated winding wound around a magnetic core. See Figure 7a and 7b. When the secondary device is placed on the primary unit, the flux lines would be attracted to travel through the magnetic core of the secondary device because it is the lowest reluctance path. This causes the secondary device and the primary unit to be coupled effectively. The

secondary core and winding may be substantially flattened to form a very thin component.

In describing the invention, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

It is to be understood that the term "charging area" used in this patent application may refer to the area of the at least one means for generating a field (e.g. one or more conductors in the form of a coil) or an area formed by a combination of primary conductors where the secondary device can couple flux effectively. Some embodiments of this are shown in Figures 6a to 6l and 9c as component **740**. A feature of a "charging area" is a distribution of conductors over a significant area of the primary unit configured such that it is possible for the at least one means for generating a field to be driven to achieve an instantaneous net flow of flux in one direction. A primary unit may have more than one charging area. One charging area is distinct from another charging area when flux cannot be effectively coupled by the secondary device (such as those shown in Figure 7a) in any rotation at the boundary.

It is to be understood that the term "coil" used in this patent refers to all conductor configurations which feature a charging area as described above. This includes windings of wire or printed tracks or a plane as shown in Figure 8e. The conductors may be made of copper, gold, alloys or any other appropriate material.

The present application refers to the rotation of a secondary device in several places. It is to be clarified here that if a secondary device is rotated, the axis of rotation being referred to is the one perpendicular to the plane of the charging area.

This radical change in design overcomes a number of drawbacks of conventional systems. The benefits of the proposed invention include:

- No need for accurate alignment: The secondary device can be placed anywhere on a charging area of the primary unit;

- Uniform coupling: In the proposed invention, the coupling between the primary unit and secondary device is much more uniform over the charging area compared to a conventional primary and secondary coil. In a conventional large coil system (see Figure 2a), the field strength dips to a minimum at the centre of the coil, in the plane of the coil (see Figure 2b). This implies that if sufficient power is to be effectively transferred at the centre, the field strength at the minimum has to be above a certain threshold. The field strength at the maximum will then be excessively higher than the required threshold and this may cause undesirable effects.

- Universality: a number of different secondary devices, even those having different power requirements, can be placed within charging areas on the charging surface of the primary unit to receive power simultaneously;

- Increased coupling coefficiency: Optional high permeability magnetic material present in the secondary device increases the induced flux significantly by offering a low reluctance path. This can significantly increase the power transfer.

- Desirable form factor for secondary device: The geometry of the system allows thin sheets of magnetic material (such as amorphous metal ribbons) to be used. This means that secondary devices can have the form factor of a thin sheet, making it suitable to be incorporated at the back of mobile phones and other electronic devices. If magnetic material was to be used in the centre of conventional coils, it is likely to increase the bulkiness of the secondary device.

- Minimised field leakage: When one or more secondary devices are present in the charging area of the primary unit, it is possible to use magnetic material in

such a way that more than half of the magnetic circuit is low reluctance magnetic material (see figure 4d). This means that more flux flows for a given magneto-motive force (mmf). As the induced voltage is proportional to the rate of change of flux linked, this will increase the power transfer to the secondary device. The fewer and shorter the air gaps are in the magnetic circuit, the less the field will fringe, the closer the flux is kept to the surface of the primary unit and hence leakage is minimized.

- Cost effectiveness: Unlike the multiple-coil design, this solution requires a much simpler control system and fewer components.

- Free axial rotation of secondary device: If the secondary device is thin or optionally even cylindrical (see Figure 10), it may be constructed such that it continues to couple well to the flux regardless of its rotation about its longest axis. This may in particular be an advantage if the secondary device is a battery cell fitted within another device, when its axial rotation may be difficult to control.

- The magnetic core in the secondary device may be located near other parallel planes of metal within or near the device, for example a copper printed circuit board or aluminium cover. In this case, the performance of embodiments of the present invention is significantly better than that of a conventional core-wound coil because the field lines through a conventional device coil will suffer flux-exclusion if the coil is placed up against the metal plane (because the lines of flux must travel perpendicular to the plane of the coil). Since in embodiments of the present invention the lines of flux travel along the plane of the core, and therefore also of the metal plane, performance is improved. An additional benefit is that the magnetic core in a secondary device of embodiments of the present invention can act as a shield between the electromagnetic field generated by the primary unit and any items (e.g. electrical circuits, battery cells) on the other side of the magnetic core.

- Because its permeability is higher than that of air, the magnetic core of the secondary device of embodiments of the present invention acts to concentrate magnetic flux, thus capturing more flux than would otherwise flow through an equivalent cross-section of air. The size of the core's "shape factor" (the equivalent flux-capturing sphere) is determined to a first-order approximation by the longest planar dimension of the core. Therefore if the core of the secondary device of embodiments of the present invention has planar dimensions with a significantly non-square aspect ratio, for example a 4:1 rectangle instead of a 1:1 square, it will capture proportionally more of any flux travelling parallel to the direction of its longest planar dimension. Therefore if used in devices which have a constrained aspect ratio (for example a long thin device such as a headset or pen), a significant increase in performance will be experienced compared with that of a conventional coil of the same area.

The primary unit typically consists of the following components. (See Figure 5)

- Power supply: This power supply converts mains voltage into a lower voltage dc supply. This is typically a conventional transformer or a switch-mode power supply;

- Control unit: The control unit serves the function of maintaining the resonance of the circuit given that the inductance of the means for generating a field changes with the presence of secondary devices. To enable this function, the control unit may be coupled to a sensing unit which feeds back the current status of the circuit. It may also be coupled to a library of capacitors which may be switched in and out as required. If the means for generating a field requires more than one driving circuit, the control unit may also coordinate the parameters such as the phase difference or on/off times of different driving circuits such that the desired effect is achieved. It is also possible for the Q (quality factor) of the system to be designed to function

over a range of inductances such that a need for the above control system is eliminated;

- Driving circuit: The driving unit is controlled by the control unit and drives a changing current through the means for generating a field or a component of the means. More than one driving circuit may be present depending on the number of independent components in the means;

- Means for generating an electromagnetic field: The means uses current supplied from the driving circuits to generate electromagnetic fields of pre-defined shapes and intensities. The exact configuration of the means defines the shape and intensity of the field generated. The means may include magnetic material to act as flux guides and also one or more independently driven components (windings), together forming the charging area. A number of embodiment designs are possible and examples are shown in Figures 6.

- Sensing unit: The sensing unit retrieves and sends relevant data to the control unit for interpretation.

The secondary device typically consists of the following components, as shown in Figure 5.

- Magnetic unit: the magnetic unit converts the energy stored in the magnetic field generated by the primary unit back into electrical energy. This is typically implemented by means of a winding wound around a highly permeable magnetic core. The largest dimension of the core typically coincides with the central axis of the winding.

- Conversion unit: the conversion unit converts the fluctuating current received from the magnetic unit into a form that is useful to the device that it is coupled to. For example, the conversion unit may convert the fluctuating

current into an unregulated dc supply by means of a full-wave bridge rectifier and smoothing capacitor. In other cases, the conversion unit may be coupled to a heating element or a battery charger. There is also typically a capacitor present either in parallel or in series with the magnetic unit to form a resonant circuit at the operating frequency of the primary unit.

In typical operation, one or more secondary devices are placed on top of the charging surface of the primary unit. The flux flows through the at least one conductor and/or core of the secondary devices present and current is induced. Depending on the configuration of the means for generating a field in the primary unit, the rotational orientation of the secondary device may affect the amount of flux coupled.

The primary unit

The primary unit may exist in many different forms, for example:

- As a flat platform or pad which can sit on top of tables and other flat surfaces;
- Built in to furniture such as desks, tables, counters, chairs, bookcases etc. such that the primary unit may not be visible;
- As part of an enclosure such as a drawer, a box, a glove compartment of a car, a container for power tools;
- As a flat platform or pad which can be attached to a wall and used vertically.

The primary unit may be powered from different sources, for example:

- A mains AC power outlet
- A vehicle lighter socket
- Batteries
- Fuel Cells
- Solar Panel
- Human power

The primary unit may be small enough such that only one secondary device may be accommodated on the charging surface in a single charging area, or may be large

enough to accommodate many secondary devices simultaneously, sometimes in different charging areas.

The means for generating a field in the primary unit may be driven at mains frequency (50Hz or 60Hz) or at some higher frequency.

The sensing unit of the primary unit may sense the presence of secondary devices, the number of secondary devices present and even the presence of other magnetic material which is not part of a secondary device. This information may be used to control the current being delivered to the field generating means of the primary unit.

The primary unit and/or the secondary device may be substantially waterproof or explosion proof.

The primary unit and/or the secondary device may be hermetically sealed to standards such as IP66.

The primary unit may incorporate visual indicators (for example, but not limited to, light emitting devices, such as light emitting diodes, electrophosphorescent displays, light emitting polymers, or light reflecting devices, such as liquid crystal displays or MITs electronic paper) to indicate the current state of the primary unit, the presence of secondary devices or the number of secondary devices present or any combination of the above.

The means for generating an electromagnetic field

The field generating means as referred to in this application includes all configurations of conductors where:

- The conductors are substantially distributed in the plane and;
- Substantial areas of the plane exist where there is a non-zero net instantaneous current flow. These are areas on which, given the correct orientation, the secondary devices will couple effectively and receive power. (See Figure 6)

- The conductors are capable of generating an electromagnetic field where the field lines subtend an angle of 45° or less or are substantially parallel to a substantial area of the plane.

Figures 6 illustrate some possibilities for such a primary conductor. Although most of the configurations are in fact coil windings, it is to be appreciated that the same effect can also be achieved with conductor planes which are not typically considered to be coils (See Figure 6e). These drawings are typical examples and are non-exhaustive. These conductors or coils may be used in combination such that the secondary device can couple effectively in all rotations whilst on the charging area(s) of the primary unit.

Magnetic Material

It is possible to use magnetic materials in the primary unit to enhance performance.

- Magnetic material may be placed below one or more charging areas or the entire charging surface such that there is also a low reluctance path on the underside of the conductors for the flux to complete its path. According to theory, an analogy can be drawn between magnetic circuits and electrical circuits. Voltage is analogous to magneto-motive force (mmf), resistance is analogous to reluctance and current is analogous to flux. From this, it can be seen that for a given mmf, flux flow will increase if the reluctance of the path is decreased. By providing magnetic material to the underside of the charging area, the reluctance of the magnetic circuit is essentially decreased. This substantially increases the flux linked by the secondary device and ultimately increases the power transferred. Figure 4d illustrates a sheet of magnetic material placed underneath the charging area and the resulting magnetic circuit.

- Magnetic material may also be placed above the charging surface and/or charging area(s) and below the secondary devices to act as a flux guide. This flux guide performs two functions: Firstly, the reluctance of the whole magnetic circuit is further decreased allowing more flux to flow. Secondly, it

provides a low reluctance path along the top surface of the charging area(s) so the flux lines will flow through these flux guides in favour of flowing through the air. Hence this has the effect of containing the field close to the charging surface of the primary unit instead of in the air. The magnetic material used for flux guides may be strategically or deliberately chosen to have different magnetic properties to the magnetic core (where provided) of the secondary device. For example, a material with lower permeability and higher saturation may be chosen. High saturation means that the material can carry more flux and the lower permeability means that when a secondary device is in proximity, a significant amount of flux would then choose to travel through the secondary device in favour of the flux guide. (See Figures 8)

- In some configurations of the primary unit field generating means, there may be conductors present that do not form part of the charging area, such as the component marked **745** in Figure 6a and 6b. In such cases, one may wish to use magnetic material to shield the effects of these conductors.

- Examples of some materials which may be used include but are not limited to: amorphous metal (metallic glass alloys such as MetGlas™), mesh of wires made of magnetic material, steel, ferrite cores, mumetal and permalloy.

The Secondary device

The secondary device may take a variety of shapes and forms. Generally, in order for good flux linkage, a central axis of the conductor (for example, a coil winding) should be substantially non-perpendicular to the charging area(s).

- The secondary device may be in the shape of a flattened winding. (See Figure 7a) The magnetic core inside can consist of sheets of magnetic material such as amorphous metals. This geometry allows the secondary device to be incorporated at the back of electronic devices such as mobile phones, personal digital assistants and laptops without adding bulk to the device.

- The secondary device may be in the shape of a long cylinder. A long cylindrical core could be wound with conductors (See Figure 7b).
- The secondary device may be an object with magnetic material wrapped around it. An example is a standard-sized (AA, AAA, C, D) or other sized/shaped (e.g. dedicated/customised for particular applications) rechargeable battery cell with for example magnetic material wrapped around the cylinder and windings around the cylindrical body.
- The secondary device may be a combination of two or more of the above. The above embodiments may even be combined with a conventional coil.

The following non-exhaustive list illustrates some examples of objects that can be coupled to a secondary device to receive power. Possibilities are not limited to those described below:

- A mobile communication device, for example a radio, mobile telephone or walkie-talkie;
- A portable computing device, for example a personal digital assistant or palmtop or laptop computer;
- Portable entertainment devices, for example a music player, games console or toy;
- Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
- A portable imaging device, for example a video camcorder or a camera;
- Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
- Consumer devices, for example torches, clocks and fans;
- Power tools, for example cordless drills and screwdrivers;
- Wireless peripheral devices, for example wireless computer mouse, keyboard and headset;
- Time keeping devices, for example clock, wrist watch, stop watch and alarm clock;
- A battery-pack for insertion into any of the above;
- A standard-sized battery cell.

In the case of unintelligent secondary devices such as a battery cell, some sophisticated charge-control means may also be necessary to meter inductive power to the cell and to deal with situations where multiple cells in a device have different charge states. Furthermore, it becomes more important for the primary unit to be able to indicate a "charged" condition, since the secondary cell or battery may not be easily visible when located inside another electrical device.

A possible system comprising an inductively rechargeable battery or cell and a primary unit is shown in Figure 10. In addition to the freedom to place the battery 920 freely in (X,Y) and optionally rotate it in rZ, relative to the primary unit 910, the battery can also be rotated along its axis rA while continuing to receive power.

When a user inserts a battery into a portable device, it is not easy to ensure that it has any given axial rotation. Therefore, embodiments of the present invention are highly advantageous because they can ensure that the battery can receive power while in any random orientation about rA.

The battery or cell may include a flux concentrating means that may be arranged in a variety of ways:

1. As shown in Figure 11a, a cell 930 may be wrapped in a cylinder of flux-concentrating material 931, around which is wrapped a coil of wire 932.
    a. The cylinder may be long or short relative to the length of the cell.
2. As shown in Figure 11b, a cell 930 may have a portion of flux-concentrating material 931 on its surface, around which is wrapped a coil of wire 932.
    a. The portion may be conformed to the surface of the cell, or embedded within it.
    b. Its area may be large or small relative to the circumference of the cell, and long or short relative to the length of the cell.
3. As shown in Figure 11c, a cell 930 may contain a portion of flux-concentrating material 931 within it, around which is wrapped a coil of wire 932.

a. The portion may be substantially flat, cylindrical, rod-like, or any other shape.
b. Its width may be large or small relative to the diameter of the cell
c. Its length may be large or small relative to the length of the cell

In any of these cases, the flux-concentrator may be a functional part of the battery enclosure (for example, an outer zinc electrode) or the battery itself (for example, an inner electrode).

Issues relating to charging of secondary cells (e.g. AA rechargeable cells in-situ within an appliance include:

- Terminal voltage could be higher than normal.
- Cells in series may behave strangely, particularly in situations where some cells are charged, others not.
- Having to provide enough power to run the device and charge the cell.
- If fast-charging is effected incorrectly, the cells may be damaged.

Accordingly, some sophisticated charge-control means to meter inductive power to the appliance and the cell is advantageously provided. Furthermore, it becomes more important for the primary unit to be able to indicate a "charged" condition, since the secondary cell or battery may not be easily visible when located inside an electrical device.

A cell or battery enabled in this fashion may be charged whilst fitted in another device, by placing the device onto the primary unit, or whilst outside the device by placing the cell or battery directly onto the primary unit.

Batteries enabled in this fashion may be arranged in packs of cells as in typical devices (e.g. end-to-end or side-by-side), allowing a single pack to replace a set of cells.

Alternatively, the secondary device may consist of a flat "adapter" which fits over the batteries in a device, with thin electrodes which force down between the battery electrodes and the device contacts.

Rotating electromagnetic field

In the coils such as those in Figure 6, 9a and 9b, the secondary devices will generally only couple effectively when the windings are placed substantially parallel to the direction of net current flow in the primary conductor as shown by the arrow **1**. In some applications, one might require a primary unit which will transfer power effectively to secondary devices regardless of their rotation as long as:

- the central axis of the secondary conductor is not perpendicular to the plane and;
- the secondary device is in close proximity to the primary unit

To enable this, it is possible to have two coils, for example one positioned on top of the other or one woven into or otherwise associated with the other, the second coil capable of generating a net current flow substantially perpendicular to the direction of the first coil at any point in the active area of the primary unit. These two coils may be driven alternately such that each is activated for a certain period of time. Another possibility is to drive the two coils in quadrature such that a rotating magnetic dipole is generated in the plane. This is illustrated in Figure 9. This is also possible with other combinations of coil configurations.

Resonant circuits

It is known in the art to drive coils using parallel or series resonant circuits. In series resonant circuits for example, the impedance of the coil and the capacitor are equal and opposite at resonance, hence the total impedance of the circuit is minimised and a maximum current flows through the primary coil. The secondary device is typically also tuned to the operating frequency to maximise the induced voltage or current.

In some systems like the electric toothbrush, it is common to have a circuit which is detuned when the secondary device is not present and tuned when the secondary device is in place. The magnetic material present in the secondary device shifts the self-inductance of the primary unit and brings the circuit into resonance. In other systems like passive radio tags, there is no magnetic material in the secondary device and hence does not affect the resonant frequency of the system. These tags are also typically small and used far from the primary unit such that even if magnetic material is present, the inductance of the primary is not significantly changed.

In the proposed system, this is not the case:

- High permeability magnetic material may be present in the secondary device and is used in close proximity to the primary unit;
- One or more secondary devices may be brought in close proximity to the primary unit simultaneously.

This has the effect of shifting the inductance of the primary significantly and also to different levels depending on the number of secondary devices present on the pad. When the inductance of the primary unit is shifted, the capacitance required for the circuit to resonant at a particular frequency also changes. There are three methods for keeping the circuit at resonance:

- By means of a control system to dynamically change the operating frequency;
- By means of a control system to dynamically change the capacitance such that resonance is achieved at the predefined frequency;
- By means of a low Q system where the system remains in resonance over a range of inductances.

The problem with changing the operating frequency is that the secondary devices are typically configured to resonate at a predefined frequency. If the operating frequency changes, the secondary device would be detuned. To overcome this problem, it is possible to change the capacitance instead of the operating frequency. The secondary devices can be designed such that each additional device placed in proximity to the primary unit will shift the inductance to a quantised level such that

an appropriate capacitor can be switched in to make the circuit resonate at a predetermined frequency. Because of this shift in resonant frequency, the number of devices on the charging surface can be detected and the primary unit can also sense when something is brought near or taken away from the charging surface. If a magnetically permeable object other than a valid secondary device is placed in the vicinity of the charging surface, it is unlikely to shift the system to the predefined quantised level. In such circumstances, the system could automatically detune and reduce the current flowing into the coil.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made, by way of example only, to the accompanying drawings, in which:

FIGURE 1 shows the magnetic design of typical prior art contact-less power transfer systems which require accurate alignment of the primary unit and secondary device;

FIGURE 2a shows the magnetic design of another typical prior art contact-less power transfer system which involves a large coil in the primary unit;

FIGURE 2b shows the non-uniform field distribution inside the large coil at 5mm distance from the plane of the coil, exhibiting a minimum in the centre;

FIGURE 3 shows a multiple-coil system where each coil is independently driven such that a localised field can be generated.

FIGURE 4a shows an embodiment of the proposed system which demonstrates a substantial departure from prior art with no secondary devices present;

FIGURE 4b shows an embodiment of the proposed system with two secondary devices present;

FIGURE 4c shows a cross section of the active area of the primary unit and the

contour lines of the magnetic flux density generated by the conductors.

FIGURE 4d shows the magnetic circuit for this particular embodiment of the proposed invention;

FIGURE 5 shows a schematic drawing of an embodiment of the primary unit and the secondary device;

FIGURE 6a to 6l show some alternative embodiment designs for the field generating means or a component of the field generating means of the primary unit;

FIGURES 7a and 7b show some possible designs for the magnetic unit of the secondary device;

FIGURES 8 shows the effect of flux guides (the thickness of the flux guide has been exaggerated for clarity);

FIGURE 8a shows that without flux guides, the field tends to fringe into the air directly above the active area;

FIGURE 8b shows the direction of current flow in the conductors in this particular embodiment;

FIGURE 8c shows that the flux is contained within the flux guides when magnetic material is placed on top of the charging area;

FIGURE 8d shows a secondary device on top of the primary unit;

FIGURE 8e shows a cross section of the primary unit without any secondary devices;

FIGURE 8f shows a cross section of the primary unit with a secondary device on top and demonstrates the effect of using a secondary core with higher permeability than

the flux guide.

FIGURE 9a shows a particular coil arrangement with a net instantaneous current flow shown by the direction of the arrow;

FIGURE 9b shows a similar coil arrangement to FIGURE 9a except rotated by 90 degrees;

FIGURE 9c shows the charging area of the primary unit if the coil of FIGURE 9a is placed on top of FIGURE 9b. If the coil in FIGURE 9a is driven in quadrature to FIGURE 9b, the effect is a rotating magnetic dipole shown here;

FIGURE 10 shows the case where the secondary device has an axial degree of rotation;

FIGURE 11 shows various arrangements of secondary devices with axial degrees of rotation;

FIGURE 12a and FIGURE 12b show another embodiment of the type of coil arrangement shown in FIGURE 9a and FIGURE 9b; and

FIGURE 13 shows a simple embodiment of driving unit electronics.

Referring firstly to Figure 1, there is shown two examples of prior art contact-less power transfer systems which both require accurate alignment of a primary unit and a secondary device. This embodiment is typically used in electric toothbrush or mobile phone chargers.

Figure 1a shows a primary magnetic unit **100** and a secondary magnetic unit **200**. On the primary side, a coil **110** is wound around a magnetic core **120** such as ferrite. Similarly, the secondary side consists of a coil **210** wound around another magnetic core **220.** In operation, an alternating current flows in to the primary coil **110** and

generates lines of flux **1**. When a secondary magnetic unit **200** is placed such that it is axially aligned with the primary magnetic unit **100**, the flux **1** will couple from the primary into the secondary, inducing a voltage across the secondary coil **210.**

Figure 1b shows a split transformer. The primary magnetic unit **300** consists of a U-shaped core **320** with a coil **310** wound around it. When alternating current flows into the primary coil **310**, changing lines of flux are generated **1**. The secondary magnetic unit **400** consists of a second U-shaped core **420** with another coil **410** wound around it. When the secondary magnetic unit **400** is placed on the primary magnetic unit **300** such that the arms of the two U-shaped cores are in alignment, the flux will couple effectively into the core of the secondary **420** and induce voltage across the secondary coil **410.**

Figure 2a is another embodiment of prior art inductive systems typically used in powering radio frequency passive tags. The primary typically consists of a coil **510** covering a large area. Multiple secondary devices **520** will have voltage induced therein when they are within the area encircled by the primary coil **510.** This system does not require the secondary coil **520** to be accurately aligned with the primary coil **510**. Figure 2b shows a graph of the magnitude of magnetic flux intensity across the area encircled by the primary coil **510** at 5mm above the plane of the primary coil. It shows a non-uniform field, which exhibits a minimum **530** at the centre of the primary coil **510**.

Figure 3 is another embodiment of a prior art inductive system wherein a multiple coil array is used. The primary magnetic unit **600** consists of an array of coils including coils **611, 612, 613.** The secondary magnetic unit **700** may consist of a coil **710.** When the secondary magnetic unit **700** is in proximity to some coils in the primary magnetic unit **600**, the coils **611, 612** are activated while other coils such as **613** remain inactive. The activated coils **611, 612** generate flux, some of which will couple into the secondary magnetic unit **700.**

Figure 4 shows an embodiment of the proposed invention. Figure 4a shows a

primary coil **710** wound or printed in such a fashion that there is a net instantaneous current flow within the active area **740.** For example, if a dc current flows through the primary coil **710,** the conductors in the active area **740** would all have current flowing in the same direction. Current flowing through the primary coil **710** generates flux **1**. A layer of magnetic material **730** is present beneath the charging area to provide a return path for the flux. Figure 4b shows the same primary magnetic unit as shown in Figure 4a with two secondary devices **800** present. When the secondary devices **800** are placed in the correct orientation on top of the charging area **740** of the primary magnetic unit, the flux **1** will flow through the magnetic core of the secondary devices **800** instead of flowing through the air. The flux **1** flowing through the secondary core would hence induce current in the secondary coil.

Figure 4c shows some contour lines for the flux density of the magnetic field generated by the conductors **711** in the charging area **740** of the primary magnetic unit. There is a layer of magnetic material **730** beneath the conductors to provide a low reluctance return path for the flux.

Figure 4d shows a cross-section of the charging area **740** of the primary magnetic unit. A possible path for the magnetic circuit is shown. The magnetic material **730** provides a low reluctance path for the circuit and also the magnetic core **820** of the secondary magnetic device **800** also provides a low reluctance path. This minimizes the distance the flux has to travel through the air and hence minimizes leakage.

Figure 5 shows a schematic drawing of an embodiment of the whole system of the proposed invention. In this embodiment, the primary unit consists of a power supply **760,** a control unit **770,** a sensing unit **780** and an electromagnetic unit **700.** The power supply **760** converts the mains (or other sources of power) into a dc supply at an appropriate voltage for the system. The control unit **770** controls the driving unit **790** which drives the magnetic unit **700.** In this embodiment, the magnetic unit consists of two independently driven components, coil 1 and coil 2, arranged such that the conductors in the charging area of coil 1 would be perpendicular to the conductors in the charging area of coil 2. When the primary unit is activated, the

control unit causes a 90-degree phase shift between the alternating current that flows through coil 1 and coil 2. This creates a rotating magnetic dipole on the surface of the primary magnetic unit **700** such that a secondary device is able to receive power regardless of its rotational orientation (See Figure 9). In standby mode where no secondary devices are present, the primary unit is detuned and current flow into the magnetic unit **700** is minimised. When a secondary device is placed on top of the charging area of the primary unit, the inductance of the primary magnetic unit **700** is changed. This brings the primary circuit into resonance and the current flow is maximised. When there are two secondary devices present on the primary unit, the inductance is changed to yet another level and the primary circuit is again detuned. At this point, the control unit **770** uses feedback from the sensing unit **780** to switch another capacitor into the circuit such that it is tuned again and current flow is maximised. In this embodiment, the secondary devices are of a standard size and a maximum of six standard-sized devices can receive power from the primary unit simultaneously. Due to the standard sizes of the secondary devices, the change in inductance due to the change in secondary devices in proximity is quantized to a number of predefined levels such that only a maximum of 6 capacitances is required to keep the system operating at resonance.

Figures 6a to 6l show a number of different embodiments for the coil component of the primary magnetic unit. These embodiments may be implemented as the only coil component of the primary magnetic unit, in which case the rotation of the secondary device is important to the power transfer. These embodiments may also be implemented in combination, not excluding embodiments which are not illustrated here. For example, two coils illustrated in Figure 6a may be placed at 90 degrees to each other to form a single magnetic unit. In Figures 6a to 6e, the charging area **740** consists of a series of conductors with net current generally flowing in the same direction. In certain configurations, such as Figure 6c, there is no substantial linkage when the secondary device is placed directly over the centre of the coil and hence power is not transferred. In Figure 6d, there is no substantial linkage when the secondary device is positioned in the gap between the two charging areas **740**.

Figure 6f shows a specific coil configuration for the primary unit adapted to generate electromagnetic field lines substantially parallel to a surface of the primary unit within the charging area **740**. Two primary windings **710**, one on either side of the charging area **740**, are formed about opposing arms of a generally rectangular flux guide **750** made out of a magnetic material, the primary windings **710** generating opposing electromagnetic fields. The flux guide **750** contains the electromagnetic fields and creates a magnetic dipole across the charging area **740** in the direction of the arrows indicated on the Figure. When a secondary device is placed in the charging area **740** in a predetermined orientation, a low reluctance path is created and flux flows through the secondary device, causing effective coupling and power transfer. It is to be appreciated that the flux guide **750** need not be continuous, and may in fact be formed as two opposed and non-linked horseshoe components.

Figure 6g shows another possible coil configuration for the primary unit, the coil configuration being adapted to generate electromagnetic field lines substantially parallel to the charging surface of the primary unit within the charging area **740**. A primary winding **710** is wound around a magnetic core **750** which may be ferrite or some other suitable material. The charging area **740** includes a series of conductors with instantaneous net current generally flowing in the same direction. The coil configuration of Figure 6g is in fact capable of supporting or defining a charging area **740** on both upper and lower faces as shown in the drawing, and depending on the design of the primary unit, one or both of the charging areas may be made available to secondary devices.

Figure 6h shows a variation of the configuration of Figure 6g. Instead of the primary windings **710** being evenly spaced as in Figure 6g, the windings **710** are not evenly spaced. The spacing and variations therein can be selected or designed so as to provide improved uniformity of performance or field strength levels over the charging area **740**.

Figure 6i shows an embodiment in which two primary windings **710** as shown in Figure 6g are located in a mutually orthogonal configuration so as to enable a

direction of the field lines to be dynamically switched or rotated to other orientations about the plane of the charging surface.

Figures 6j and 6k show additional two-coil configurations for the primary unit which are not simple geometric shapes with substantially parallel conductors.

In Figure 6j, line **710** indicates one of a set of current-carrying conductors lying in the plane of the charging surface **600**. The shape of the main conductor **710** is arbitrary and need not be a regular geometric figure – indeed, conductor **710** may have straight and curved sections and may intersect with itself. One or more subsidiary conductors **719** are arranged alongside and generally parallel (at any given local point) to the main conductor **710** (only two subsidiary conductors **719** are shown here for clarity). Current flow in subsidiary conductors **719** will be in the same direction as in the main conductor **710**. The subsidiary conductors **719** may be connected in series or parallel so as to form a single coil arrangement.

In Figure 6k, a set of current-carrying conductors **720** (only some of which are shown for clarity) is arranged in the plane of the charging surface **600**. A main conductor **710** is provided as in Figure 6j, and the conductors **720** are each arranged so as to be locally orthogonal to the main conductor **710**. The conductors **720** may be connected in series or parallel so as to form a single coil arrangement. If a first sinusoidal current is fed into the conductor **710**, and a second sinusoidal current having a 90° phase shift relative to the first current is fed into the coil **720**, then by varying the relative proportions and signs of the two currents a direction of a resultant electromagnetic field vector at most points on the charging area **740** will be seen to rotate through 360°.

Figure 6l shows yet another alternative arrangement in which the magnetic core **750** is in the shape of a round disc with a hole in the centre. The first set of current carrying conductors **710** is arranged in a spiral shape on the surface of the round disc. The second set of conductors **720** is wound in a toroidal format through the centre of the disc and out to the perimeter in a radial fashion. These conductors can be driven

in such a way, for example with sinusoidal currents at quadrature, that when a secondary device is placed at any point inside the charging area **740** and rotated about an axis perpendicular to the charging area, no nulls are observed by the secondary device.

Figure 7a and 7b are embodiments of the proposed secondary devices. A winding **810** is wound around a magnetic core **820**. Two of these may be combined in a single secondary device, at right angles for example, such that the secondary device is able to effectively couple with the primary unit at all rotations. These may also be combined with standard coils, as the ones shown in Figure 2a **520** to eliminate dead spots.

Figure 8 shows the effect of flux guides **750** positioned on top of the charging area. The thickness of the material has been exaggerated for the sake of clarity but in reality would be in the order of millimetres thick. The flux guides **750** will minimize leakage and contain the flux at the expense of reducing the amount of flux coupled to the secondary device. In Figure 8a, a primary magnetic unit is shown without flux guides **750**. The field will tend to fringe into the air directly above the charging area. With flux guides **750,** as shown in Figure 8b to 8f, the flux is contained within the plane of the material and leakage is minimised. In Figure 8e, when there is no secondary device **800** on top, the flux remains in the flux guide **750**. In Figure 8f, when a secondary device **800** is present with a relatively more permeable material as the core, part of the flux will flow via the secondary device. The permeability of the flux guide **750** can be chosen such that it is higher than that of typical metals such as steel. When other materials such as steel, which are not part of secondary devices **800**, are placed on top, most of the flux will remain in the flux guide **750** instead of travelling through the object. The flux guide **750** may not be a continuous layer of magnetic material but may have small air gaps in them to encourage more flux flow into the secondary device **800** when it is present.

Figure 9 shows an embodiment of a primary unit whereby more than one coil is used. Figure 9a shows a coil **710** with a charging area **740** with current flow parallel to the

direction of the arrow **2**. Figure 9b shows a similar coil arranged at 90 degrees to the one in Figure 9a. When these two coils are placed on top of each other such that the charging area **740** overlaps, the charging area will look like the illustration in Figure 9c. Such an embodiment would allow the secondary device to be at any rotation on top of the primary unit and couple effectively.

Figure 10 shows an embodiment where the secondary device has an axial degree of rotation, for example where it is, or is embedded within, a battery cell. In this embodiment the secondary device may be constructed such that it couples to the primary flux when in any axial rotation (rA) relative to the primary unit (**910**), as well as having the same degrees of freedom described above (i.e. translational (X,Y) and optionally rotational perpendicular to the plane of the primary (rZ)).

Figure 11a shows one arrangement where a rechargeable battery cell **930** is wrapped with an optional cylinder of flux-concentrating material **931** which is itself wound with copper wire **932**. The cylinder may be long or short relative to the length of the cell.

Figure 11b shows another arrangement where the flux-concentrating material **931** covers only part of the surface of the cell **930**, and has copper wire **932** wrapped around it (but not the cell). The material and wire may be conformed to the surface of the cell. Their area may be large or small relative to the circumference of the cell, and long or short relative to the length of the cell.

Figure 11c shows another arrangement where the flux-concentrating material **931** is embedded within the cell **930** and has copper wire **932** wrapped around it. The material may be substantially flat, cylindrical, rod-like, or any other shape, its width may be large or small relative to the diameter of the cell, and its length may be large or small relative to the length of the cell.

In any case shown in Figures 10 and 11, any flux-concentrating material may also be a functional part of the battery enclosure (for example, an outer zinc electrode) or the battery itself (for example, an inner electrode).

In any case shown in Figures 10 and 11, the power may be stored in a smaller standard cell (e.g. AAA size) fitted within the larger standard cell enclosure (e.g. AA).

Figure 12 shows an embodiment of a primary unit similar to that shown in Figure 9. Figure 12a shows a coil generating a field in a direction horizontal to the page, Figure 12b shows another coil generating a field vertical to the page, and the two coils would be mounted in a substantially coplanar fashion, possibly with one above the other, or even intertwined in some fashion. The wire connections to each coil are shown **940** and the charging area is represented by the arrows **941**.

Figure 13 shows a simple embodiment of the Driving Unit (790 of Figure 5). In this embodiment there is no Control Unit. The PIC processor **960** generates two 23.8kHz square waves 90 degrees out of phase with one another. These are amplified by components **961** and driven into two coil components **962**, which are the same magnetic units shown in Figure 12a and Figure 12b. Although the driving unit is providing square waves, the high resonant "Q" of the magnetic units shapes this into a sinusoidal waveform.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A system for transferring power without requiring direct electrical conductive contacts, the system comprising:

i) a primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area; and

ii) at least one secondary device including at least one electrical conductor;

wherein, when the at least one secondary device is placed on or in proximity to a charging area of the primary unit, the electromagnetic field lines couple with the at least one conductor of the at least one secondary device and induce a current to flow therein.

2. A system as claimed in claim 1, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

3. A system as claimed in claim 1, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

4. A system as claimed in any preceding claim, wherein the means includes a plurality of conductors configured so as to cause a directional component of the electromagnetic field lines, resolved onto the charging area, to be changed over time.

5. A system as claimed in claim 4, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be switched between at least two different directions.

6. A system as claimed in claim 4, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be moved through an angle.

7. A system as claimed in claim 6, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be rotated.

8. A system as claimed in any preceding claim, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

9. A system as claimed in any preceding claim, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

10. A system as claimed in any preceding claim, wherein the means does not project beyond the charging surface.

11. A system as claimed in any preceding claim, wherein the at least one charging area is provided with a substrate of a magnetic material.

12. A system as claimed in any preceding claim, wherein the primary unit includes at least one selectively operable capacitor configured such that a capacitance of a circuit including the at least one means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

13. A system as claimed in any preceding claim, wherein the at least one charging area is provided with a flux guide having a relative permeability less than that of the core of the at least one secondary device.

14. A system as claimed in any preceding claim, wherein the primary unit includes a power supply.

15. A system as claimed in any preceding claim, wherein the at least one conductor in the secondary device is wound about a core that serves to concentrate flux therein.

16. A system as claimed in claim 15, wherein the core is a magnetically permeable material.

17. A system as claimed in claim 16, wherein the core is an amorphous magnetic material.

18. A system as claimed in claim 17, wherein the core is a substantially non-annealed amorphous magnetic material.

19. A system as claimed in any one of claims 15 to 18, wherein the core is formed as a flexible ribbon.

20. A system as claimed in any preceding claim, wherein the secondary device comprises an inductively rechargeable battery or cell.

21. A system as claimed in claim 20, wherein the inductively rechargeable battery or cell includes at least one conductor wound about a flux concentrating means.

22. A system as claimed in any preceding claim, wherein at least one of the at least one means is configured to generate an electromagnetic field over more than one charging area.

23. A system as claimed in any one of claims 1 to 21, wherein a plurality of means is configured to generate an electromagnetic field over a single charging area.

24. A system as claimed in any preceding claim, wherein the means has a height that is no more than half of the length or half of the width of the charging area.

25. A system as claimed in any preceding claim, wherein the means has a height that is no more than 1/5 of the length or 1/5 of the width of the charging area.

26. A primary unit for transferring power without requiring direct electrical conductive contacts, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, wherein the means is configured such that, when a predetermined current is supplied thereto and the primary unit is effectively in electromagnetic isolation, an electromagnetic field generated by the means has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in

two dimensions thereover, and wherein the means has a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area.

27. A primary unit as claimed in claim 26, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

28. A primary unit as claimed in claim 26, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

29. A primary unit as claimed in any one of claims 26 to 28, wherein the means includes a plurality of conductors configured so as to cause a directional component of the electromagnetic field lines, resolved onto the charging area, to be changed over time.

30. A primary unit as claimed in claim 29, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be switched between at least two different directions.

31. A primary unit as claimed in claim 29, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be moved through an angle.

32. A primary unit as claimed in claim 31, wherein the plurality of conductors is configured so as to cause the resolved directional component of the field lines to be rotated.

33. A primary unit as claimed in any one of claims 26 to 32, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

34. A primary unit as claimed in any one of claims 26 to 33, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

35. A primary unit as claimed in any one of claims 26 to 34, wherein the means does not project beyond the charging surface.

36. A primary unit as claimed in any one of claims 26 to 35, wherein the at least one area is provided with a substrate of a magnetic material.

37. A primary unit as claimed in any one of claims 26 to 36, including at least one selectively operable capacitor configured such that a capacitance of a circuit including the at least one means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

38. A primary unit as claimed in any one of claims 26 to 37, wherein the primary unit includes a power supply.

39. A primary unit as claimed in any one of claims 26 to 38, wherein the at least one area is provided with a flux guide having a relative permeability less than that of any core that may be provided in the at least one secondary device.

40. A primary unit as claimed in any one of claims 26 to 39, wherein at least one of the at least one means is configured to generate an electromagnetic field over more than one charging area.

41. A primary unit as claimed in any one of claims 26 to 39, wherein a plurality of means is configured to generate an electromagnetic field over a single charging area.

42. A primary unit as claimed in any one of claims 26 to 41, wherein the means has a height that is no more than half of the length or half of the width of the charging area.

43. A primary unit as claimed in any one of claims 26 to 42, wherein the means has a height that is no more than 1/5 of the length or 1/5 of the width of the charging area.

44. A method of transferring power in a non-conductive manner from a primary unit to a secondary device, the primary unit including a substantially laminar charging surface and at least one means for generating an electromagnetic field, the means being distributed in two dimensions across a predetermined area in or parallel to the charging surface so as to define at least one charging area of the charging surface that is substantially coextensive with the predetermined area, the charging area having a width and a length on the charging surface, the means having a height measured substantially perpendicular to the charging area that is less than either of the width or the length of the charging area, and the secondary device having at least one electrical conductor; wherein:

i) an electromagnetic field, generated by the means when energised with a predetermined current and measured when the primary unit is effectively in electromagnetic isolation, has electromagnetic field lines that, when averaged over any quarter length part of the charging area measured parallel to a direction of the field lines, subtend an angle of 45° or less to the charging surface in proximity thereto and are distributed in two dimensions over the at least one charging area when averaged thereover; and

ii) the electromagnetic field links with the conductor of the secondary device when this is placed on or in proximity to the charging area.

45. A method according to claim 44, wherein the means comprises at least one electrical conductor that is distributed in two dimensions in or substantially parallel to the charging surface.

46. A method according to claim 44, wherein the means comprises at least one electrical conductor wound onto at least part of a magnetically permeable former that is distributed in two dimensions in or substantially parallel to the charging surface.

47. A method according to any one of claims 44 to 46, wherein a directional component of the electromagnetic field lines, resolved onto the charging area, is changed over time.

48. A method according to claim 47, wherein the resolved directional component of the field lines is switched between at least two different directions.

49. A method according to claim 47, wherein the resolved directional component of the field lines is moved through an angle.

50. A method according to claim 49, wherein the resolved directional component of the field lines is rotated.

51. A method according to any one of claims 44 to 50, wherein the field lines over a given charging area are substantially parallel to each other when projected onto the charging area.

52. A method according to any one of claims 44 to 51, wherein an instantaneous net flow of current in a given one of the at least one means when energised is in substantially one direction.

53. A method according to any one of claims 44 to 52, wherein the at least one charging area is provided with a substrate of a magnetic material and wherein the magnetic material completes a magnetic circuit.

54. A method according to any one of claims 44 to 53, wherein the primary unit includes at least one selectively operable capacitor that is switched in or out such that a capacitance of a circuit including the at least one primary unit means for generating an electromagnetic field and the at least one capacitor may be changed in response to a detected presence of one or more secondary devices.

55. A method according to any one of claims 44 to 54, wherein the charging surface, at least within the at least one charging area, is provided with a flux guide having a relative permeability less than that of any core that may be provided in the at least one secondary device.

56. A secondary device for use with the system, primary unit or method of any one of the preceding claims, the secondary device including at least one electrical conductor and having a substantially laminar form factor.

57. A secondary device as claimed in claim 56, wherein the at least one electrical conductor is wound about a core that serves to concentrate flux therein.

58. A secondary device as claimed in claim 57, wherein the core is a magnetically permeable material.

59. A secondary device as claimed in claim 58, wherein the core is an amorphous magnetic material.

60. A secondary device as claimed in claim 59, wherein the core is a substantially non-annealed amorphous magnetic material.

61. A secondary device as claimed in any one of claims 57 to 60, wherein the core is formed as a flexible ribbon.

62. A secondary device as claimed in any one of claims 56 to 61, wherein the secondary device comprises an inductively rechargeable battery or cell.

63. A secondary device as claimed in claim 57 or any claim depending therefrom, having a core thickness of 2mm or less.

64. A secondary device as claimed in claim 63, having a core thickness of 1mm or less.

65. A secondary device as claimed in any one of claims 56 to 64, wherein the secondary device has a primary axis and couples with the electromagnetic field when located on or in proximity to the charging area in any rotation about its axis.

66. A secondary device as claimed in claim 65 depending from claim 62, wherein the core is at least partially wrapped around a central part of the battery or cell.

67. A system as claimed in any one of claims 1 to 25, wherein the primary unit includes a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending generally parallel to the plane of the windings but substantially at right angles to the parallel sections.

68. A system as claimed in claim 67, wherein the windings are formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

69. A system as claimed in claim 67 or 68, wherein the primary unit includes first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged

generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

70. A primary unit as claimed in any one of claims 26 to 43, including a pair of conductors having adjacent coplanar windings which have mutually substantially parallel linear sections arranged so as to produce a substantially uniform electromagnetic field extending generally parallel to the plane of the windings but substantially at right angles to the parallel sections.

71. A primary unit as claimed in claim 70, wherein the windings are formed in a generally spiral shape, comprising a series of turns having substantially parallel straight sections.

72. A primary unit as claimed in claim 70 or 71, including first and second pairs of conductors which are superimposed in substantially parallel planes with the substantially parallel linear sections of the first pair arranged generally at right angles to the substantially parallel linear sections of the second pair, and further comprising a driving circuit which is arranged to drive them in such a way as to generate a resultant field which rotates in a plane substantially parallel to the planes of the windings.

73. A system for transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

74. A primary unit for transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

75. A method of transferring power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

76. A secondary device for receiving power, substantially as hereinbefore described with reference to Figures 4 to 13 of the accompanying drawings.

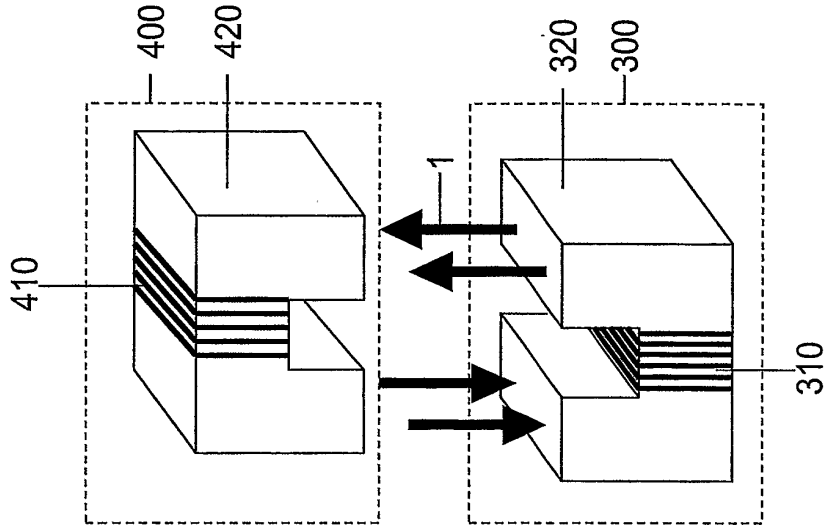


Figure 1b
(Prior Art)

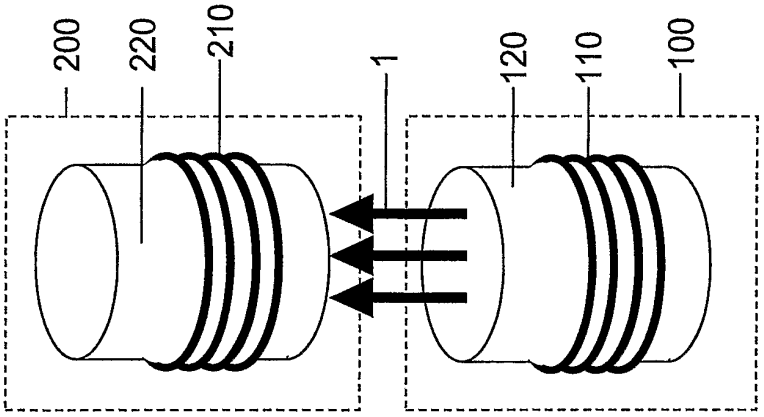


Figure 1a
(Prior Art)

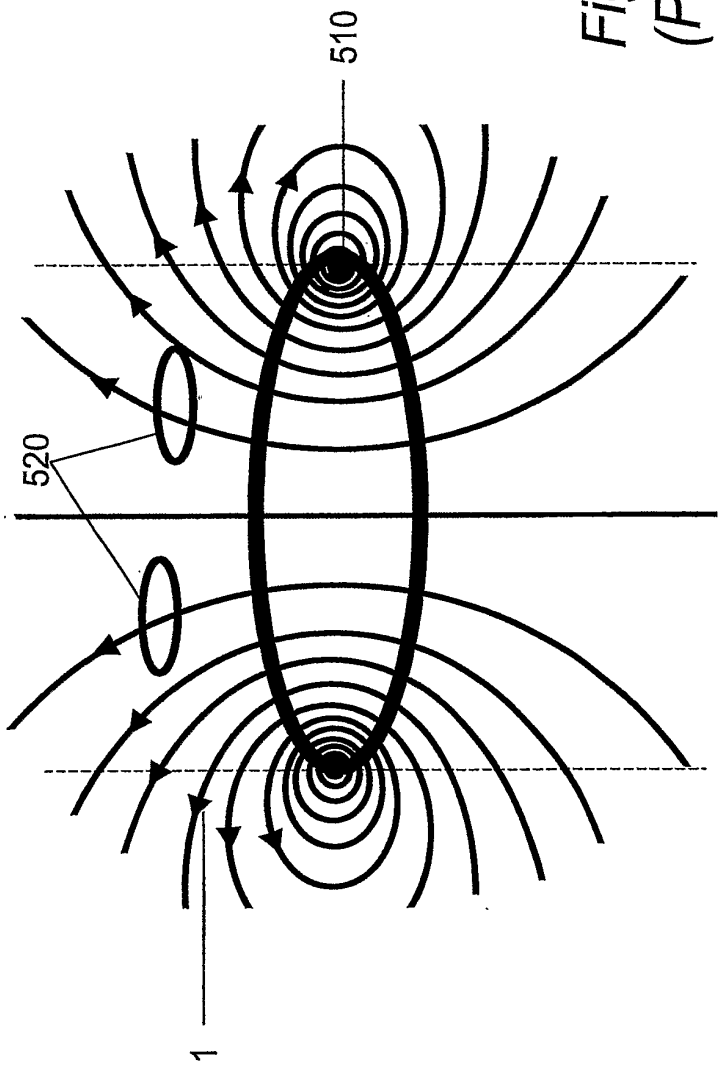


Figure 2a
(Prior Art)

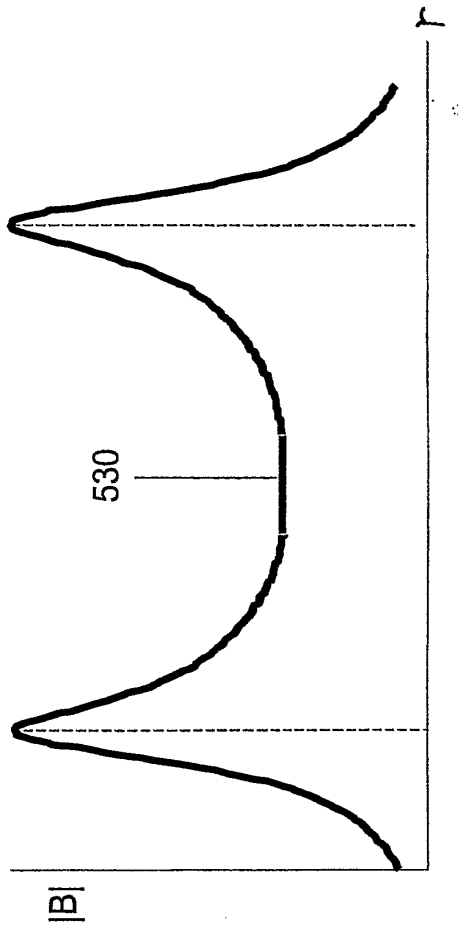


Figure 2b

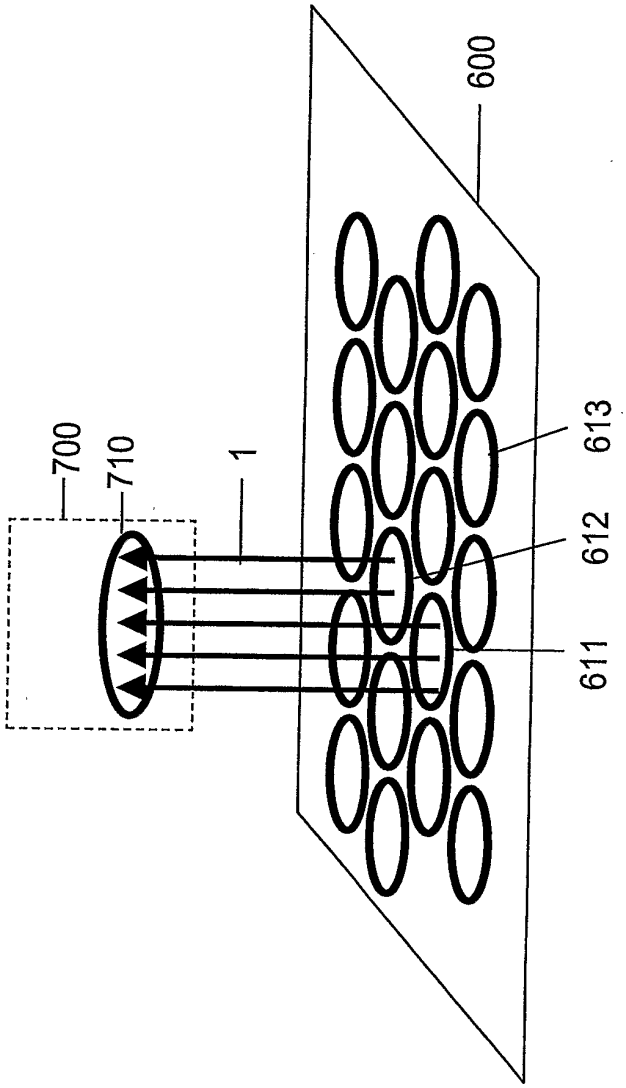


Figure 3

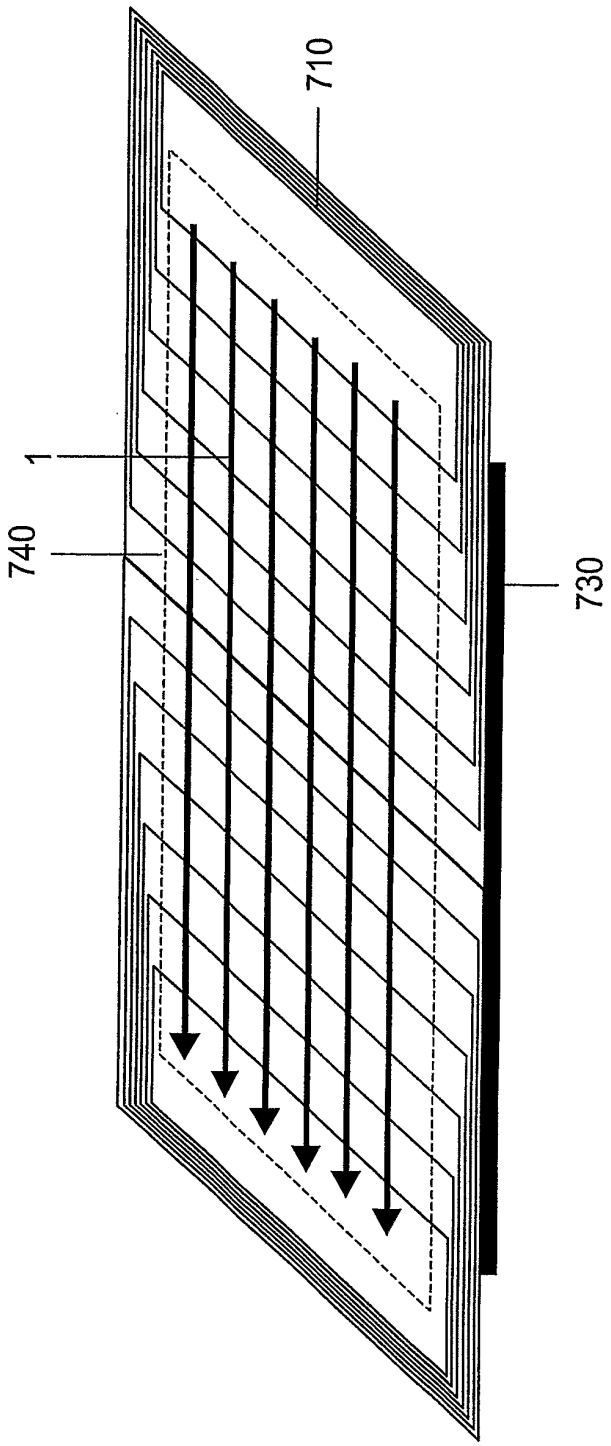


Figure 4a

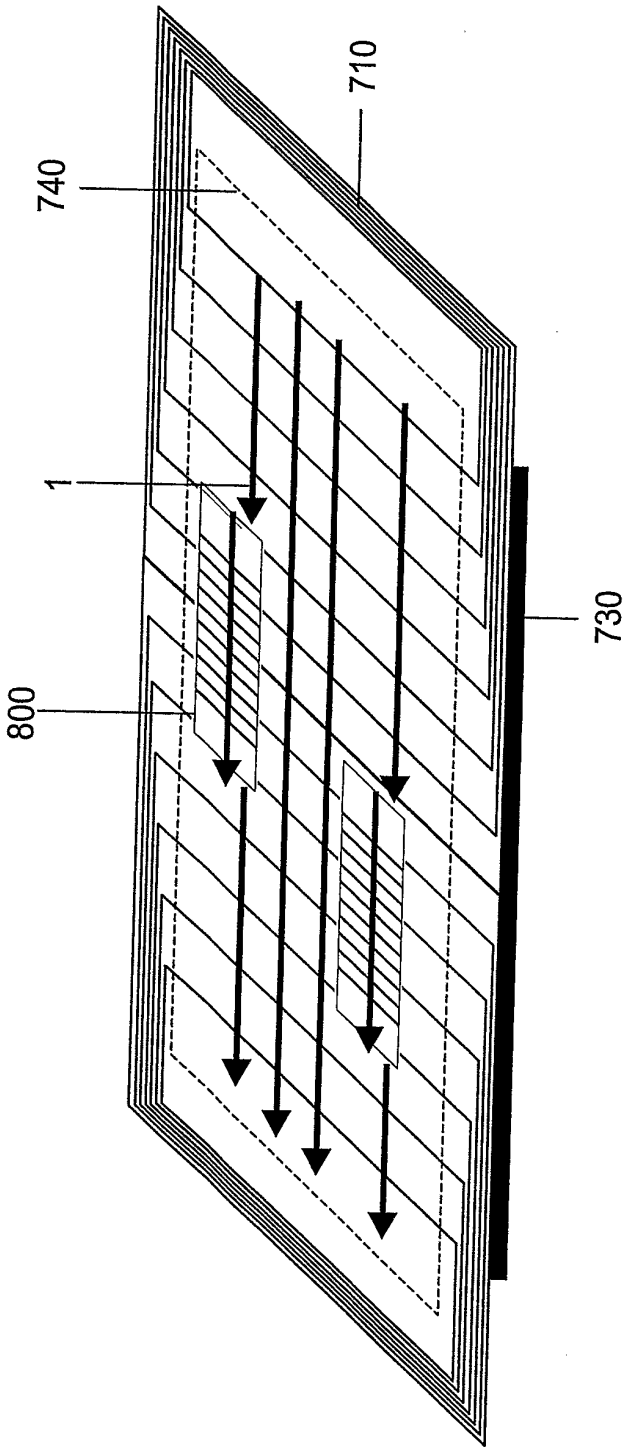


Figure 4b

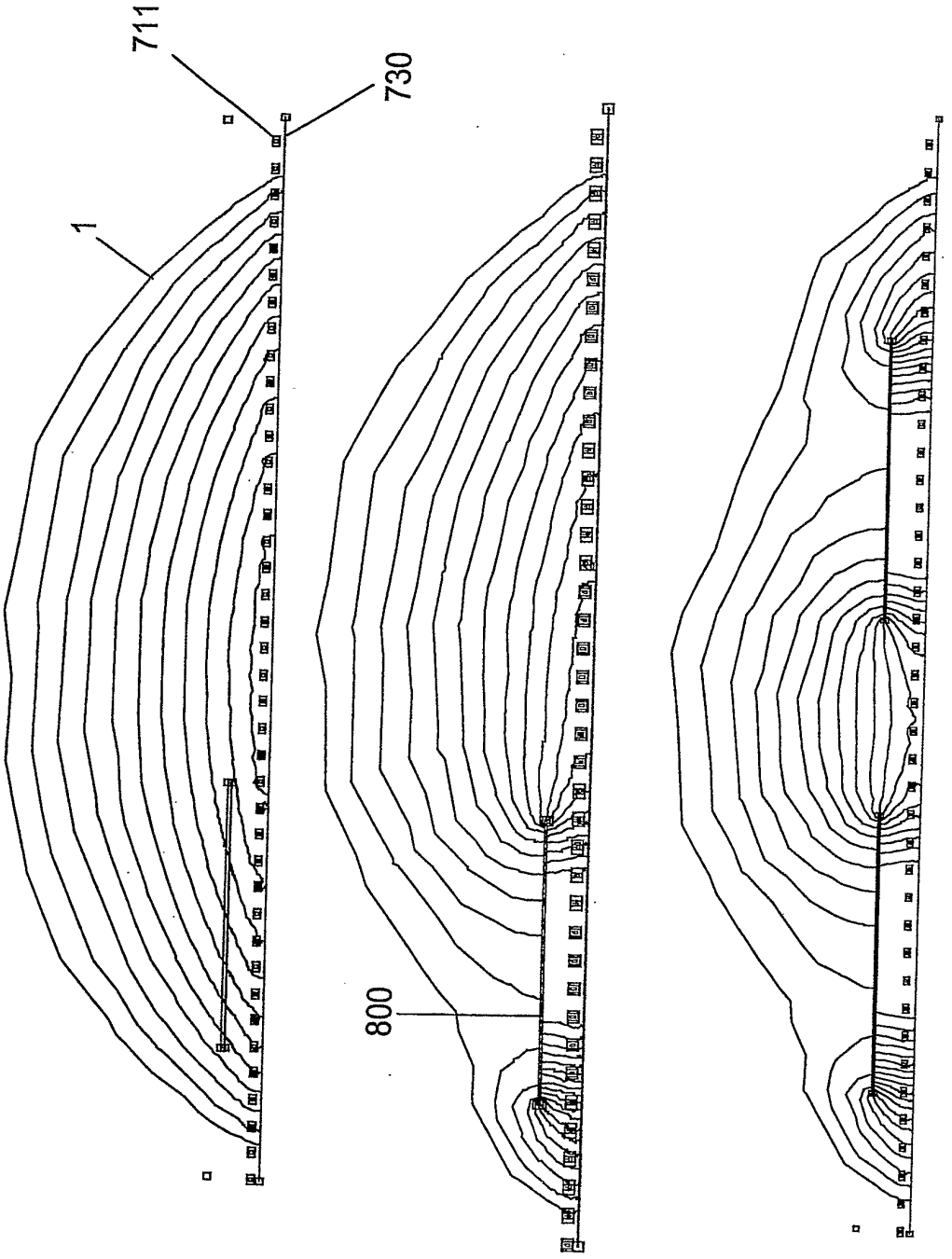


Figure 4c

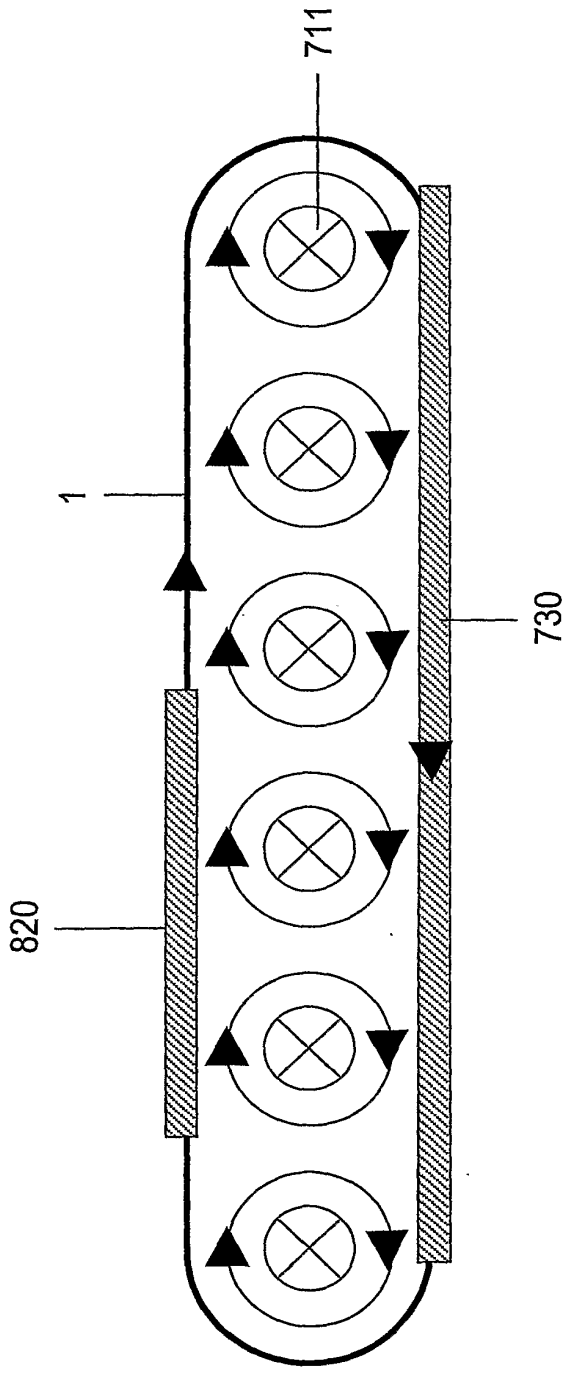


Figure 4d

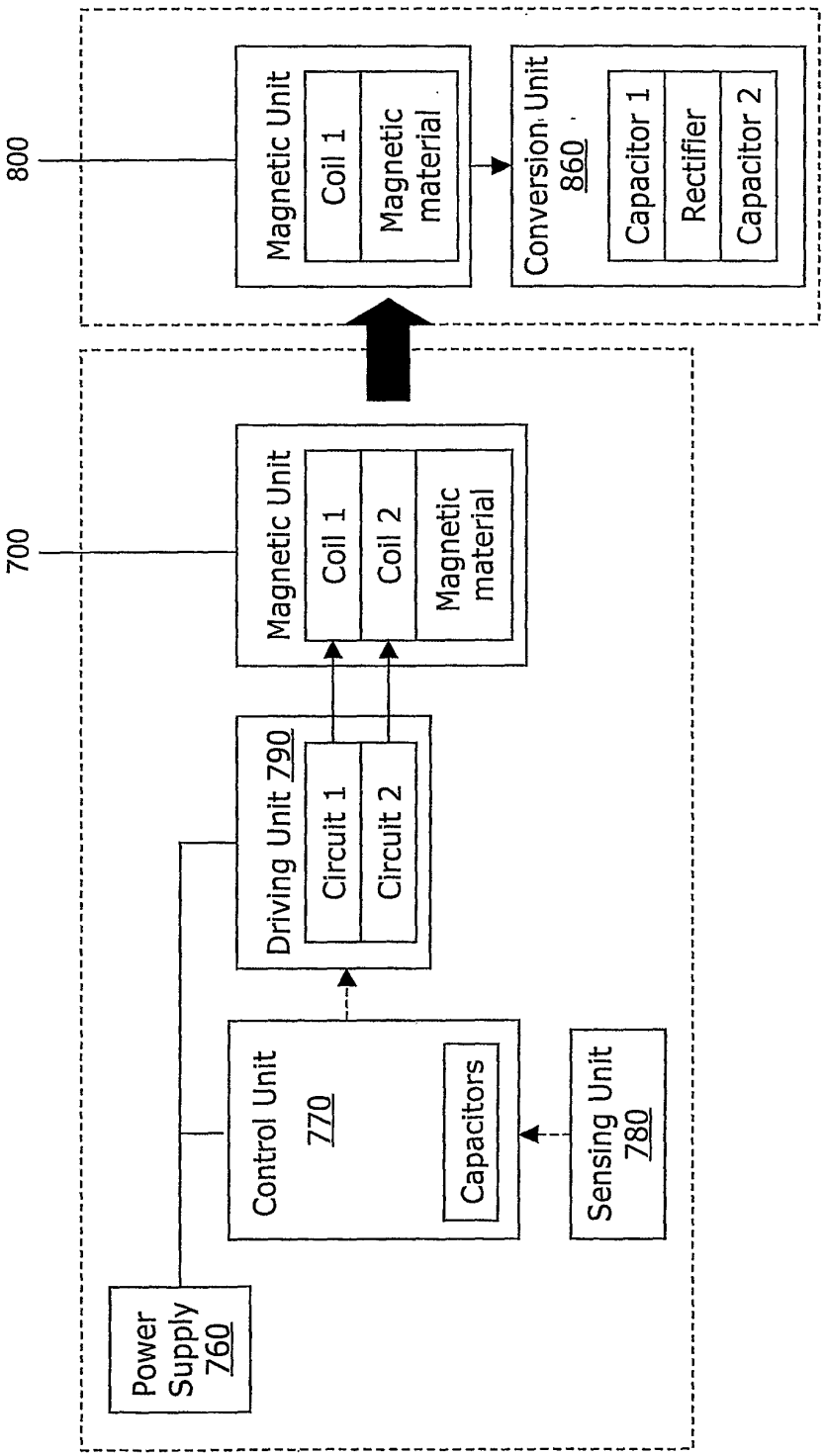

800
Magnetic Unit
Coil 1
Magnetic material
Conversion Unit 860
Capacitor 1
Rectifier
Capacitor 2
700
Magnetic Unit
Coil 1
Coil 2
Magnetic material
Driving Unit 790
Circuit 1
Circuit 2
Control Unit 770
Capacitors
Sensing Unit 780
Power Supply 760

Figure 5

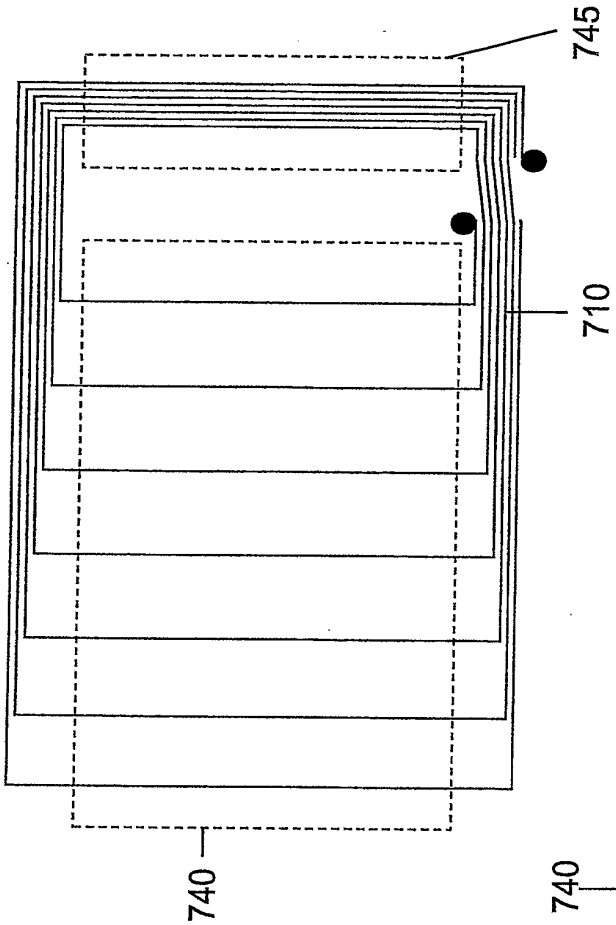


Figure 6a

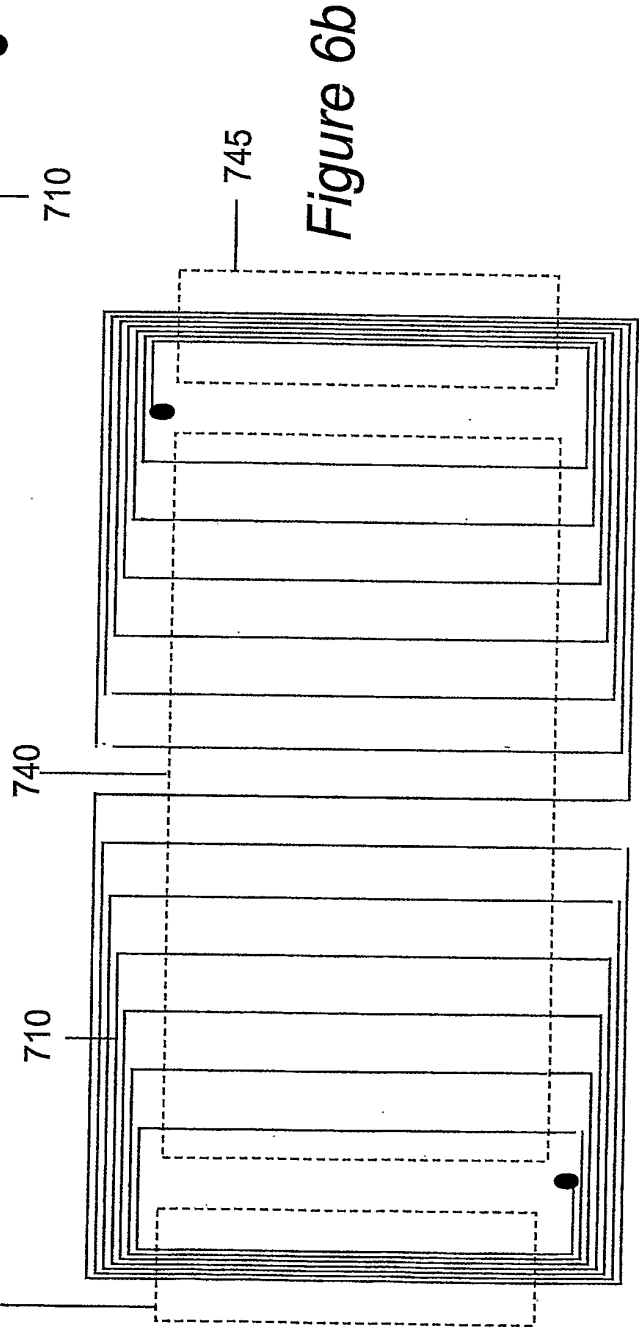


Figure 6b

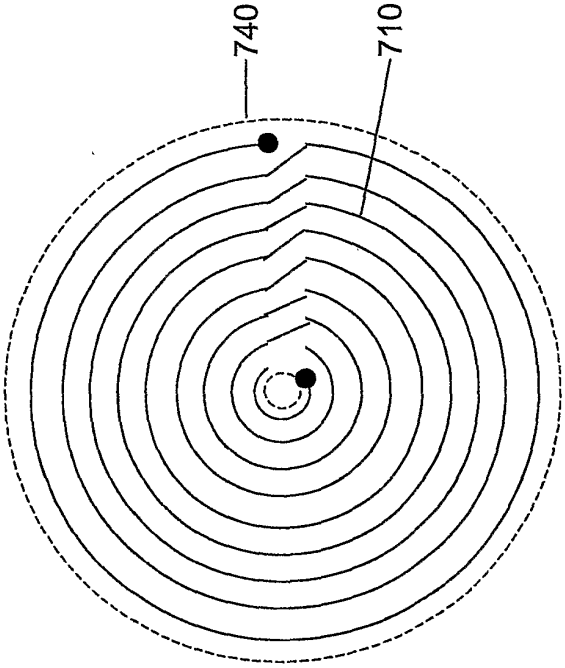


Figure 6c

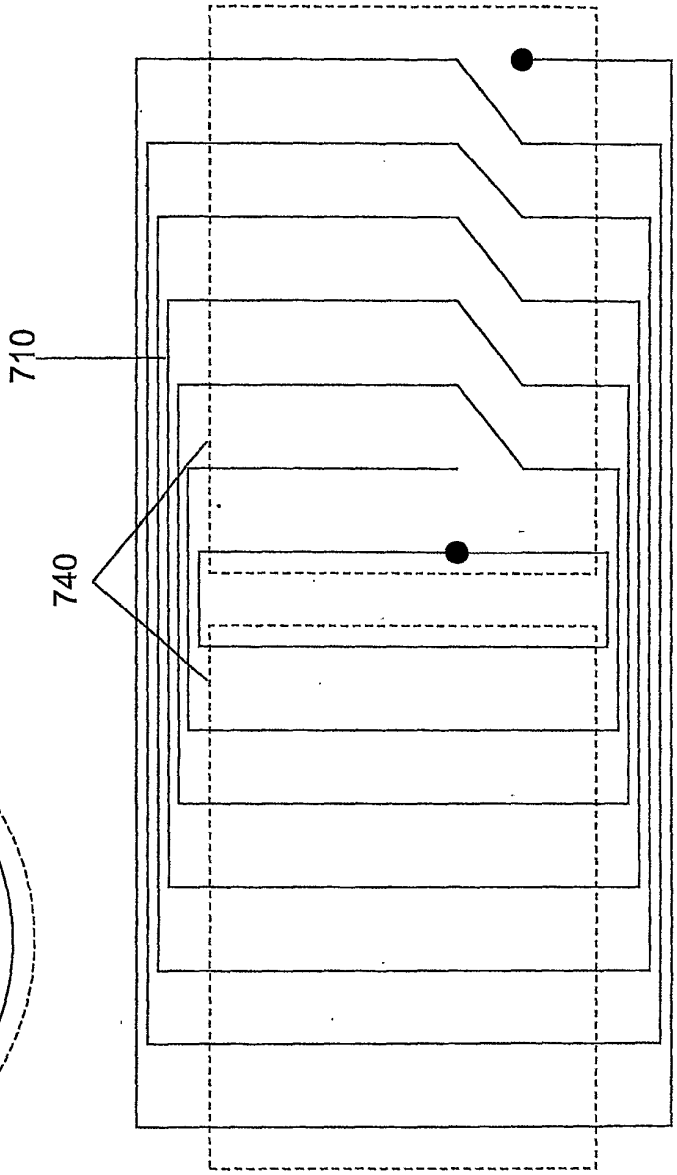


Figure 6d

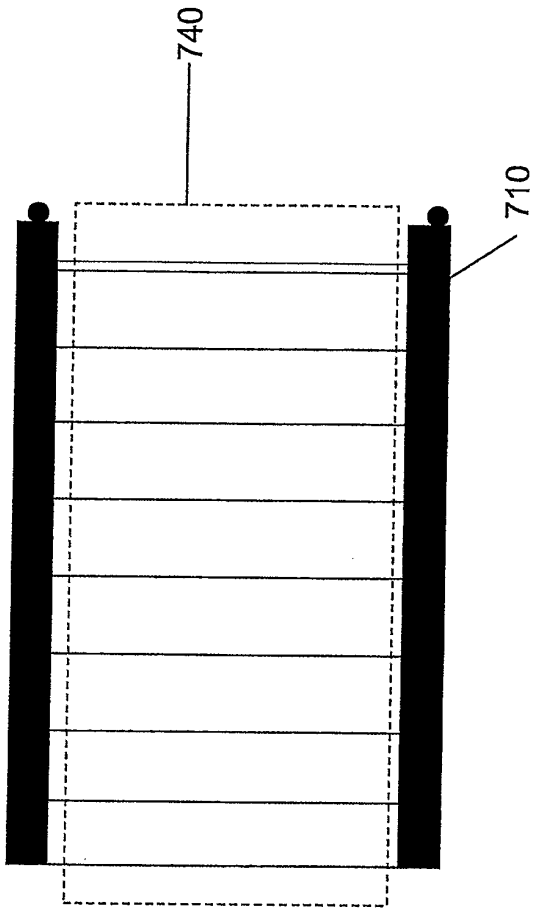


Figure 6e

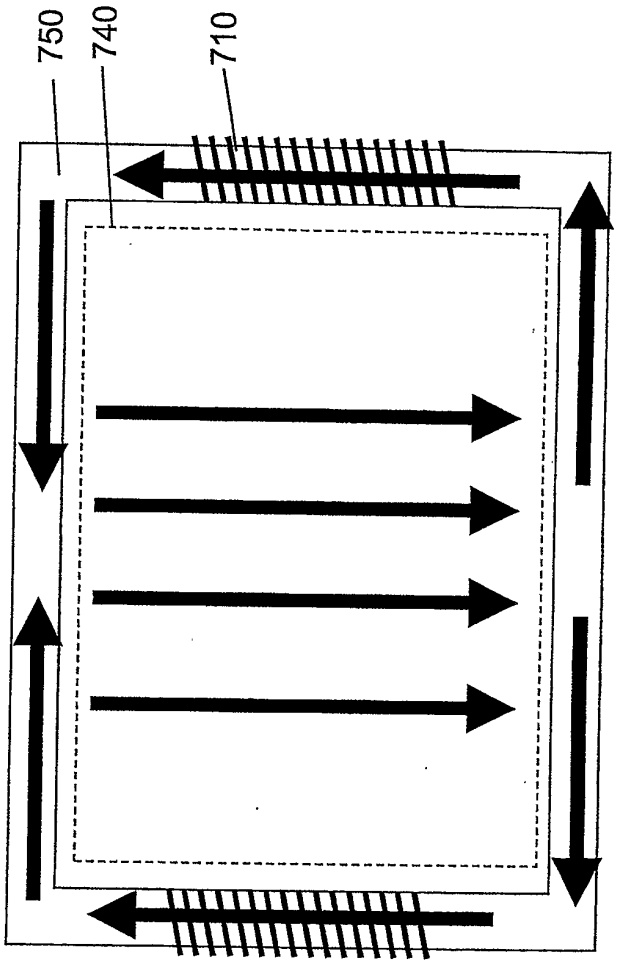


Figure 6f

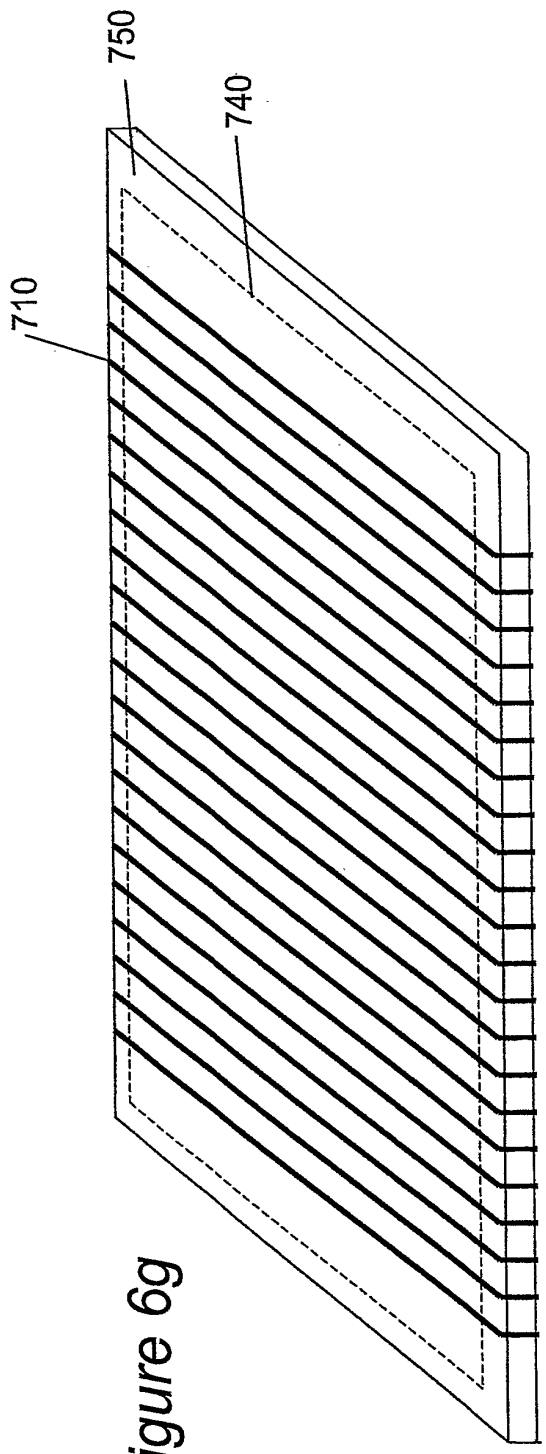


Figure 6g

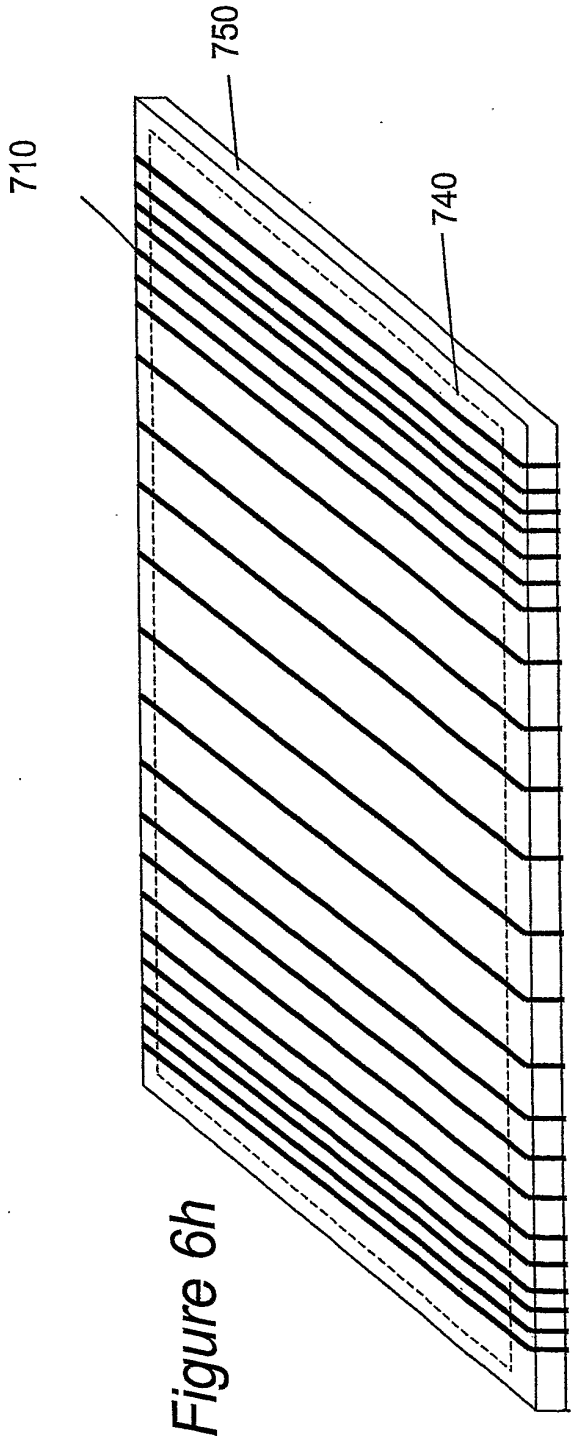


Figure 6h

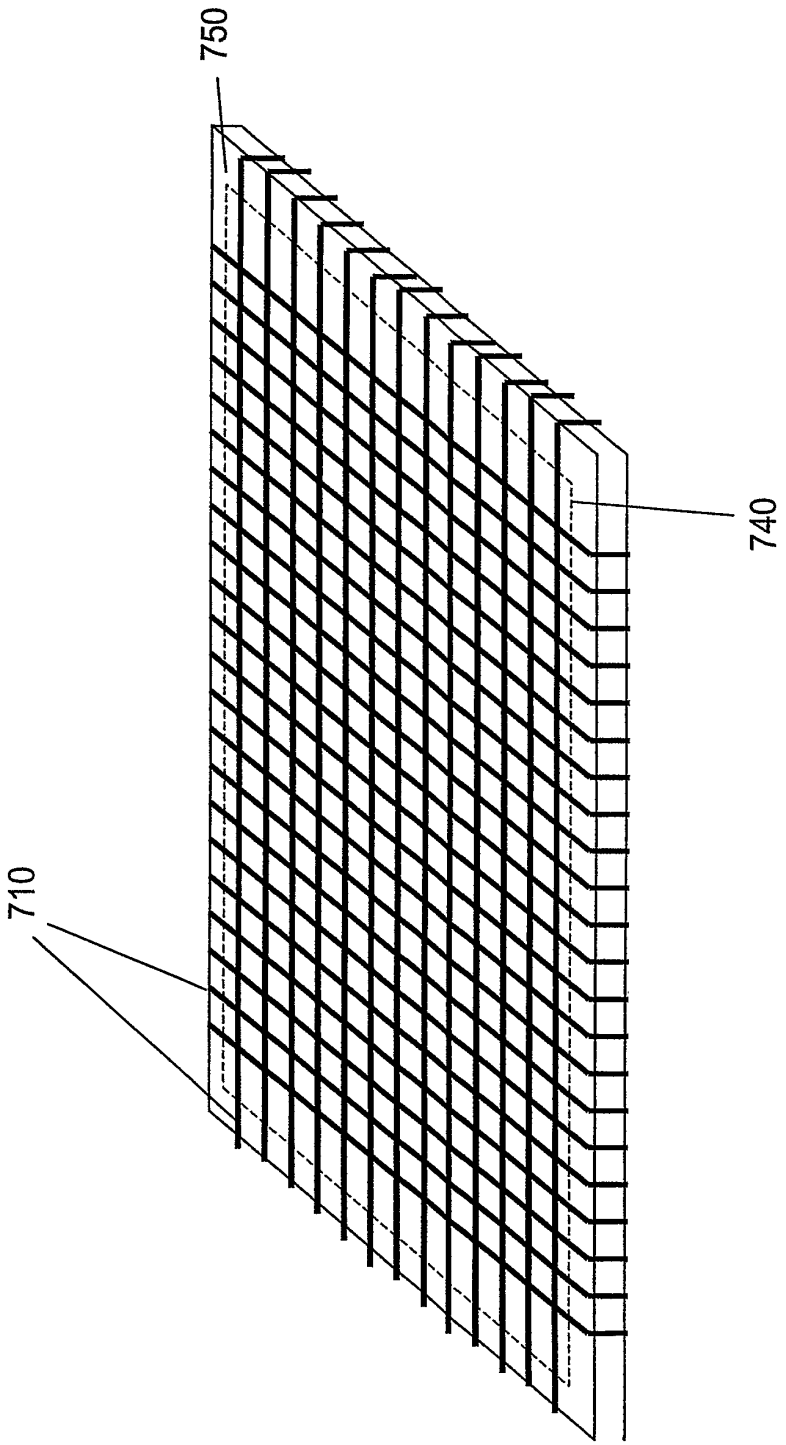


Figure 6i

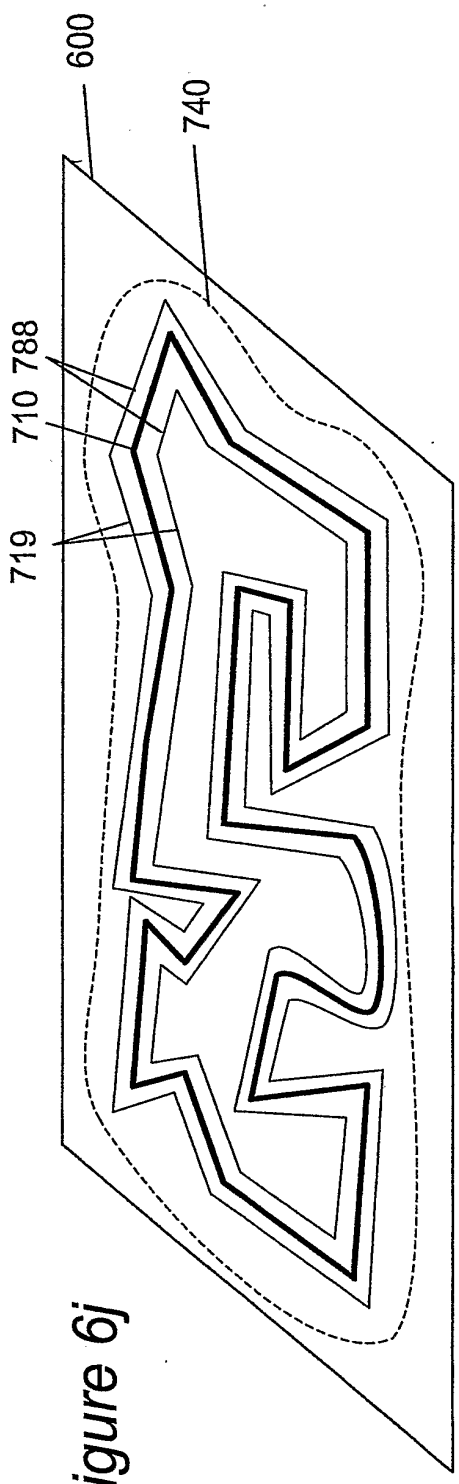


Figure 6j

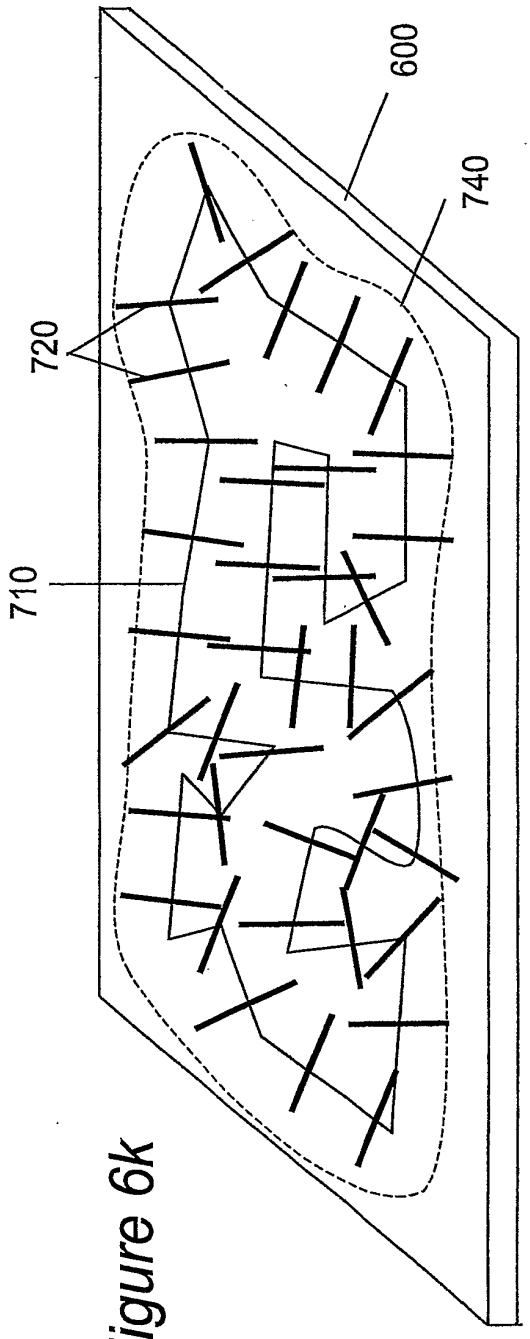


Figure 6k

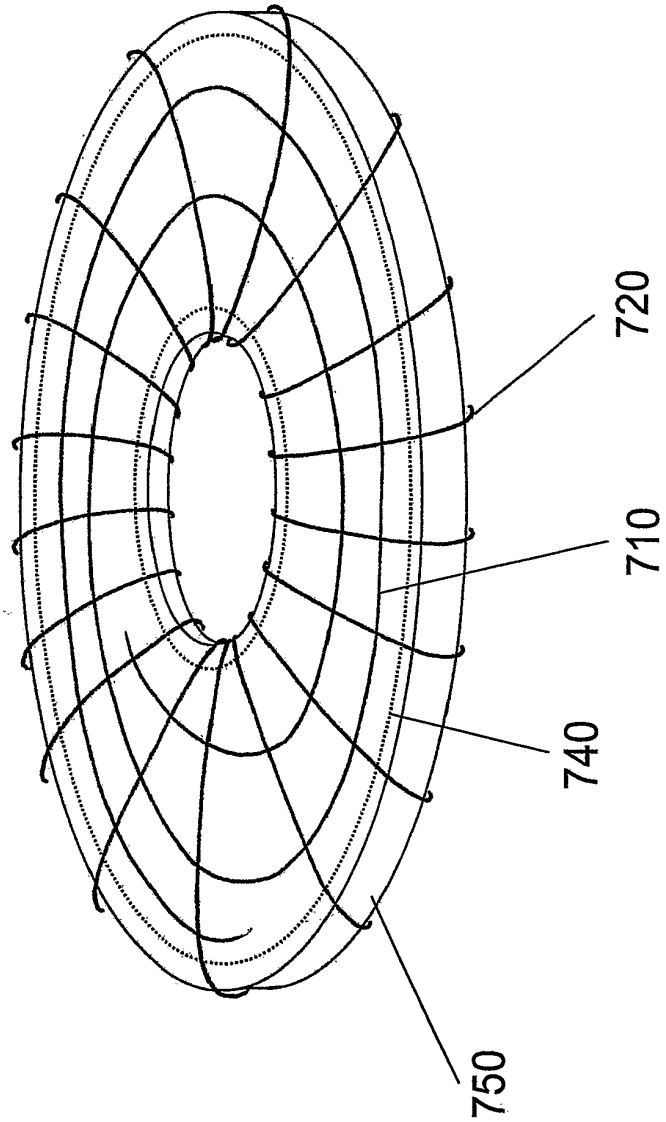


Figure 6L

Figure 7a

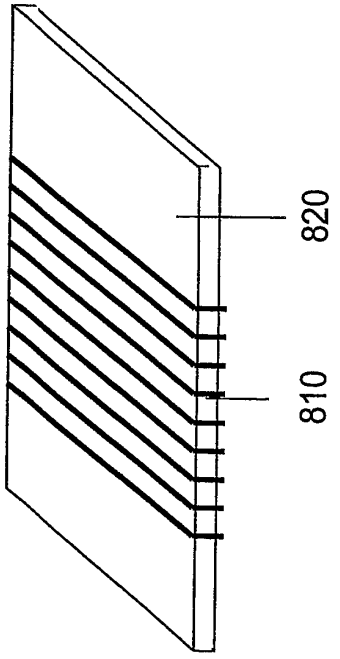
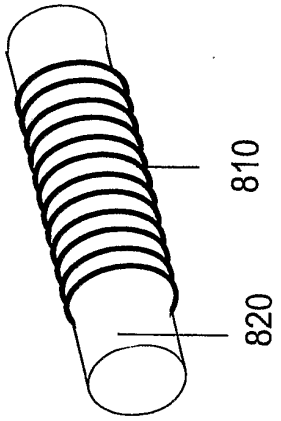
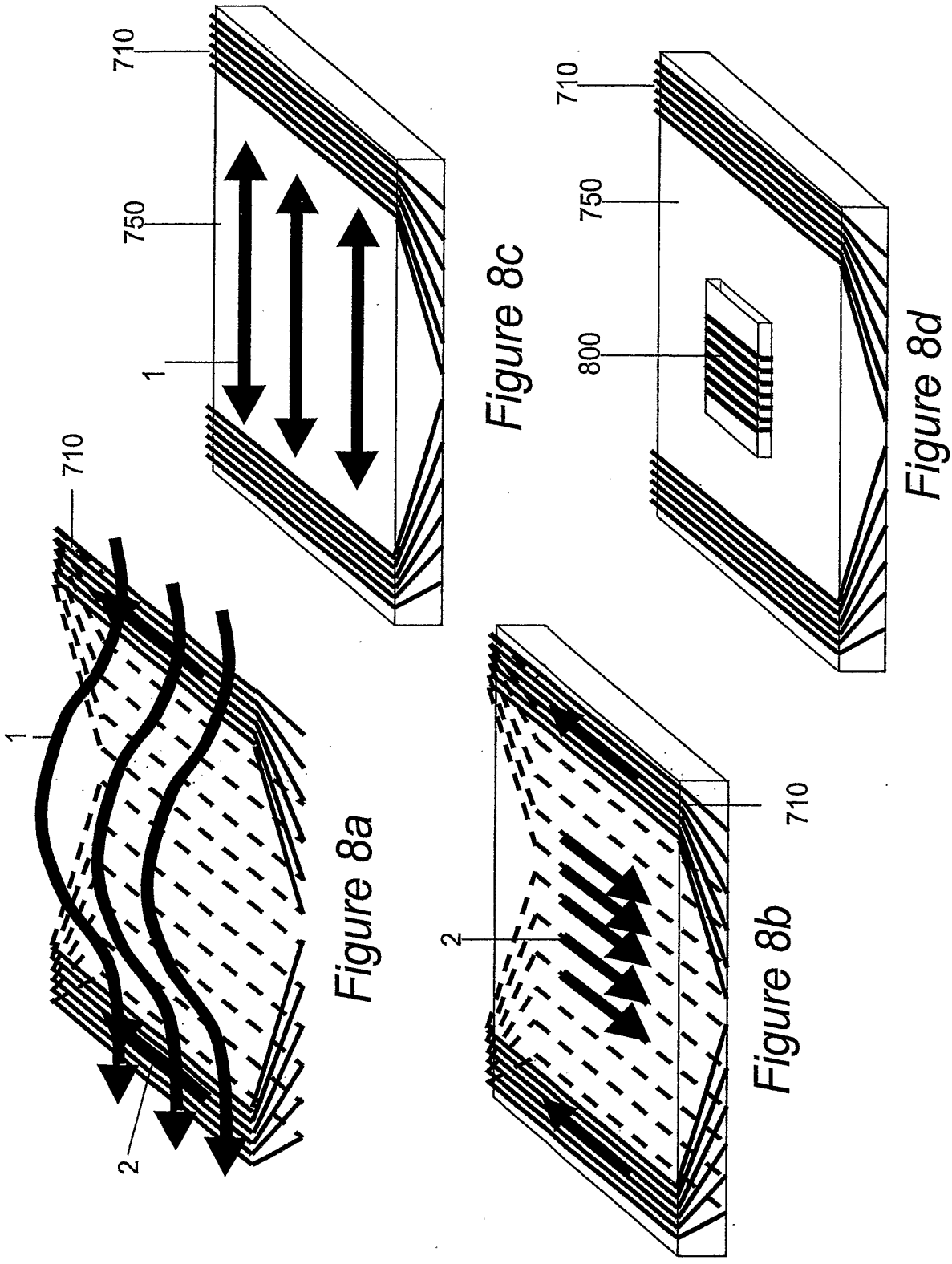


Figure 7b




710
750
1
Figure 8c
710
750
800
Figure 8d
710
1
2
Figure 8a
710
2
Figure 8b

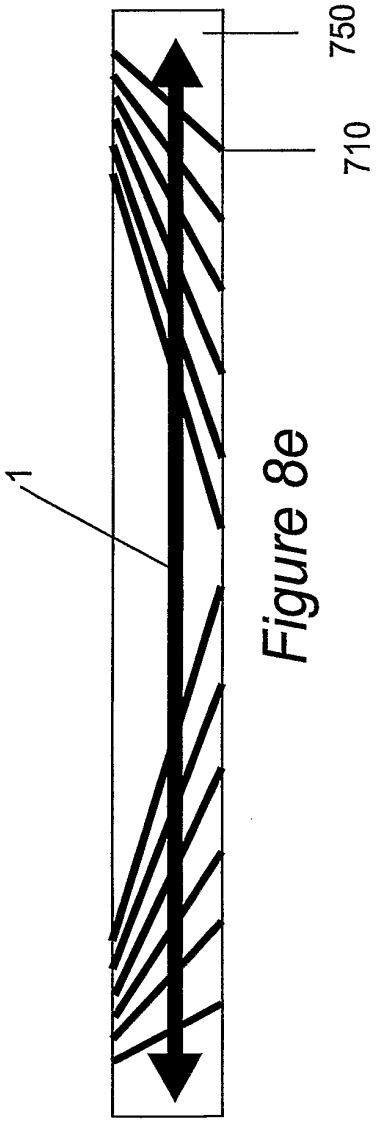


Figure 8e

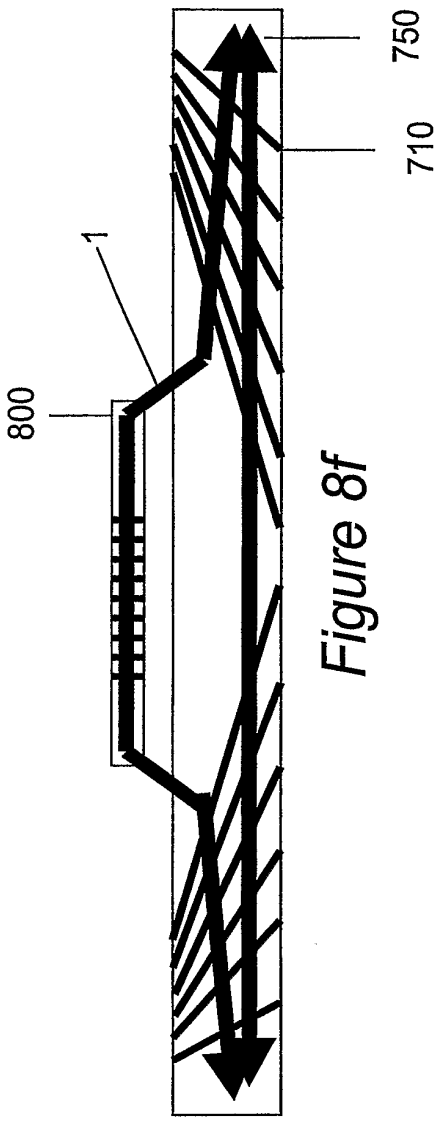


Figure 8f

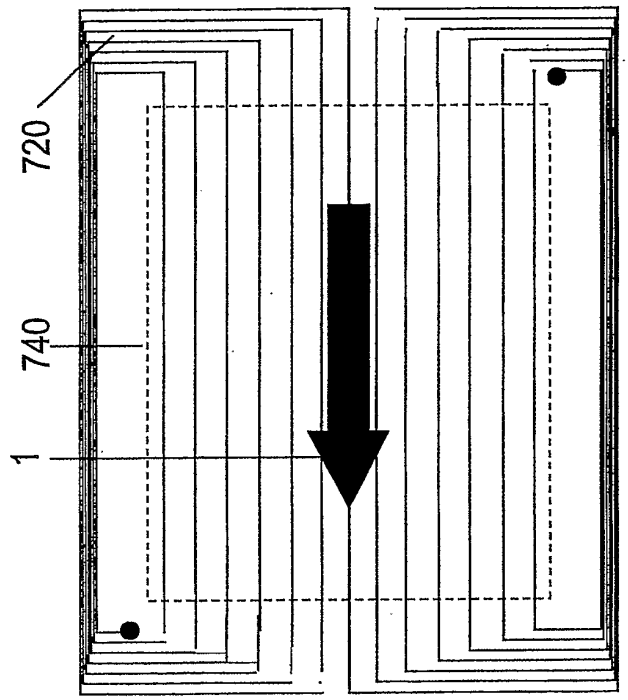


Figure 9b

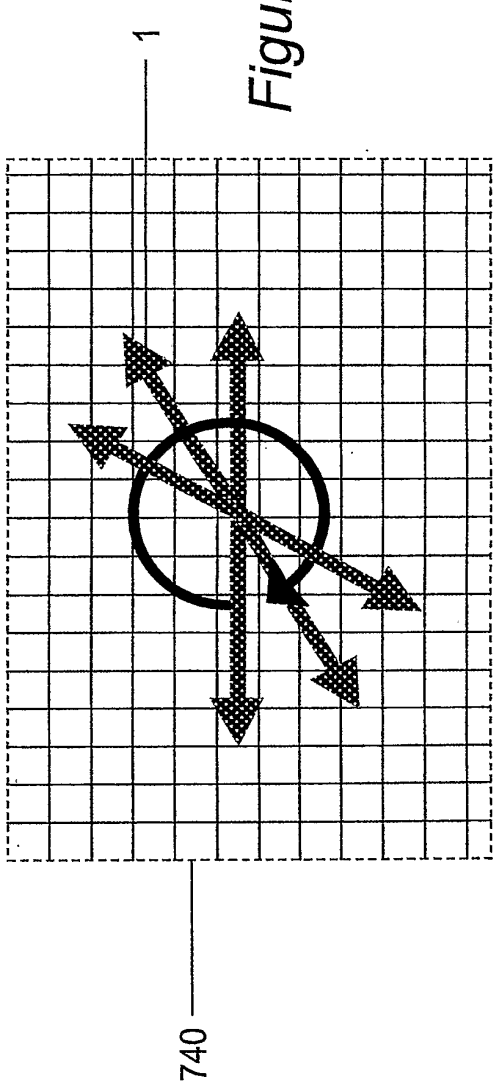


Figure 9c

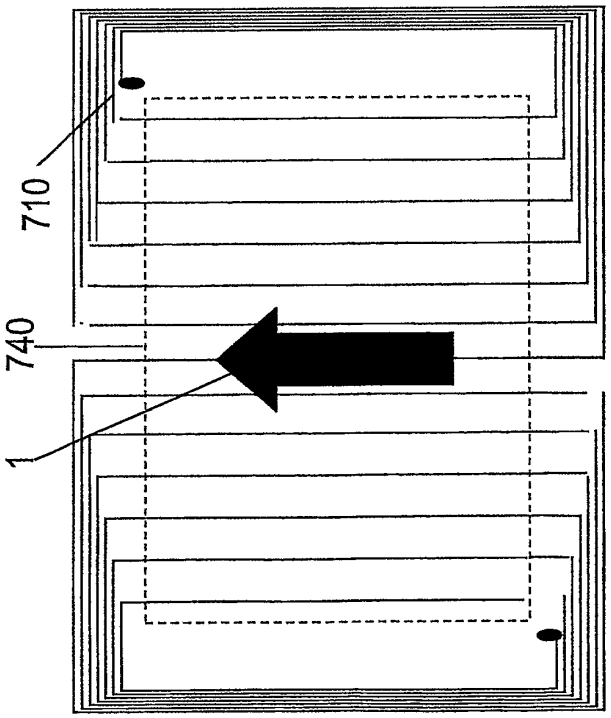


Figure 9a

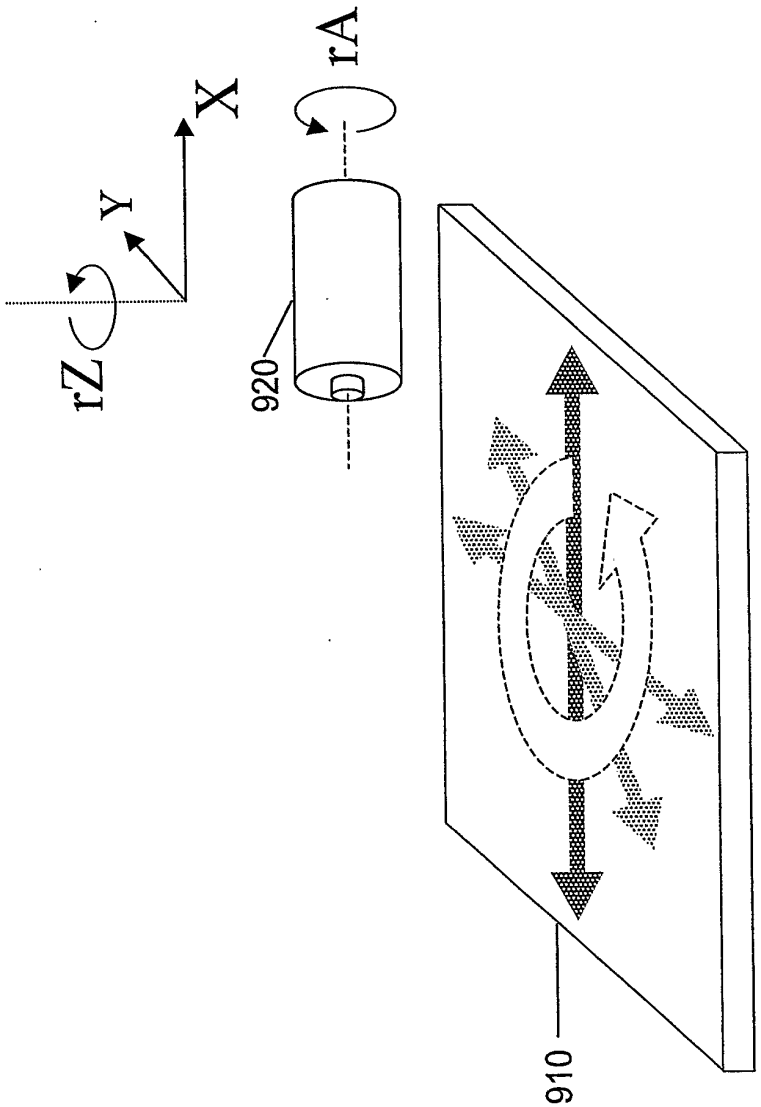


Figure 10

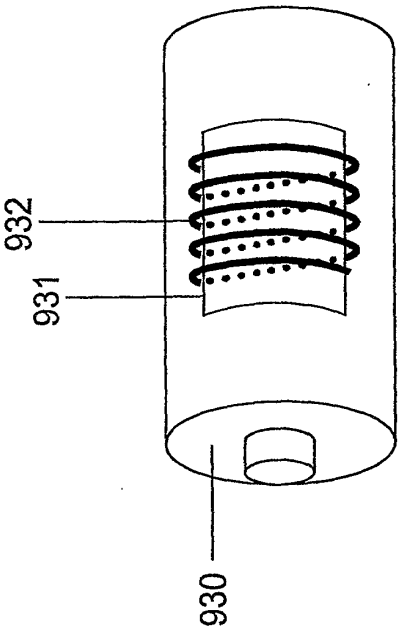


Figure 11b

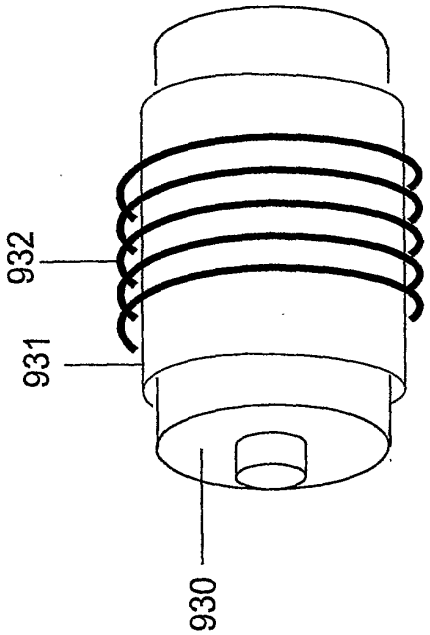


Figure 11a

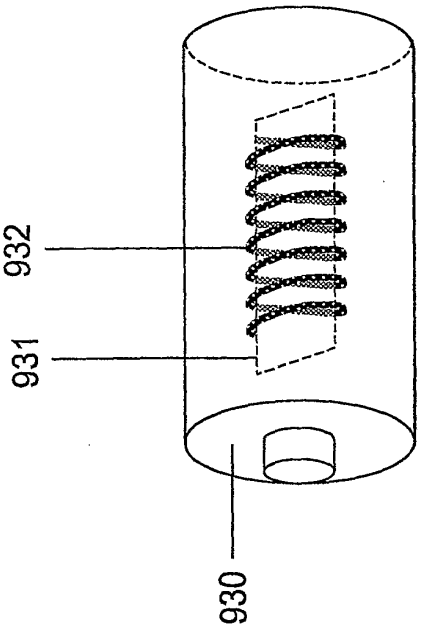


Figure 11c

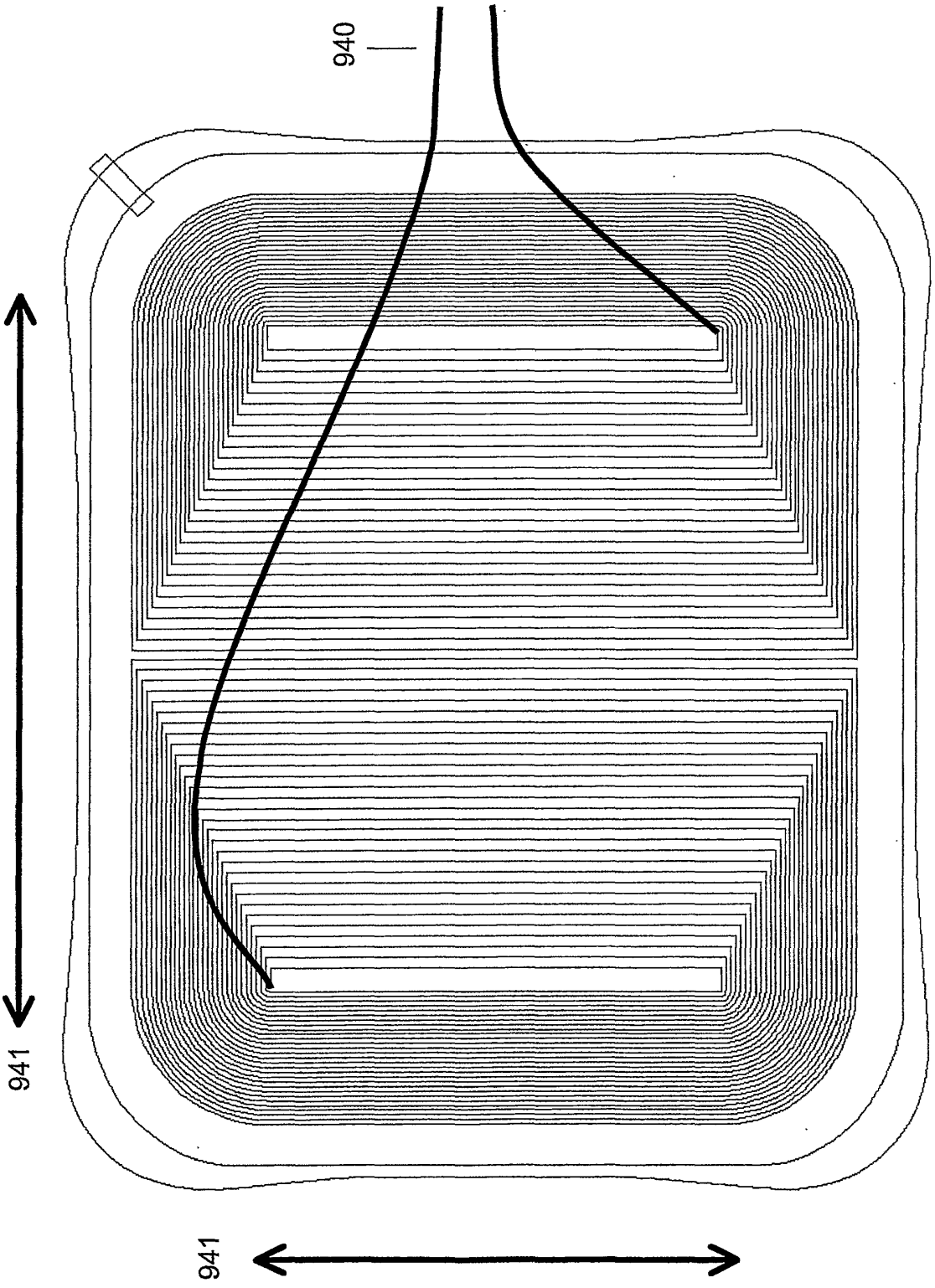


Figure 12a

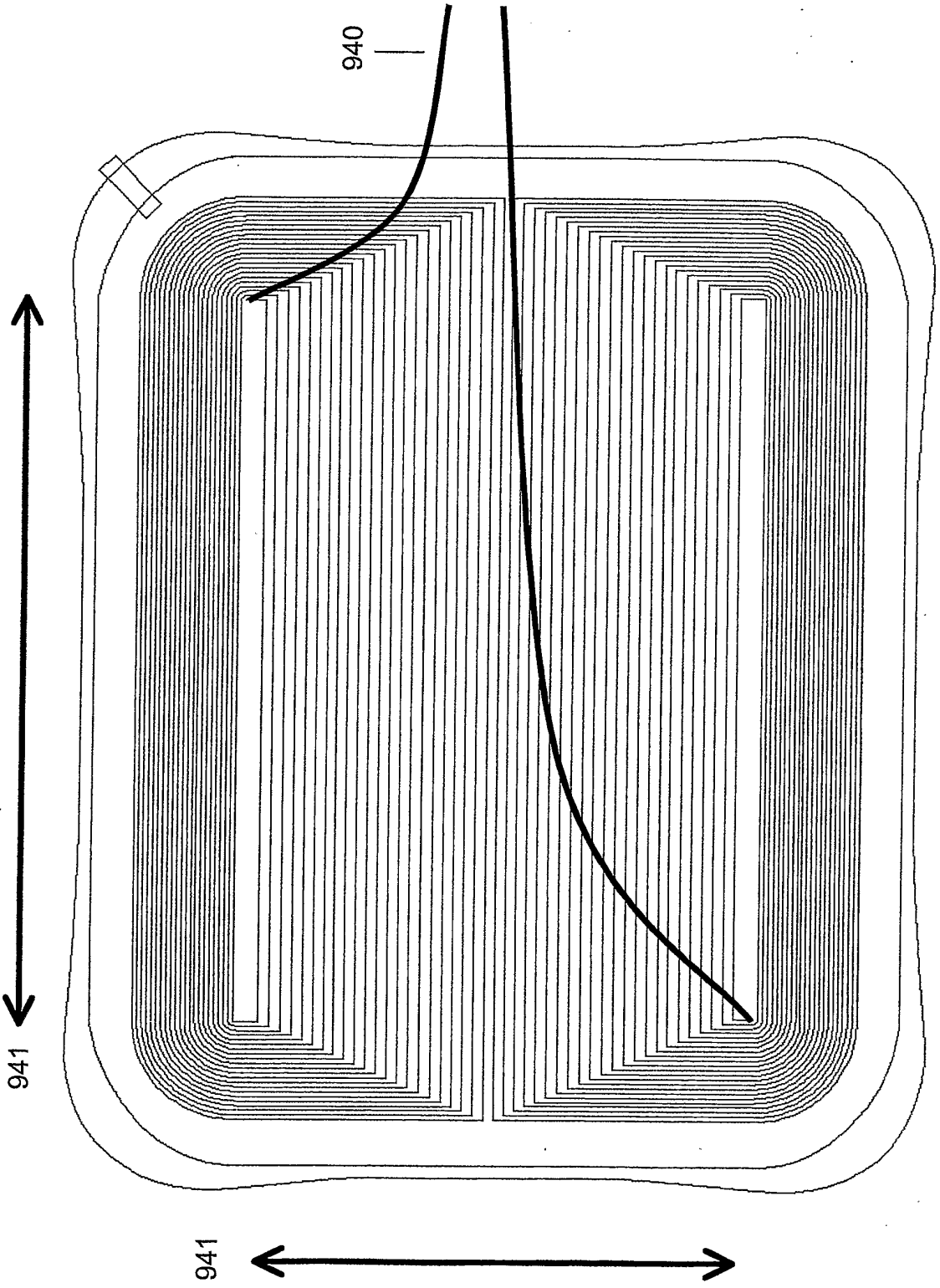
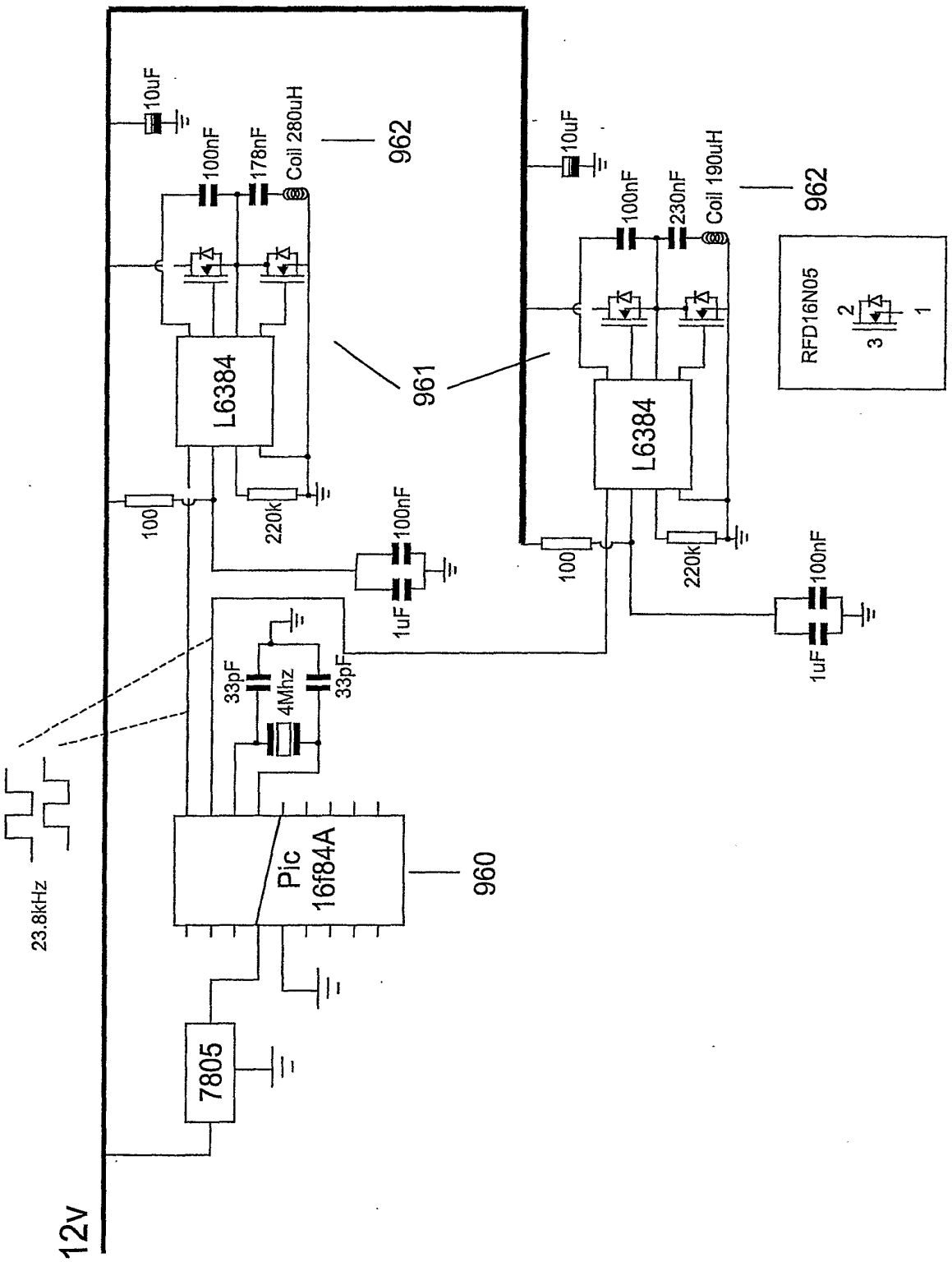


Figure 12b


12v
7805
Pic 16f84A
960
23.8kHz
33pF
4Mhz
33pF
L6384
961
962
10uF
100nF
178nF
Coil 280uH
100
220k
100nF
1uF
L6384
962
10uF
100nF
230nF
Coil 190uH
100
220k
100nF
1uF
RFD16N05
1
2
3

Fiaure 13

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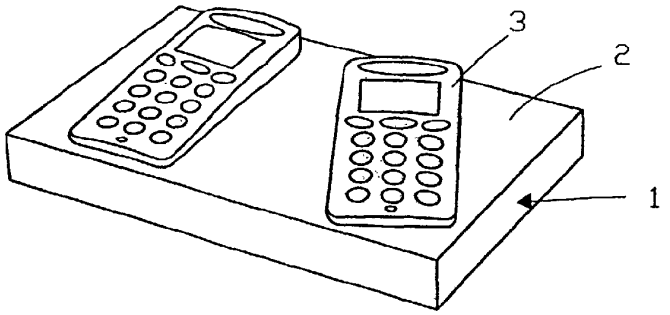
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(54) Title: PLANAR INDUCTIVE BATTERY CHARGER



(57) Abstract: There is provided a planar inductive battery charging system designed to enable electronic devices to be recharged. The system includes a planar charging module having a charging surface on which a device is placed. Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that couple energy inductively to a secondary winding formed in the device. The invention also provides secondary modules that allow the system to be used with conventional electronic devices not formed with secondary windings.

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PLANAR INDUCTIVE BATTERY CHARGER

FIELD OF THE INVENTION

This invention relates to a battery charger, and in particular to a battery charger having a planar surface on which one or more battery powered devices may be placed for battery recharging through induction. The invention also extends to a battery charging system for use with conventional electronic devices and that allows conventional electronic devices to be charged using the battery charging system of the present invention.

BACKGROUND OF THE INVENTION

Portable electronic equipment such as mobile phones, handheld computers, personal data assistants, and devices such as a wireless computer mouse, are normally powered by batteries. In many cases, rechargeable batteries are preferred because of environmental and economical concerns. The most common way to charge rechargeable batteries is to use a conventional charger, which normally consists of an AC-DC power supply (in case of using the ac mains) or a DC-DC power supply (in case of using a car battery). Conventional chargers normally use a cord (an electric cable for a physical electrical connection) to connect the charger circuit (a power supply) to the battery located in the portable electronic equipment. The basic schematic of the conventional battery charger is shown in Fig.1.

PRIOR ART

Inductive electronic chargers without direct physical electrical connection have been developed in some portable electronic equipment such as electric toothbrushes

where because they are designed to be used in the bathroom in the vicinity of sinks and water, it is not safe to provide a conventional electrical connection. US6,356,049, US6301,128, US6,118,249, also all describe various forms of inductive chargers. These inductive type chargers, however, use traditional transformer designs with windings wound around ferrite magnetic cores as shown in Fig.2. The main magnetic flux between the primary winding and secondary winding has to go through the magnetic core materials. Other contactless chargers proposed also use magnetic cores as the main structure for the coupled transformer windings.

A contactless charger using a single primary printed winding without any EMI shielding has been proposed by Choi et al in "A new contactless battery charger for portable telecommunications/computing electronics" ICCE International Conference on Consumer Electronics 2001 Pages 58-59. However, the magnetic flux distribution of a single spiral winding has a major problem of non-uniform magnetic flux distribution. As illustrated further below, the magnitude of the magnetic field in the centre of the core of a spiral winding is highest and decreases from the centre. This means that if the portable electronic device is not placed properly in the central region, the charging effect is not effective in this non-uniform field distribution. Furthermore, without proper EMI shielding, undesirable induced currents may flow in other metallic parts of the portable electronic equipment.

SUMMARY OF THE INVENTION

According to the present invention there is provided a battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer,

said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

In a preferred embodiment the primary winding is formed on a planar printed circuit board.

Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface. In this way the precise position and orientation of the electronic device on the charging surface is not critical. To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array.

In a preferred embodiment the primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface. This shielding may include a sheet of ferrite material, and more preferably also may further include a sheet of conductive material such as copper or aluminium

It is an advantage of the present invention that in preferred embodiments the planar charging surface may be large enough to receive two or more electronic devices, and the primary charging circuit is adapted to charge two or more devices simultaneously. In this way it is possible to charge more than one device simultaneously. For example the planar charging surface may be divided into a plurality of charging regions, which regions may be defined by providing a plurality of primary transformer windings arranged in a regular array and connecting the windings in groups to define said charging regions. A further advantage of the present invention is that it enables the possibility of allowing a device to move over the charging surface while being charged

at the same time. This possibility is particularly useful to a device which is designed to be moved such as a wireless computer mouse

Viewed from another aspect the present invention provides a battery charging system comprising a charging module comprising a primary charging circuit and being formed with a charging surface for receiving an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device.

Preferably the shielding comprises a sheet of ferrite material and a sheet of conductive material such as copper.

Preferably the winding is formed integrally with a back cover of said device.

An important aspect of the present invention is that it provides a battery charging system that employs a localised charging concept. In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged. In other words, when a device is placed on a planar charging surface that is greater in size than the device, energy is only transferred from that part of the planar charging surface that is directly beneath the device, and possibly also immediately adjacent areas that are still able to couple to the secondary coil.

Viewed from another aspect the present invention provides a battery charging system comprising a primary module and at least one secondary module, said primary

module comprising means for connecting to a mains supply, and at least one primary winding adjacent to a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent to a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

According to another aspect the invention also extends to a secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Fig.1 is a schematic view of a conventional prior art battery charger with direct electrical connection,

Fig.2 is a schematic view of a conventional magnetic core-based transformer as used in prior art inductive battery charger systems,

Fig.3 is a schematic view of a planar transformer with shielding,

Figs.4(a)-(c) are (a) a perspective view of a battery charger system according to an embodiment of the present invention, (b) a view similar to (a) but showing

the structure of the primary charging system, and (c) a view similar to (a) and (b) but showing the top cover removed for clarity,

Figs.5(a) & (b) show the structure of the primary charger with the top cover removed for clarity, and in Fig.5(a) with the structure shown in exploded view,

Figs.6(a) & (b) show (a) a single spiral PCB winding, and (b) the measured magnetic field distribution of a single spiral winding,

Figs.7(a) & (b) illustrate the use of a magnetic core to control magnetic field distribution,

Fig.8 shows an embodiment of the invention in which a plurality of primary windings are arranged in an array structure,

Figs.9(a) & (b) shows (a) a 4 x 4 primary winding array, and (b) the resulting magnetic field distribution,

Figs.10(a)-(c) illustrate an embodiment of the invention in which primary windings are arranged in groups with Fig.10(c) showing the equivalent circuit,

Fig.11 shows an example of the back cover of an electronic device designed to be recharged using an embodiment of the present invention,

Figs.12(a)-(d) show exploded views of the back cover of Fig.11,

Figs.13(a) & (b) show views of a watch that may be recharged in accordance with an embodiment of the invention,

Fig.14 shows a charging module in accordance with an alternative embodiment of the invention,

Fig.15 shows a first layer of a 4x5 winding array for use in a multi-layer embodiment,

Fig.16 shows a second layer of a 3x4 winding array for use in conjunction with the layer of Fig.15 in a multi-layer embodiment,

Fig.17 shows the layers of Fig.15 and Fig.16 in the two-layer structure,

Fig.18 is simplified version of Fig.15,

Fig.19 is a simplified version of Fig.16,

Fig.20 is a simplified version of Fig.17,

Fig.21 is a plot showing the smoothing effect of the two-layer structure,

Fig.22 shows a hexagonal spiral winding,

Fig.23 is a simplified form of Fig.22,

Fig.24 shows a single-layer of hexagonal spiral windings,

Fig.25 shows two adjacent hexagonal spiral windings,

Fig.26 shows the mmf distribution of the adjacent windings of Fig.25,

Fig.27 shows three adjacent hexagonal spiral windings and the peaks and minima of the flux distribution,

Fig.28 shows two overlapped layers of hexagonal spiral windings,

Fig.29 shows the location of the peak flux in the structure of Fig.28,

Fig.30 corresponds to Fig.29 but also shows the location of the flux minima,

Fig.31 shows an embodiment of the invention formed with three overlapped layers,

Fig.32 corresponds to Fig.31 but shows the location of the flux peaks,

Fig.33 is a plot showing the uniformity of the flux distribution along a line,

Fig.34 shows a square spiral winding,

Fig.35 is a simplified version of Fig.34,

Fig.36 shows a first layer of square spiral windings,

Fig.37 corresponds to Fig.36 but shows the location of the flux maxima and minima,

Fig.38 shows two overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.39 shows three overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.40 shows four overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.41 illustrates a battery charging system according to a further embodiment of the invention,

Fig.42 is a view similar to Fig.41 but part broken away to show the primary winding,

Fig.43 is a view similar to Fig.42 but of an alternate embodiment,

Figs.44(a) and (b) illustrate possible magnetic cores for use in the embodiment of Fig.42,

Fig.45 shows an equivalent circuit for the charging system of an embodiment of the invention,

Fig.46 illustrates an example of a secondary module for use in an embodiment of the invention,

Fig.47 shows a part broken away view of secondary module of an embodiment of the invention,

Fig.48 is a view similar to Fig.47 but of a further embodiment,

Fig.49 is a view showing the complete charging system according to an embodiment of the invention,

Fig.50 is a view similar to Fig.49 but showing how the charging system according to an embodiment of the invention can be used to charge multiple devices having different forms of charging connections, and

Fig.51 is a view illustrating how an embodiment of the present invention can be used to enable a conventional electronic device to be charged using an inductive charging platform as shown in Fig.4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described in respect of a preferred embodiment in the form of an inductive battery charger for portable electronic equipment such as mobile phones, handheld computers and personal digital assistants (PDA), and devices such as a wireless computer mouse.

Referring firstly to Fig.4, the inductive charger system comprises two modules, a power delivering charger module that contains the primary circuit of a planar isolation transformer and a secondary circuit that is located in the portable electronic equipment to be charged. In this embodiment of the invention, the charger circuit is located within a housing 1 that is formed with a flat charging surface 2. The secondary circuit is formed in the portable equipment to be charged (in this example a mobile phone 3) and the equipment is formed with at least one planar surface. As will be seen from the following description the equipment is charged simply by placing the equipment on the surface so that the planar surface on the equipment is brought into contact with the flat charging surface 2. It is a particularly preferred aspect of the present invention that the equipment to be charged does not have to be positioned on the charging surface in any special orientation. Furthermore, in preferred embodiments of the invention two or more mobile devices may be charged simultaneously on the same charging surface, and/or a device that is designed to be moved (such as a wireless computer mouse) can be charged while being moved over the charging surface (which could be integrated into a computer mouse pad). It will also be seen from the following description that the energy

transfer is "localised" in the sense that energy is only transferred from the charging surface to the device from that part of the charging surface that is directly beneath the device (and possibly to a lesser extent regions adjacent thereto).

Referring in particular to Fig.4(b) the primary charging module comprises a printed circuit board 4 formed with at least one spiral conductive track formed thereon as a primary winding. It will be understood, however, that the primary winding need not necessarily be formed on a PCB and could be formed separately. Alternatively, multiple PCBs each formed with at least one winding could be "stacked" on top of each other to increase the total flux. Preferably, as will be described further below, there are in fact a plurality of such spiral tracks disposed in an array as shown in Fig.4(c) in which a top insulating sheet has been removed for clarity. Beneath the PCB 4 (ie the side of the PCB away from the charging surface) is provided EMI shielding comprising firstly a ferrite sheet 5 adjacent the PCB 4, and then a conductive sheet 6 which in this example may be a copper sheet. Beneath the copper sheet 6 may be provided any suitable form of substrate material 7, eg a plastics material. Above the PCB 4 may be provided a sheet of insulating material 8 which forms the charging surface. Preferably the PCB 4, the EMI shielding sheets 5,6, the substrate 7 and the insulating cover sheet 8 may also be generally the same size and shape, for example rectangular, so as to form the primary charging module with the charging surface being large enough to accommodate at least one, and more preferably two or more, devices to be charged. Figs.5(a) and (b) also show the structure of the charging module without the cover sheet and without any devices to be charged thereon for the sake of clarity.

As shown in Fig.4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings. The secondary winding is also planar and is located in the

portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit. The rectified DC voltage is applied to the battery via mechanical contacts provided in an integrated back cover as will be described further below. No physical electrical connection between the primary charger circuit and the portable electronic equipment is needed.

The primary charger circuit has (1) a switched mode power electronic circuit, (2) the primary side of a planar transformer that consists of a group of primary windings connected in series or in parallel or a combination of both, (3) an EMI shield and (4) a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The schematic of the primary charger system is shown in Fig.5(a) and (b) without the insulating cover.

The battery charging system can be powered by AC or DC power sources. If the power supply is the AC mains, the switched mode power electronic circuit should perform a low-frequency (50 or 60Hz) AC to DC power conversion and then DC to high-frequency (typically in the range from 20kHz to 10MHz) AC power conversion. This high-frequency AC voltage will feed the primary planar windings of the primary charger circuit. If the power supply is a battery (e.g. a car battery), the switched mode power supply should perform a DC to high-frequency AC power conversion. The high-frequency voltage is fed to the primary windings of the planar transformer.

Preferably, the charger should be able to charge one or more than one items of portable electronic equipment at the same time. In order to achieve such a function, the AC magnetic flux experienced by each item of portable equipment placed on the charging surface should be as even as possible. A standard planar spiral winding as

shown in Fig.6(a) is not suitable to meet this requirement because its flux distribution is not uniform as shown in Fig.6(b) when the winding is excited by an AC power source. The reason for such non-uniform magnetic flux distribution is that the number of turns in the central region of the single spiral winding is largest. As the magnitude of the magnetic flux and the magnetomotive force (mmf) is proportional to the product of the number of turn and the current in the winding, the magnetic flux is highest in the centre of the winding.

One method to ensure uniform magnetic flux or mmf distribution is to use a concentric primary winding with a planar magnetic core as shown in Fig.7(a). This magnetic core-based approach allows the magnetic flux to concentrate inside the core and typical magnetic flux distribution is shown in Fig.7(b). In general, the flat charging interface surface of the primary charger should be larger than the total area of the portable electronic equipment.

In order to ensure that more than one item of portable electronic equipment can be placed on the flat charging surface and charged simultaneously, a second and more preferred method proposed is to ensure that the magnetic flux distribution experienced by each items of portable electronic equipment is as uniform as possible. This method can be realized by using a "distributed" primary planar transformer winding array structure as shown in Fig.8. This planar winding array consists of many printed spiral windings formed on the PCB. These printed spiral windings can be hexagonal, circular, square or rectangular spirals, and can be connected in series, in parallel or a combination of both to the high-frequency AC voltage generated in the power supply in the primary charger circuit. The array should comprises relatively closely spaced coils so as to be able to generate the required near-uniform magnetic flux distribution, as an array of widely spaced apart coils may not generate such a near-uniform field.

Fig.9(a) shows a practical example with the transformer winding array connected in series so that all the fluxes created in the windings point to the same direction. Fig.9(b) show the measured flux distribution of one planar transformer when the windings in the transformer array are connected in series. This measurement confirms the near uniform magnetic flux distribution of the array structure. Comparison of Fig.6(b) and Fig.9(b) confirms the improvement of the uniform magnetic field distribution using the transformer array structure. In addition, this transformer array structure provides for the possibility of multiple primary transformer windings being provided for localized charging as will now be explained.

The primary transformer windings can also take the form of a combination of series and parallel connections if desired. Such an arrangement allows the charging surface to be divided into various charging regions to cater for different sizes of the secondary windings inside the portable electronic equipment. Fig.10(a) illustrates this localized charging zone principle. Assume that the transformer array is divided into 4 zones (A, B, C, and D). The transformer windings within each zone are connected in series to form one primary winding group with the distributed magnetic flux feature. There will be four primary windings in the equivalent circuit as shown in Fig.10(c). If the portable electronic equipment is placed on Zones A and B as shown in Fig.10(b), the equivalent electrical circuit is shown in Fig.10(c). Only the parallel primary transformer winding groups for Zones A and B are loaded because they can sense a nearby secondary winding circuit in the portable electronic equipment. Therefore, they will generate magnetic flux in Zones A and B. Primary transformer windings C and D are not loaded because they have no secondary transformer circuit close to them and their equivalent secondary circuits are simply an open-circuit (Fig.10(c)). As a result, power transfer between the primary charger circuit and the secondary windings inside the

portable electronic equipment takes place basically through the coupled regions (areas) of the charging interface surface covered by the portable electronic equipment. The non-covered area of the charging surface will transfer virtually no energy. This special design avoids unnecessary electromagnetic interference. A further advantage of this localised energy transfer concept, is that it enables a movable device (such as a wireless computer mouse) to be continually charged as it moves over the charging surface. In the case of a wireless computer mouse, for example, the primary charging circuit could be integrated into a mousepad and the mouse may be charged as it rests on and/or moves over the mousepad.

The back cover of the portable electronic equipment is a detachable back cover shown in Fig.12(a) that covers the battery and which may be removed when the battery is replaced. In preferred embodiments of the present invention, this back cover has a built-in secondary planar transformer winding 10, a diode rectifier circuit 13 and preferably a thin EMI shield 11,12 as shown in Fig.12(b) & (c). When the back cover side of the portable equipment is placed near the flat charging surface of the primary charger circuit, this secondary winding couples the energy from the nearby primary transformer winding or windings. The rectifier circuit rectifies the coupled AC voltage into a DC voltage for charging the battery through mechanical contacts 14. This rectifier circuit also prevents the battery from discharging into the secondary winding. In order to avoid induced circuit from circulating in other metal parts inside portable electronic circuit, it is preferable to include a thin EMI shield as part of the integrated back cover structure as shown in Fig.12. This EMI shield can be a thin piece of ferrite material (such as a flexible ferrite sheet developed by Siemens) or ferrite sheets, or more preferably a combination of a ferrite sheet 11 and then a thin sheet 12 of copper of another conductive material such as aluminium..

It will thus be seen that, at least in its preferred forms, the present invention provides a new planar inductive battery charger for portable electronic equipment such as mobile phones, handheld computers, personal data assistant (PDA) and electronic watches, and wireless computer mice. The inductive charger system consists of two modules, including (1) a power delivering charger circuit that contains the primary circuit of a planar isolation transformer and a flat charging surface and (2) a separate secondary transformer circuit that consists of a printed winding, a rectifier and preferably a thin EMI shield and which is located in the portable electronic equipment to be charged.

An advantage of the present invention, at least in preferred forms, is that the primary charger circuit system has the primary side of a planar transformer and a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The secondary circuit can be integrated into the back cover of the portable electronic device or separately placed inside the electronic device. The invention also extends to a back cover design with an in-built secondary circuit for the portable equipment. The secondary winding of the planar transformer can be EMI shielded and integrated into the back cover adjacent to the battery in the portable electronic device. As long as the back cover sides of the portable electronic device are placed on the charger surface, one or more portable electronic devices can be charged simultaneously, regardless of their orientations.

Figs.13(a) and (b) show how an embodiment of the invention may be used to recharge a watch battery. A watch is formed with a basic watch mechanism 20, which is powered by a rechargeable battery 21. The watch mechanism is shielded from electrical interference in the charging process by an EMI shield consisting of, for example, a copper sheet 22 and a ferrite sheet 23 (with the copper sheet closer to the watch

mechanism than the ferrite sheet). The other side of the EMI shield is provided a planar coreless transformer secondary winding 24 formed with electrical contacts 26 for connection to the battery 21 and with a rectifier circuit to prevent discharge of the battery. Finally, the watch structure is completed by the provision of a planar back cover 25 formed of non-metallic material. It will be understood that the watch battery may be recharged by placing the watch on the charging surface of a battery charging system as described in the above embodiments such that the back cover 25 lies flat on the planar charging surface. Electrical energy is then coupled from the primary winding(s) in the battery charging module to the secondary winding in the watch and then to the rechargeable battery.

In the embodiments described above the charging module is formed as a single integral unit (as shown for example in Figs.4 and 5). However, in some situations it may be desirable to separate the electronic charging circuit from the planar charging surface. This possibility is shown in Fig.14 in which the electronic charging circuit 30 is connected by a cable 31 to the charging surface 32. The charging surface 32 includes an insulating top cover, the planar primary windings printed on a PCB, and a bottom EMI shield formed of ferrite and a conductive sheet such as copper. This embodiment has the advantage that the charging surface is relatively thin, and therefore may be useful for example when the device to be charged is a wireless computer mouse because the charging surface can double as a mousepad as well as a charging surface.

In the embodiments described above a single layer of transformer arrays is provided. However, in order to generate a more uniform magnetic field distribution, multi-layer transformer arrays can be used. The following embodiments describe how multiple layers of transformer arrays may be used that can provide a very uniform magnetic field distribution on the charging surface.

Fig.15 shows a 4x5 primary planar transformer winding array which consists of square-sprial winding patterns. This can be fabricated on one layer of the printed circuit board structure. It should be noted that, for an individual winding pattern in the array, the magnitude of the magnetic flux is highest in the center of the spiral winding. The magnitude of the magnetic flux is smallest in the small gap between adjacent winding patterns.

A second layer with a 3x4 transformer winding array is shown in Fig.16. The individual winding patterns in both layers are identical. As shown in Fig.17, by having the two layers of arrays arranged in such a manner that the center (region of maximum magnetic flux magnitude) of a winding pattern on one layer is placed on the gap (region of minimum magnetic flux magnitude) between adjacent winding patterns on the other layer, the variation of the magnetic field magnitude can be minimized and the magnetic flux magnitude can therefore be made as even as possible over the overlapped surface. The essence of the multi-layer transformer arrays is to have a displacement between the individual winding patterns of the two layers so that the regions of the maximum magnetic field magnitude of one layer is "evened out" by the regions of the minimum magnetic field magnitude.

In order to examine the 'uniform magnetic field magnitude' feature of the proposed overlapped multi-layer transformer arrays, this 'magnitude smoothing' concept is illustrated in simplified diagrams in Fig.18 to 20. Fig.18 is a simplified version of Fig.15. Each solid square in Fig.18 represents a square-spiral winding pattern in the first layer (Fig.15). Fig.19 is a simplified version of the Fig.16. Each dotted square represents a square-spiral winding pattern in the second layer (Fig.16). The simplified version of the multi-layer array structure is shown in Fig.20. From Fig.20, it can be seen that the overlapped array structure (with correct displacement between the

two layers) divides each square-spiral winding pattern into four smaller sub-regions. The important feature is that the four sub-regions are identical in terms of winding structure. Despite that fact that the distribution of the magnetic field magnitude on the surface of each individual square-spiral winding is not uniform, the distribution of the resultant magnitude field magnitude on the surface of each sub-region is more or less identical because of the overlapped multi-layer winding structure. The concept of the generating uniform magnetic field magnitude over the charging surface is illustrated in Fig.21.

In this example, a multi-layer transformer winding array structure that can provide a uniform magnetic field magnitude distribution is described. This example is based on square-spiral winding patterns. In principle, winding patterns of other shapes can also be applied as long as the resultant magnetic field magnitude distribution is as uniform as possible.

The use of two layers of transformer arrays can reduce the variation in the magnetic flux over the charging surface. However, there may still be some variations and the use of a three or four layer structure may provide a still more uniform flux distribution as described in the following embodiments.

The following embodiment is a structure comprising three layers of planar winding arrays. This PCB winding structure can generate magnetomotive force (*mmf*) of substantially even magnitude over the charging surface. Each winding array consists of a plurality spiral windings each of which are of an hexagonal shape. A spiral winding arranged in a hexagonal shape is shown in Fig.22. For simplicity, it will be represented as a hexagon as shown in Fig.23. A plurality of hexagonal spiral windings can be arranged as an array as shown in Fig.24. These windings can be connected in parallel, in series or a combination of both to the electronic driving circuit. If a current passes

through each spiral winding pattern, a magnetomotive force (*mmf*), which is equal to the product of the number of turns (*N*) and current (*I*) (i.e. *NI*), is generated. Fig.25 shows two spiral winding patterns adjacent to each other and the per-unit *mmf* plot over the distance (dotted line) can be linearized as shown in Fig.26. It can be seen that the *mmf* distribution over the distance is not uniform. The maximum *mmf* occurs in the center of the hexagonal pattern and the minimum *mmf* occurs in the edge of the pattern.

Fig.27 shows three adjacent windings. The maximum *mmf* region is labelled by a symbol 'P' (which stands for Peak *mmf*). The minimum *mmf* region at the junction of two patterns is labeled as 'V' (which stands for Valley of the *mmf* distribution). In order to generate a uniform *mmf* distribution over the planar charging surface, two more layers of PCB winding arrays should be added. This principle is explained firstly by adding a second layer of PCB winding array to the first one as shown in Fig.28. The second layer is placed on the first one in such a way that the peak *mmf* positions (P) of the patterns of one layer are placed directly over the valley positions (V) of the patterns in the other layer. Fig.29 highlights the peak positions of the patterns that are directly over the valley positions of the other layer for the two overlapped PCB layers in Fig.28.

It can be observed from Fig.29, however, that the use of two layers of PCB winding arrays, while presenting an improvement over a single layer, does not offer the optimal solution for generating uniform *mmf* over the inductive charging surface. For each hexagonal pattern in the 2-layer structure, the peak positions occupy the central position and three (out of six) vertices of each hexagon. The remaining three vertices are valley positions (V) that need to be filled by a third layer of PCB winding arrays. These valley positions are shown in Fig.30 as empty squares.

Careful examination of Fig.30 shows that there are six peak positions (P) surrounding each valley position. Therefore, a third layer of a hexagonal PCB winding

array can be used to fill up all these remaining valley positions. By placing the central positions (peak *mmf* positions) of the hexagonal winding patterns of the third layer of the PCB winding array over the remaining valley positions of the two-layer structure, an optimal three-layer structure is formed as shown in Fig.31. Fig.32 highlights the peak *mmf* positions of the three-layer structure. It can be observed that all central positions and vertices of all hexagonal patterns have peak *mmf*.

In order to confirm that the *mmf* over the surface has uniform *mmf* distribution, any distance between any two adjacent peak *mmf* positions can be considered as illustrated in Fig.33. If the winding patterns are excited in the same manner and polarity so that the *mmf* generated by each layer of the winding array are always in the same direction at any moment, the resultant *mmf* is simply the sum of the *mmf* generated by each layer. The dotted line in Fig.33 shows that the resultant *mmf* over the distance between any two adjacent peak positions in Fig.33 is equal to 1.0 per unit. This confirms that the proposed three-layer PCB winding array structure can be used to generate highly uniform *mmf* over the inductive charging surface. When used as a contactless, inductive charging surface, this uniform *mmf* distribution feature ensures that, for a given airgap, a secondary PCB coupling winding can always couple the same amount of magnetic flux regardless of the position of the secondary (coupling) PCB on the inductive charging surface. In addition, the voltage induced in the secondary winding would be the same over the inductive charging surface.

In another embodiment, the three-layer PCB winding array structure can be constructed as a four-layer PCB, with one of the four layers accommodating the return paths of the spiral windings to the electronic driving circuit.

A further embodiment is based again on square spiral winding patterns. In this embodiment four layers of square-spiral winding arrays are used to generate highly

uniform *mmf* over the PCB surface. As in the hexagonal embodiment described above, for convenience of illustration each square-spiral winding pattern (Fig.34) is simplified as a square symbol (Fig.35) in the following description.

Fig.36 shows the first layer of the square-spiral PCB winding array. The *mmf* in the central region of each square pattern is highest. These regions are highlighted as 'Peak' or (P) in Fig.37. The regions of the minimum *mmf* (i.e. the valleys) occurs along the edges of the square patterns. These regions are highlighted with dots (•) in Fig.37.

In order to reduce the *mmf* ripples on the surface, the peak (P) positions of a second layer of square-spiral PCB winding array can placed over some of the valley positions (•) as shown in Fig.38. When a third layer of square-spiral PCB winding array is added to the structure in Fig.38, the resultant layout is shown in Fig.39. It can now be observed that one more layer of the square-spiral PCB windings is needed to fill up all the valleys with peaks as shown in Fig.40.

The inductive battery charging platform described above, which can be regarded as the primary circuit of a transformer system (or the primary inductive charging system), can be used as a standard battery charging platform for portable electronic equipment with compatible inbuilt secondary circuitry in the electronic equipment to be charged. However, existing electronic equipment that is not designed for compatibility with the abovedescribed battery charging platform cannot take advantage of the convenience offered by the battery charging platform. Another embodiment of the present invention therefore provides both a battery charging system that can stand independently and can be used to charge existing conventional devices, and a means by which a conventional electronic device can be charged using the charging platform described above.

Referring firstly to Fig.41 there is shown therein a perspective view of a part of a battery charging system according to an embodiment of the present invention. The part of the charging system shown in Fig.41 may be termed the primary inductive charging system since as will be explained below it comprises at least one primary winding. The part of the battery charging system shown in Fig.41 may also be considered to be an extension system since in preferred forms it may be adapted to charge multiple devices and is therefore analogous to a conventional extension lead that allows multiple items of electronic equipment to share the same power socket.

The charging system is provided with multiple charging slots 100,101,102 for receiving secondary charging modules to be described further below. As will be explained further below each charging slot is provided with a primary winding. Fig.41 shows a schematic of the primary inductive charging extension system with three charging slots. However, it should be noted that the number of slots is not restricted to three and can be as few as a single charging slot, or can be more than three. It will be understood that the number of charging slots dictate the number of devices that can be charged simultaneously. The primary charging extension system is connected to the mains through a plug 103 and includes a power electronic circuit 104 that provides a high-frequency (typically in the range of 1kHz to 2MHz) AC voltage to the primary windings that are located under the charging slot surfaces. It should be noted that the surfaces of the slots are flat and the slots are separated from each other by dividing walls. Each slot is therefore the same size as the surface of a housing of a secondary module to be described below, and the separating walls and mechanical switches to be described below together act to engage a secondary module and hold it in a correct orientation for efficient charging.

Each primary winding can be a coil 105 as shown in Fig.42 or a printed-circuit-board (PCB) winding 106 as shown in Fig.43. If the primary winding is a coil 105, the coil 105 is preferably accommodated in a space 107 defined by a magnetic structure 108 such as the two examples shown in Fig.44(a) and (b) in which the coil is wound around a magnetic core 108. If a PCB winding is used, appropriate electromagnetic (EM) shielding, such as the combined use of ferrite and copper sheets described in US 6501364, can be placed under the PCB winding in order to ensure that the magnetic flux generated in the PCB winding will not penetrate through the base of the primary inductive charging extension system. Preferably, mechanical switches 109 can be provided in each charging slot that when closed activate the primary winding to the high-frequency AC voltage source when the secondary charging module (to be described below) is inserted in that particular slot. As discussed above, the mechanical switches may also serve to engage and hold the secondary module in place. This mechanism ensures that only windings in the slots used by the secondary modules are excited by the high-frequency AC voltage source. The equivalent circuit is shown in Fig.45.

It will also be understood that the primary winding could be constructed as a multiple layer structure as discussed above in order to provide a particularly preferred even flux distribution over the charging surface.

Fig.46 shows a typical secondary charging module 200 for use with the primary charging extension system shown in Fig.41. Each secondary module has a conventional cable 201 and charger connecter 202 that is adapted to be received within the charging socket of a conventional electronic device. It will be understood that different secondary charging modules 200 may be provided differing only by the type of the connector 202. Each secondary charging module 200 is provided with a housing 203 that contains a

secondary circuit to be described below. The housing is preferably rectangular (but of course could be any suitable shape) and of such a size that it may be received in one of the slots 100-102 of the primary charging extension system. The housing 203 should have at least one preferably flat surface for placing on the charging slot of the primary charging extension system. This flat surface is preferably parallel to the plane of the secondary winding within the housing such that when the secondary module is placed in a slot of the primary extension system the secondary winding is substantially parallel to the primary winding beneath the surface of the slot. The housing 203 of the secondary module should preferably be made of non-conductive and non-ferromagnetic material so that no current will be induced in the housing material.

As can be seen from Figs.47 and 48 inside each secondary charging module 200 are at least one secondary winding 204 and charger circuitry 205 that receives the induced AC voltage in the secondary winding and provides a regulated DC output voltage for the charging purpose. The secondary winding should be kept inside the housing. The secondary winding can be a coil (Fig.47) or it can be printed on a PCB (Fig.48). The function of the secondary winding is to act as the secondary winding of a transformer system to pick up the changing magnetic flux generated by the primary winding of the primary charging extension system.

The secondary coil or PCB winding should be placed close to the (preferably flat) surface of the housing of the secondary charging module so as to pick up maximum changing AC magnetic flux from the primary inductive charging extension system or platform. According to Faraday's Law, an AC voltage will be induced across the secondary winding if the secondary winding senses a changing magnetic flux (that can be generated by the primary winding in the primary inductive charging system).

The terminals of the secondary winding are connected to the input terminals of an electronic circuit 205 that (1) performs the AC-DC power conversion function (i.e. rectifying the AC voltage into DC) and (2) preferably also regulate the DC voltage to a desired value (typically in the range from 3V to 24V) within a certain tolerance. Through a cable and a charger connector for connecting to charging socket in the portable equipment, this DC voltage can be used to charge the portable equipment a shown in Fig.49.

The secondary winding design (such as number of turns and dimensions of windings), the DC regulated voltage level and the type of connector can be designed according to the charging requirements of specific electronic products. Therefore, different secondary charging modules can be designed for different ranges of products, but all secondary modules are compatible with the same primary charging extension system as shown in Fig.50 in which two different types of secondary modules adapted for charging different devices and having different connectors 202,202' are shown in adjacent slots of the primary charging extension system. As the primary inductive charging extension system preferably has several charging slots for accommodating the secondary charging modules, it can be used to charge several items of conventional portable electronic equipment simultaneously.

A further advantage of the secondary charging module is that it allows a conventional electronic device to be charged using the inductive battery charging platform described above. Although a conventional electronic device cannot be charged by placing it directly on the charging platform surface because it does not have the in-built secondary winding, instead a secondary charging module can be placed in the inductive charging system and charge the conventional device therefrom as shown in Fig.51

In principle, the housing of the secondary charging module can have more than one preferably flat interface surface. If the housing is a cuboid it will have two large opposed interface surfaces (eg upper and lower surfaces of a relatively thin flat cuboid structure a shown in the Figures) and with this cuboid design, either interface surface of the secondary module housing can be placed on the charging slots of the primary inductive charging extension system or other charging platform. This cuboid design makes the secondary charging modules very user-friendly because it does not matter which way up the housing of the secondary module is placed on the primary charging surface.

In summary, a preferred embodiment of the secondary charging module consists of

(i) a non-conductive housing that has at least one surface (and preferably two surfaces) for placing on the charging slot of the primary charging extension system or the charging platform and that accommodates the secondary winding and circuitry for charging the electronic equipment,

(ii) A secondary winding, that can either be printed in a printed-circuit-board (PCB) or a conductor coil,

(iii) an AC-DC power conversion circuit that converts the ac induced voltage picked by the secondary winding from the primary AC voltage excitation into a regulated or unregulated DC voltage, typically in the range from 3V to 24V,

(iv) a conventional cable that connects the DC voltage output of the secondary circuitry to a connector that is compatible with the charging socket in the conventional electronic equipment.

It will thus be seen that, at least in preferred forms, the charging system of the present invention including the proposed secondary charging modules offers users a

convenient and user-friendly battery charging system for a wide range of portable electronic equipment. Using the appropriate charger connectors that are compatible with different portable equipment, the proposed charging system enables one single charging system (that occupies only one power point or socket in the ac mains) to charge a wide range of electronic equipment.

The present invention, at least in preferred forms, provides a new charging system allows more than one piece of equipment to be charged simultaneously, and regardless of their orientations on the charging surface, and allows a movable device to be charged while it moves over the charging surface.

CLAIMS

1. A battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer, said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

2. A battery charger system as claimed in claim 1 wherein said transformer primary winding is formed on a printed circuit board.

3. A battery charging system as claimed in claim 1 wherein the magnetic flux generated by said primary winding is substantially uniform over at least a major part of said planar charging surface.

4. A battery charging system as claimed in claim 1 wherein said charging module comprises a plurality of primary windings.

5. A battery charging system as claimed in claim 4 wherein said primary windings are disposed in a regular array.

6. A battery charging system as claimed in claim 4 wherein said primary windings are formed in a multi-layer structure comprising at least two layers and with each said layer including an array of primary windings.

7. A battery charging system as claimed in claim 6 wherein the array of a first said layer is offset relative to the array of a second said layer whereby regions of said first layer generating maximum magnetic flux coincide with regions of said second layer that generate minimum magnetic flux.

8. A battery charging system as claimed in claim 6 comprising three layers of hexagonal windings.

9. A battery charging system as claimed in claim 6 comprising four layers of square windings.

10. A battery charging system as claimed in claim 5 wherein said primary windings are hexagonal, circular, rectangular, square or polygonal in shape.

11. A battery charger system as claimed in claim 1 wherein said shielding includes a sheet of ferrite material.

12. A battery charging system as claimed in claim 11 wherein said shielding further includes a second sheet of conductive material.

13. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to receive two or more electronic devices, and wherein said primary charging circuit is adapted to charge two or more devices simultaneously.

14. A battery charging system as claimed in claim13 wherein said planar charging surface is divided into a plurality of charging regions.

15. A battery charging system as claimed in claim 14 wherein said primary charging circuit comprises a plurality of primary transformer windings arranged in a regular array and wherein said windings are connected in groups to define said charging regions.

16. A battery charging system as claimed in claim 1 wherein said primary charging circuit comprises an array of primary windings, and wherein when a device is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

17. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to enable a said device to be moved over said charging surface while being charged.

18. A charging module for a battery charging system, said module comprising a primary charging circuit and being formed with a charging surface for receiving

an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

19. A charging module as claimed in claim 18 wherein when an electronic device to be charged is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

20. A charging module as claimed in claim 18 wherein said transformer primary windings are connected to each other in series and/or in parallel.

21. A charging module as claimed in claim 18 wherein said primary transformer windings are planar and substantially parallel to a planar charging surface.

22. A charging module as claimed in claim 21 wherein said primary windings are formed in at least two planes, each said plane including an array of said windings.

23. A charging module as claimed in claim 22 wherein the array of a first said plane is offset relative to the array of a second said plane whereby regions of said first array that generate maximum magnetic flux coincide with regions of said second array that generate minimum magnetic flux.

24. A charging module as claimed in claim 22 comprising three layers of hexagonal windings.

25. A charging module as claimed in claim 22 comprising four layers of square windings.

26. A charging module as claimed in claim 21 wherein said primary windings are formed on a printed circuit board.

27. A charging module as claimed in claim 21 wherein electromagnetic shielding is provided on the side of said primary windings opposite from said planar charging surface.

28. A charging module as claimed in claim 27 wherein said shielding comprises a sheet of ferrite material.

29. A charging module as claimed in claim 28 wherein said shielding further comprises a second sheet of conductive material.

30. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow two or more devices to be charged thereon simultaneously.

31. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow a device to be moved over the charging surface while being charged.

32. A battery powered portable electronic device comprising a rechargeable battery, and wherein said device includes a planar secondary winding for receiving

electrical energy from a battery charger, and electromagnetic shielding between said winding and the major electronic components of said device.

33. An electronic device as claimed in claim 32 wherein said shielding comprises a sheet of ferrite material and a sheet of conductive material.

34. An electronic device as claimed in claim 32 wherein said winding is formed integrally with a back cover of said device.

35. A battery charging system comprising a primary module and at least one secondary module, said primary module comprising means for connecting to a mains supply, and at least one primary winding adjacent a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

36. A battery charging system as claimed in claim 35 wherein said primary charging module comprises a plurality of primary windings each associated with a respective charging surface whereby said primary charging module is able to receive a plurality of secondary charging modules simultaneously.

37. A battery charging system as claimed in claim 36 wherein said charging surfaces are provided with engagement means for engaging a secondary module.

38. A battery charging system as claimed in claim 37 wherein said engagement means include a mechanical switch whereby power is supplied to said primary winding only when a secondary module is engaged by a charging surface.

39. A battery charging system as claimed in claim 35 wherein said primary winding is formed by a coil.

40. A battery charging system as claimed in claim 39 wherein said coil is wound on a magnetic structure.

41. A battery charging system as claimed in claim 39 wherein said coil is parallel to said charging surface.

42. A battery charging system as claimed in claim 35 wherein said primary winding is printed in a printed circuit board.

43. A battery charging system as claimed in claim 42 wherein said printed circuit board is parallel to said charging surface.

44. A battery charging system as claimed in claim 35 wherein said secondary winding is formed by a coil.

45. A battery charging system as claimed in claim 44 wherein said coil is parallel to said charging surface.

46. A battery charging system as claimed in claim 1 wherein said secondary winding is printed on a printed circuit board.

47. A battery charging system as claimed in claim 46 wherein said printed circuit board is parallel to said charging surface.

48. A secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

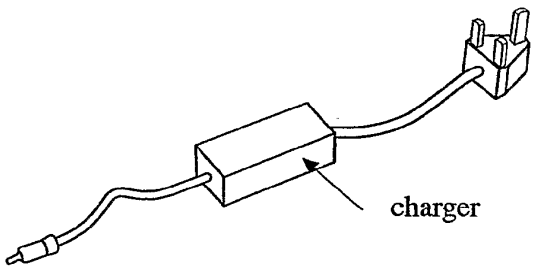


FIG.1 (PRIOR ART)

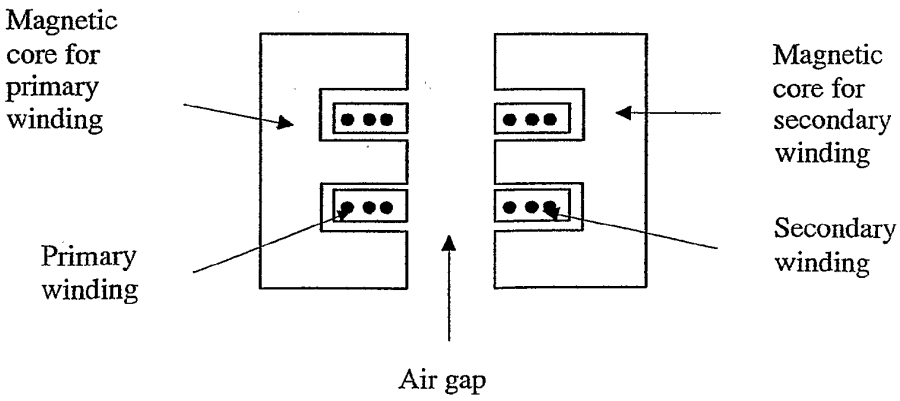


FIG.2 (PRIOR ART)

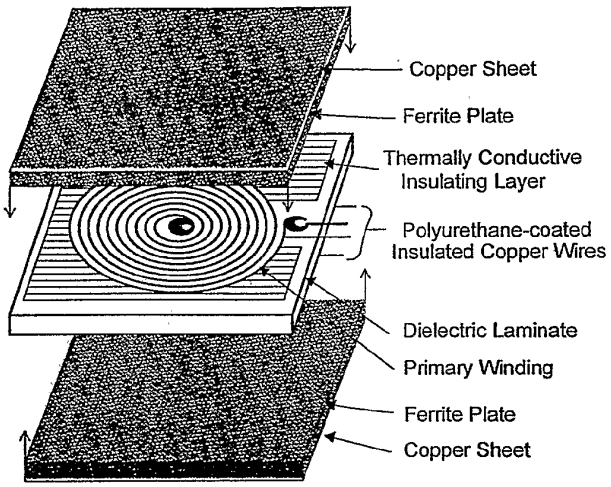


FIG.3 (PRIOR ART)

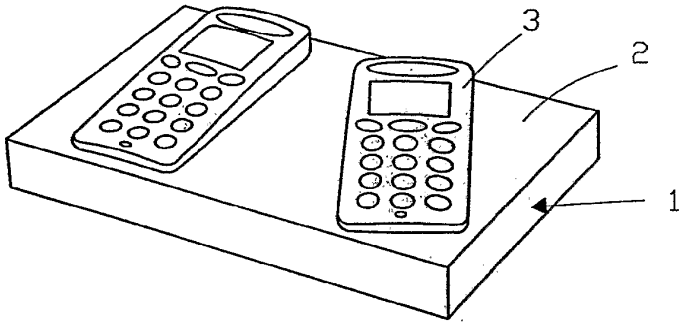


FIG.4(a)

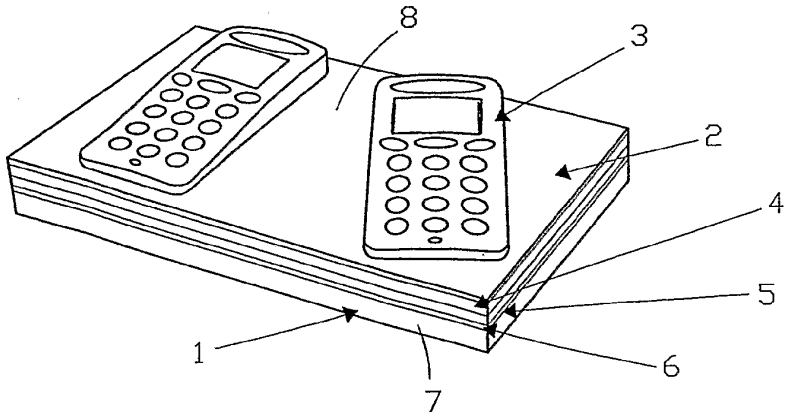


FIG.4(b)

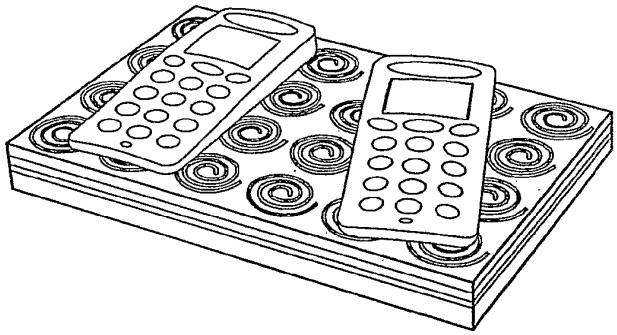


FIG.4(c)

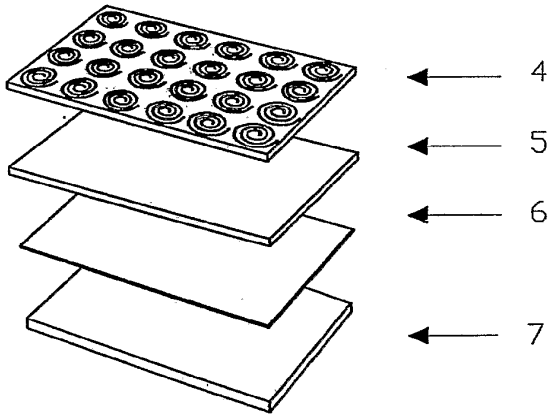


FIG.5(a)

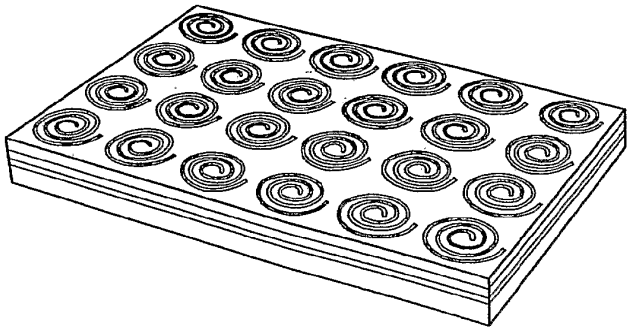


FIG.5(b)

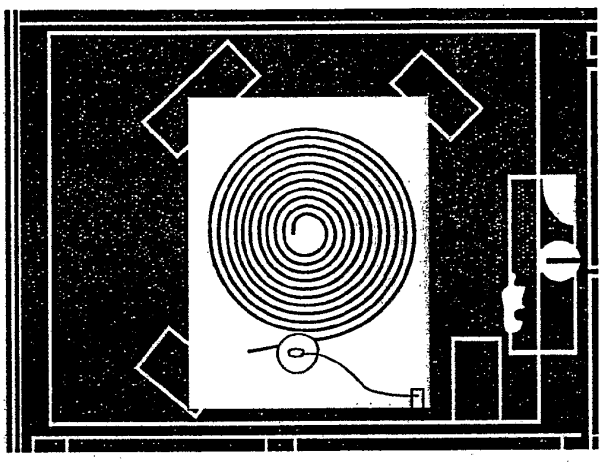


FIG.6(a)

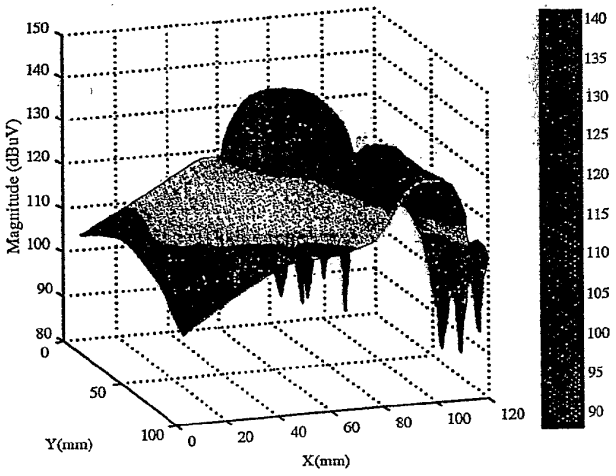

Magnitude (dBuV)
150
140
130
120
110
100
90
80
0
50
100
Y(mm)
0
20
40
60
80
100
120
X(mm)
140
135
130
125
120
115
110
105
100
95
90

FIG.6(b)

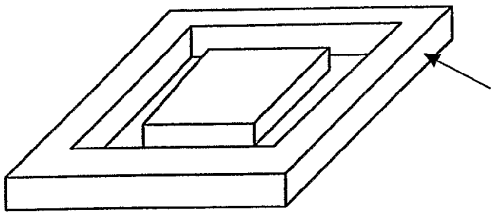


FIG.7(a)

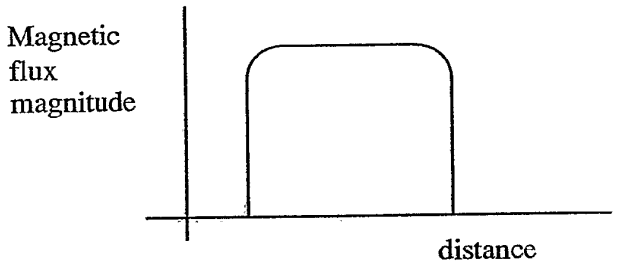


FIG.7(b)

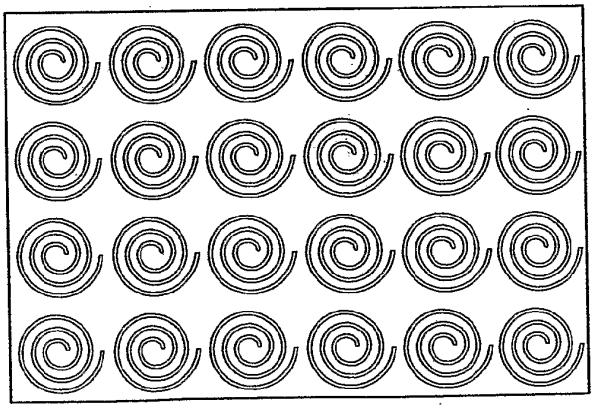


FIG.8

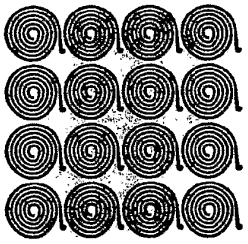


FIG.9(a)

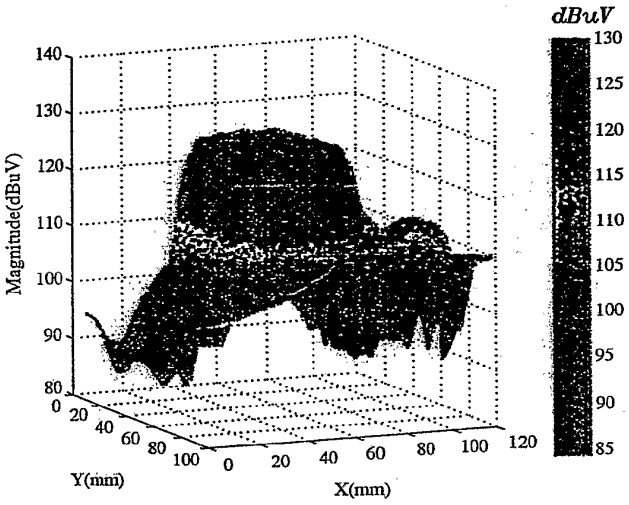

dBuV
130
125
120
115
110
105
100
95
90
85
Magnitude(dBuV)
140
130
120
110
100
90
80
0
20
40
60
80
100
Y(mm)
0
20
40
60
80
100
120
X(mm)

FIG.9(b)

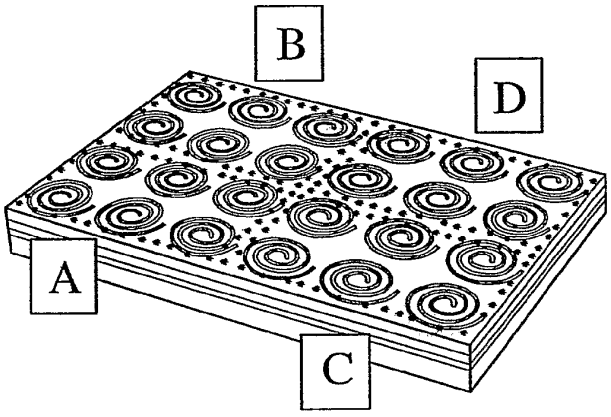


FIG.10(a)

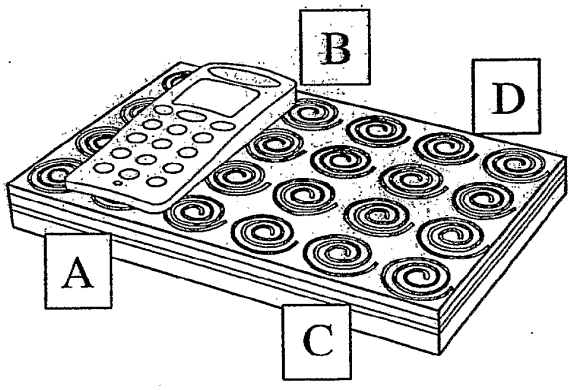


FIG.10(b)

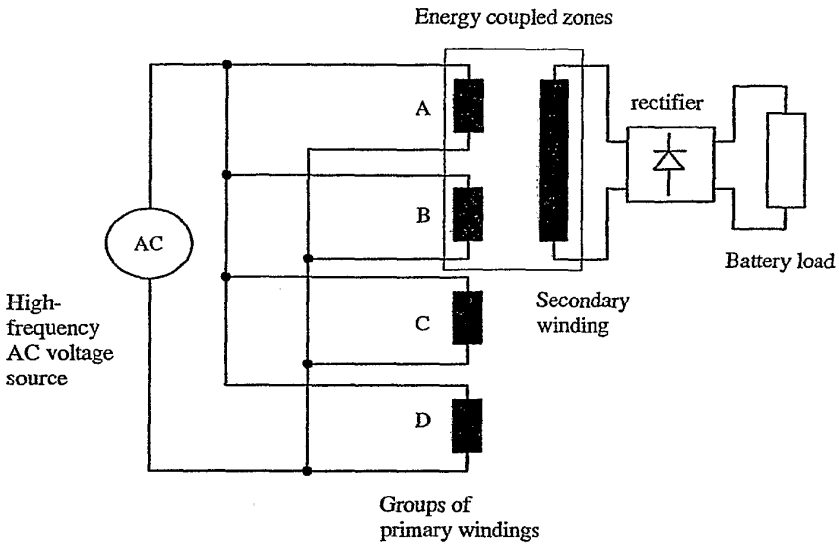


FIG.10(c)

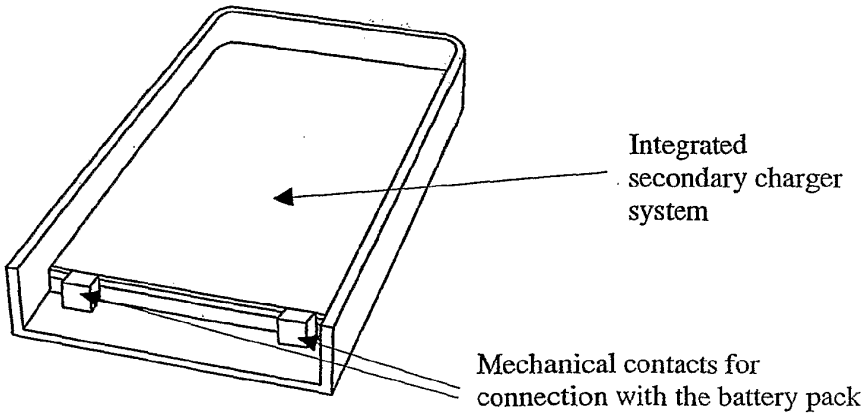


FIG.11

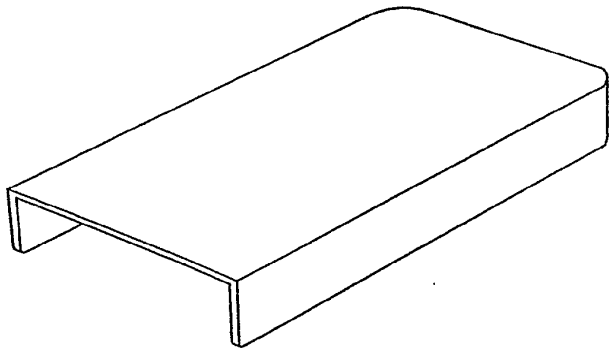


FIG.12(a)

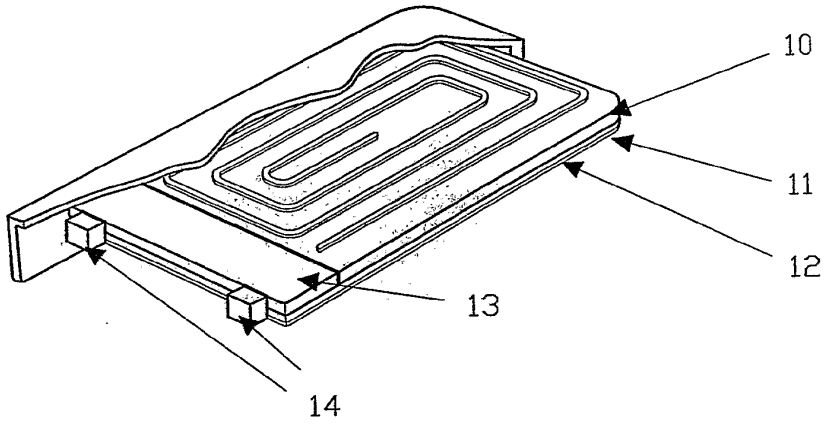


FIG.12(b)

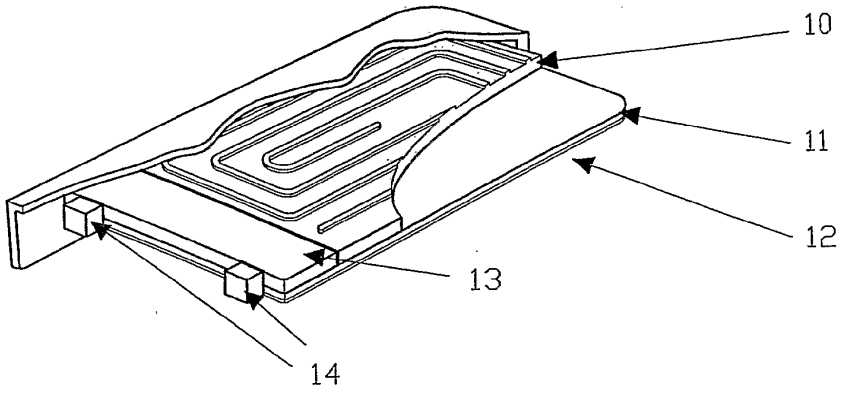


FIG.12(c)

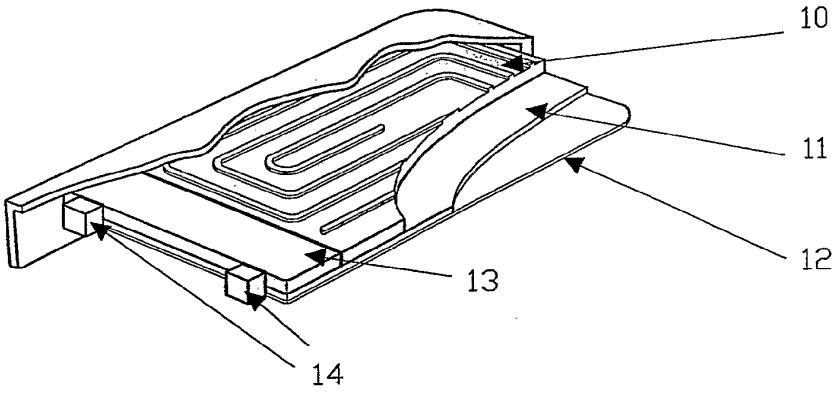


FIG.12(d)

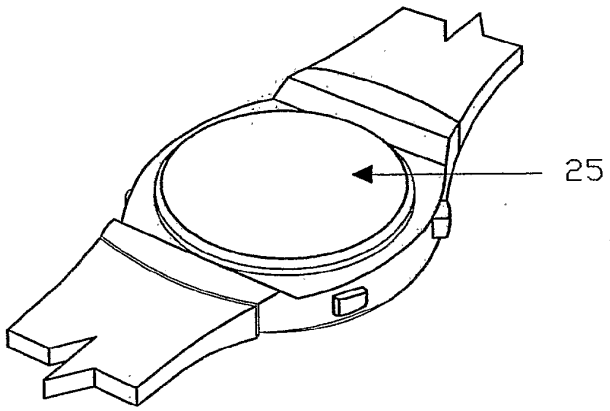


FIG.13(a)

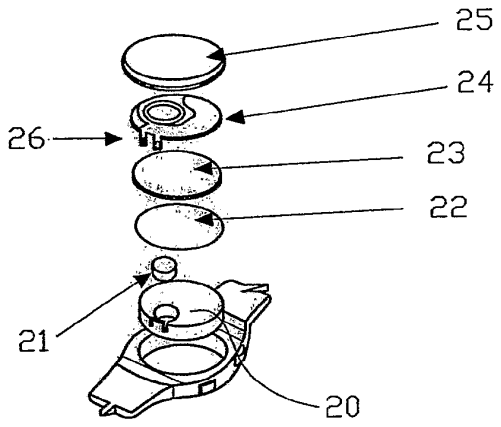


FIG.13(b)

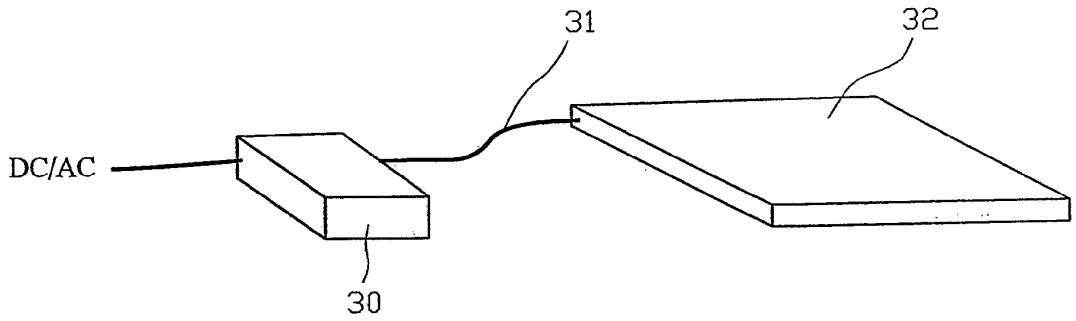


FIG.14

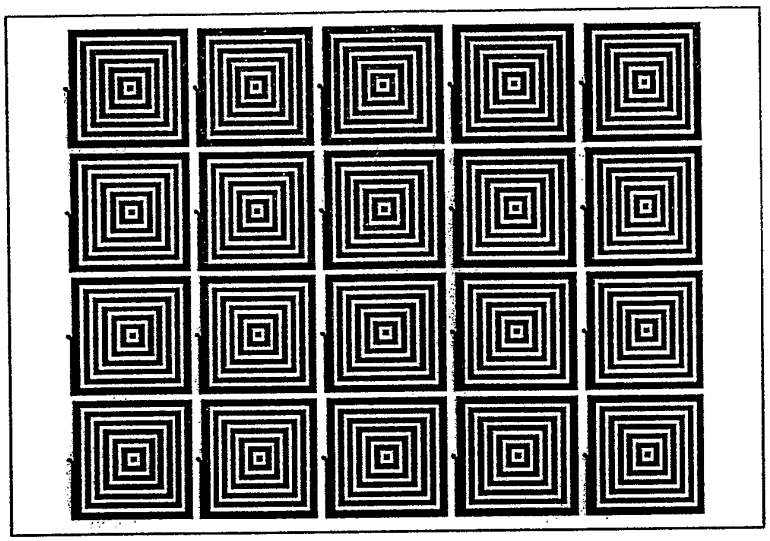


FIG.15

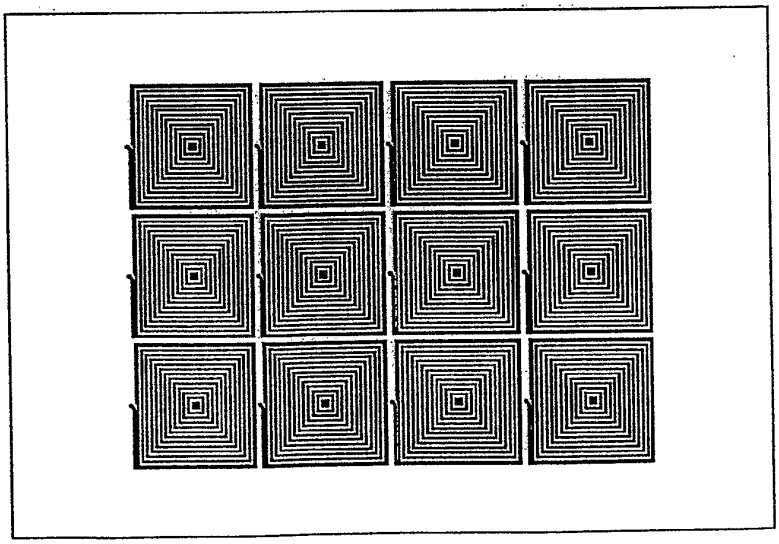


FIG.16

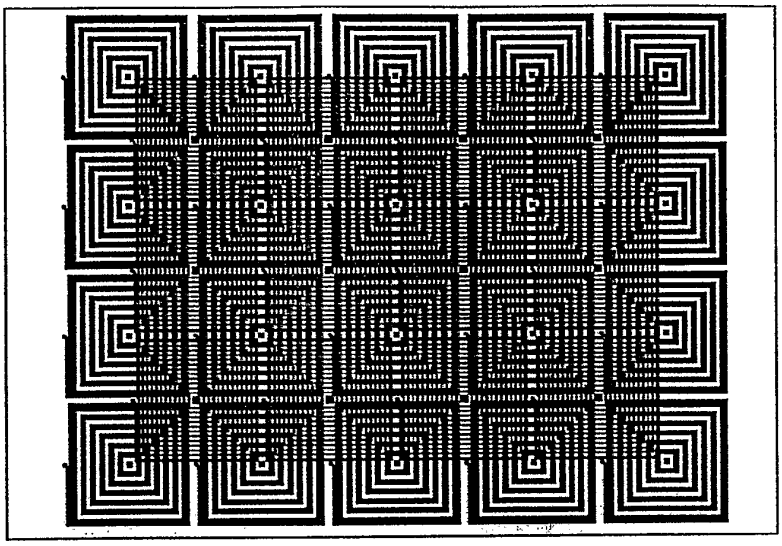


FIG.17

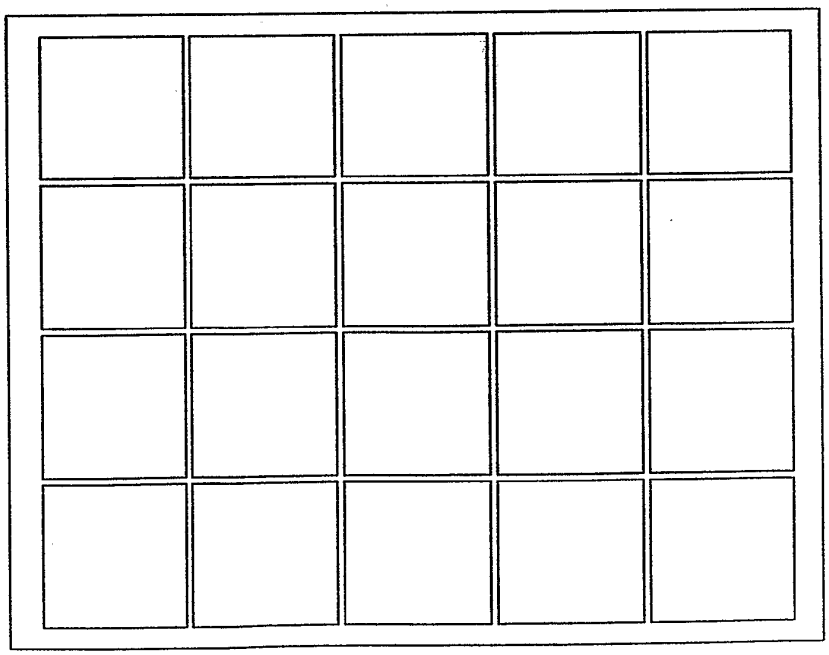


FIG.18

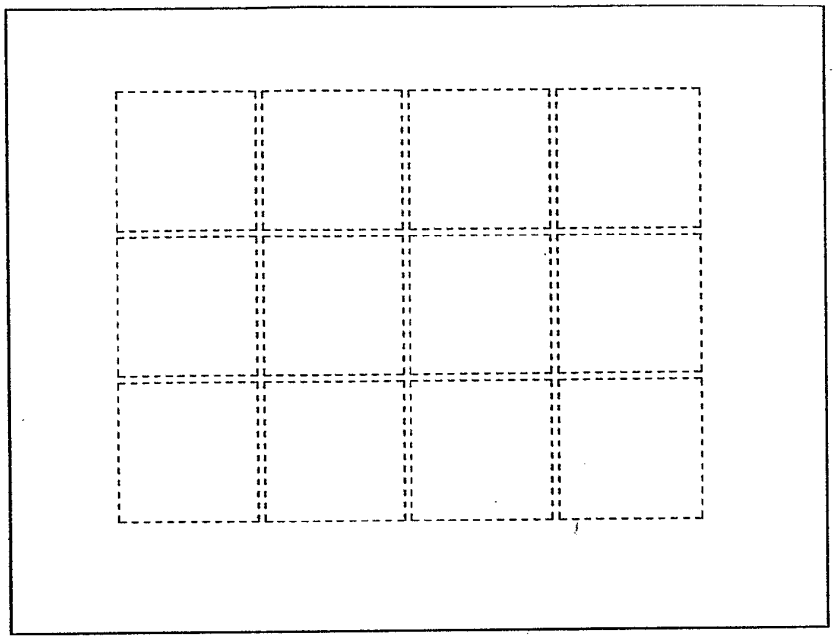
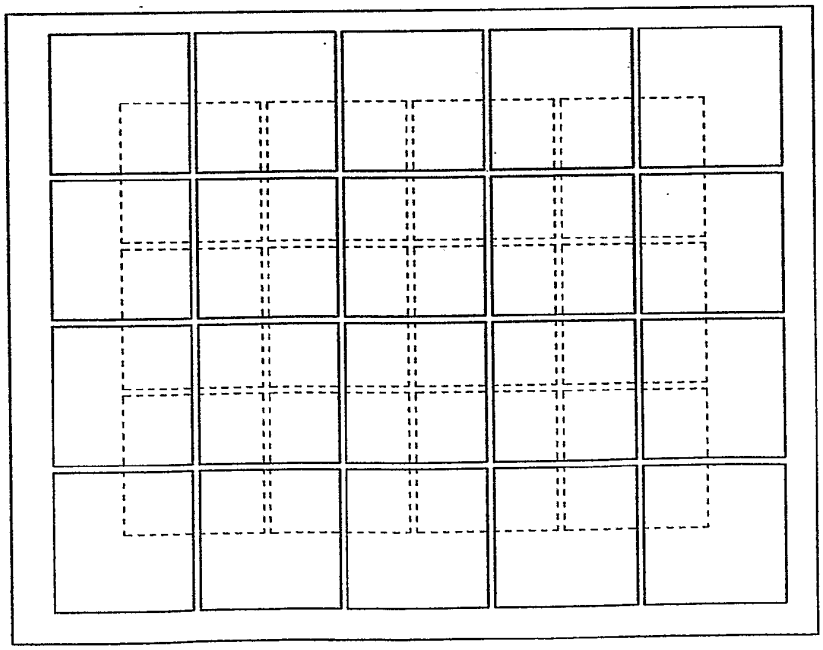


FIG.19



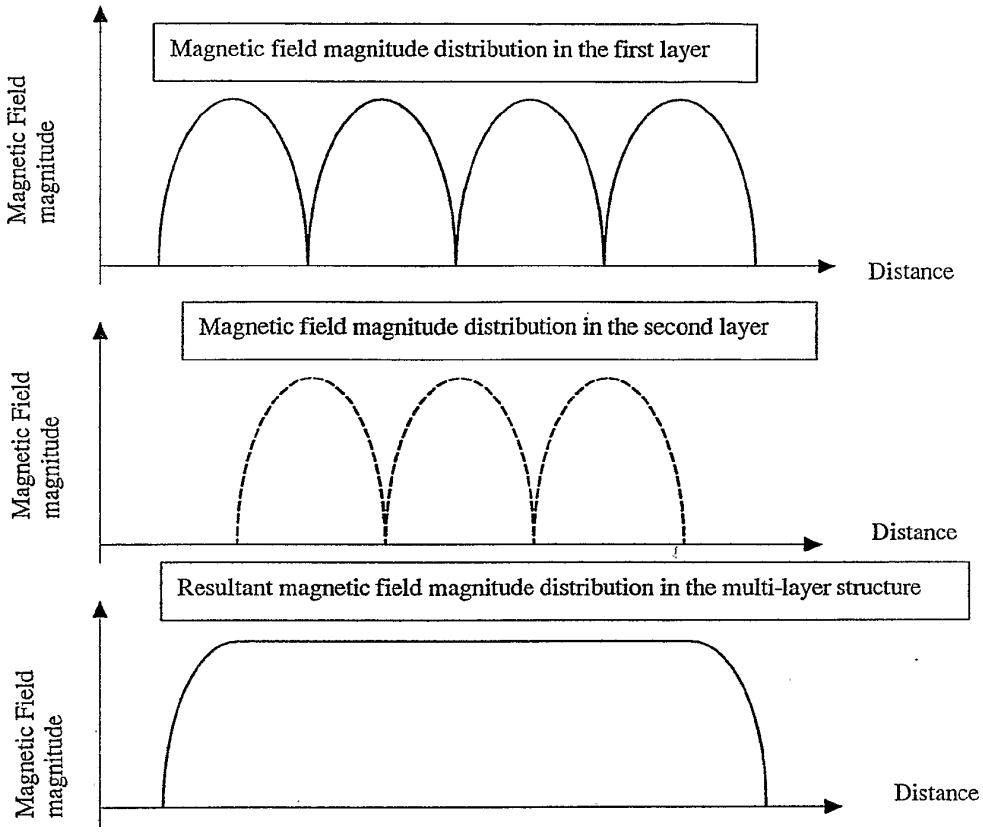


FIG.21

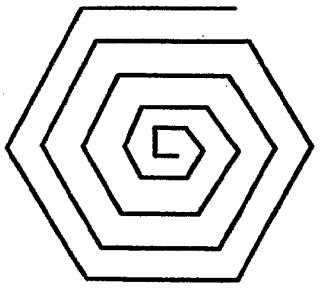


FIG.22

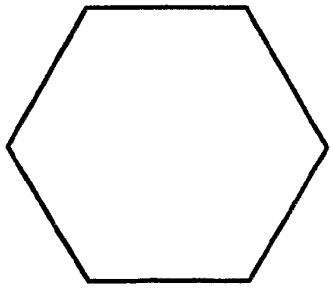


FIG.23

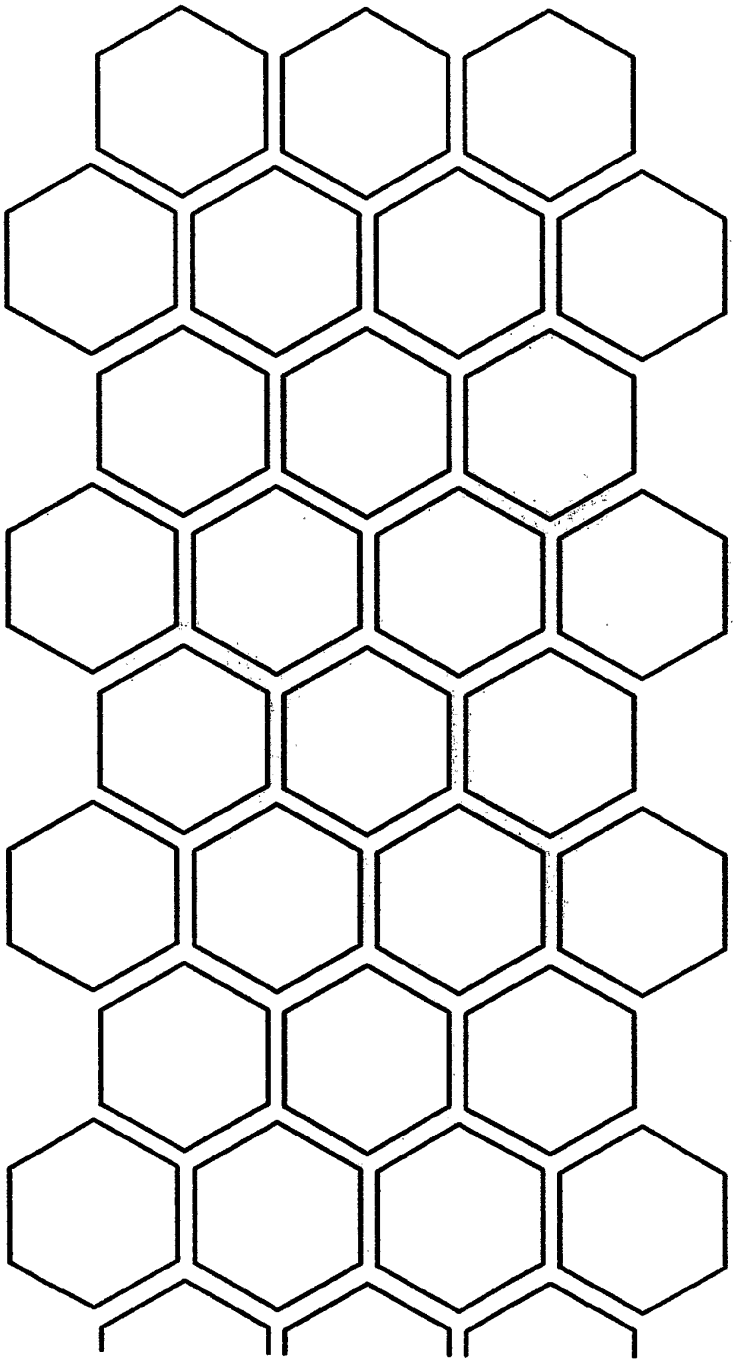


FIG.24

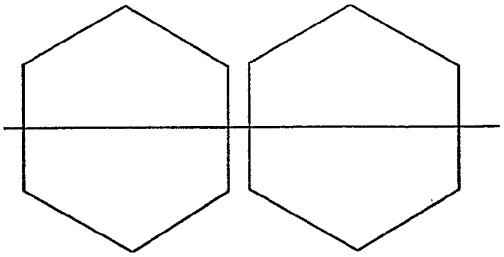


FIG.25

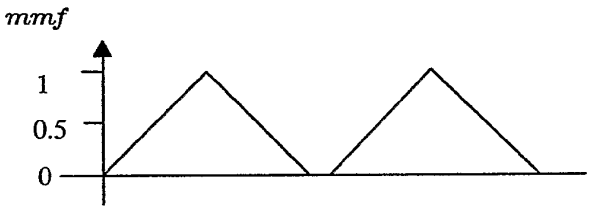


FIG.26

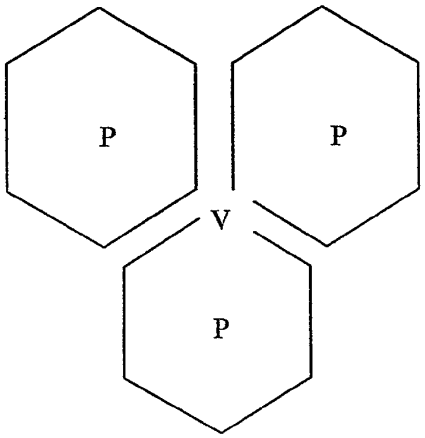


FIG.27

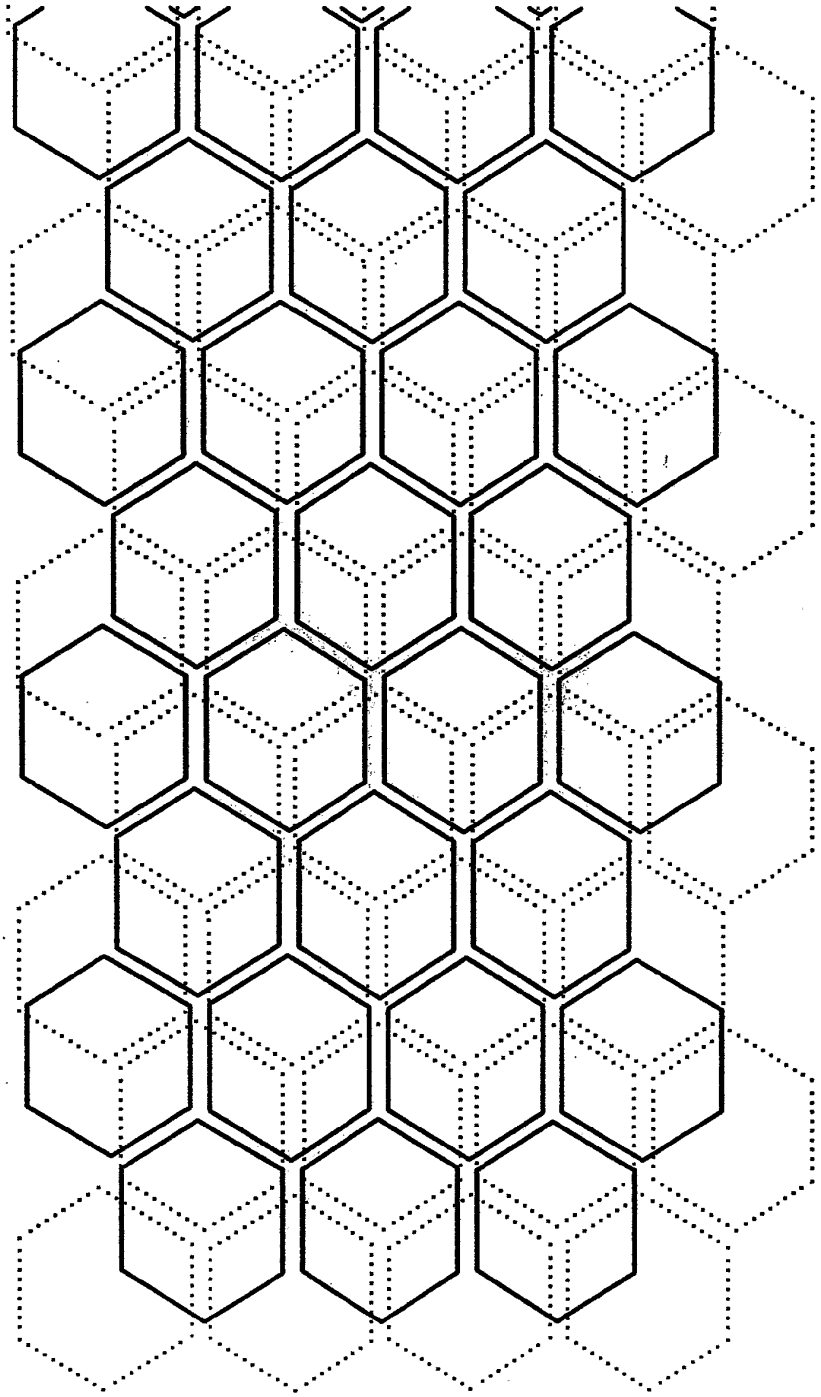


FIG.28

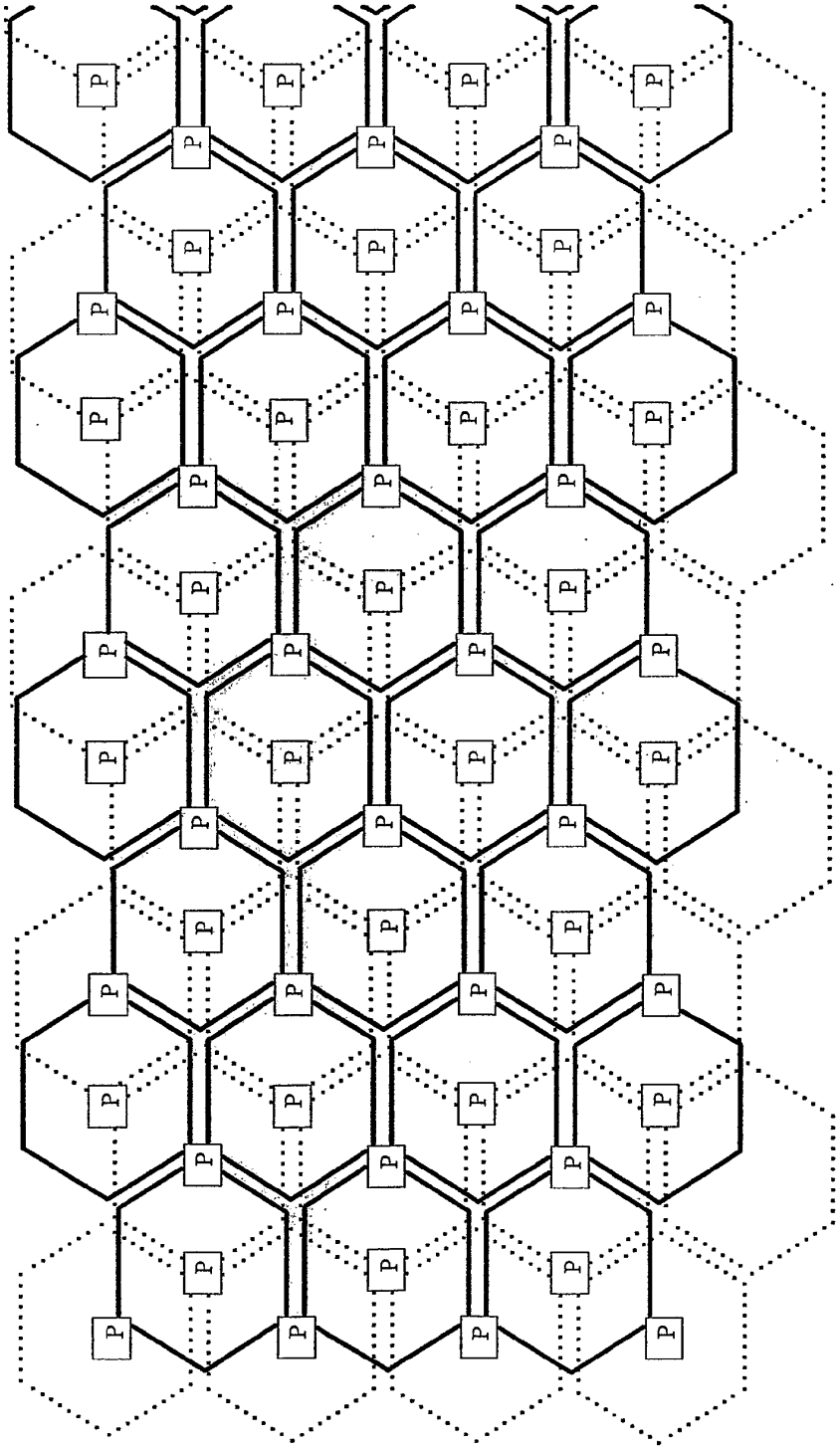


FIG.29

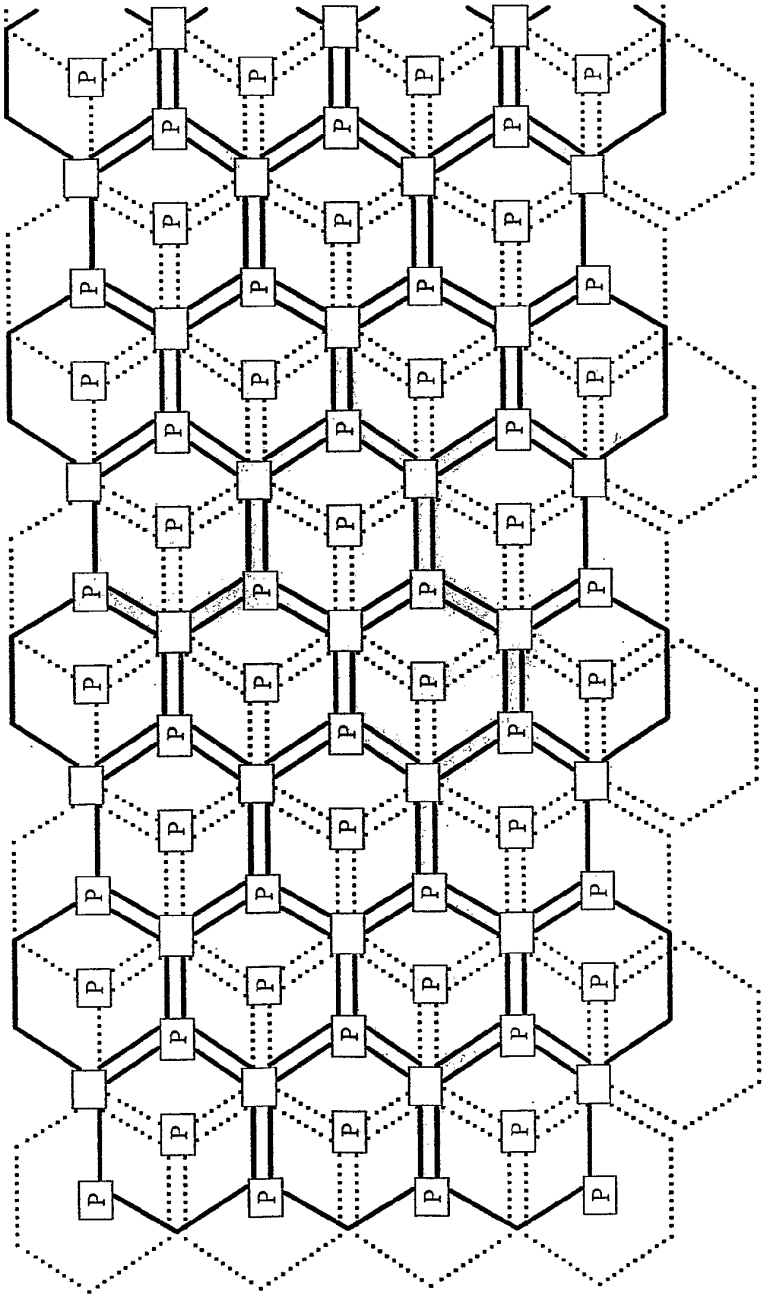


FIG.30

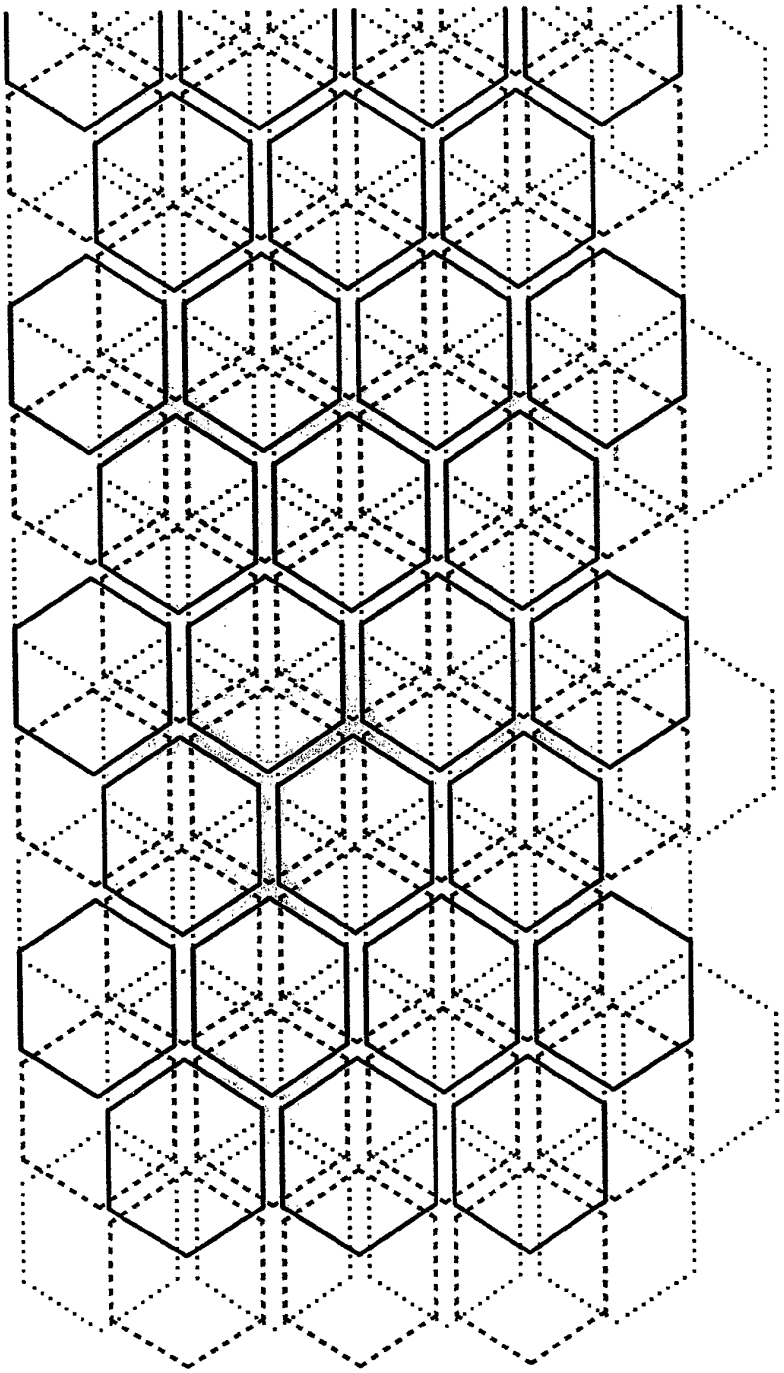


FIG.31

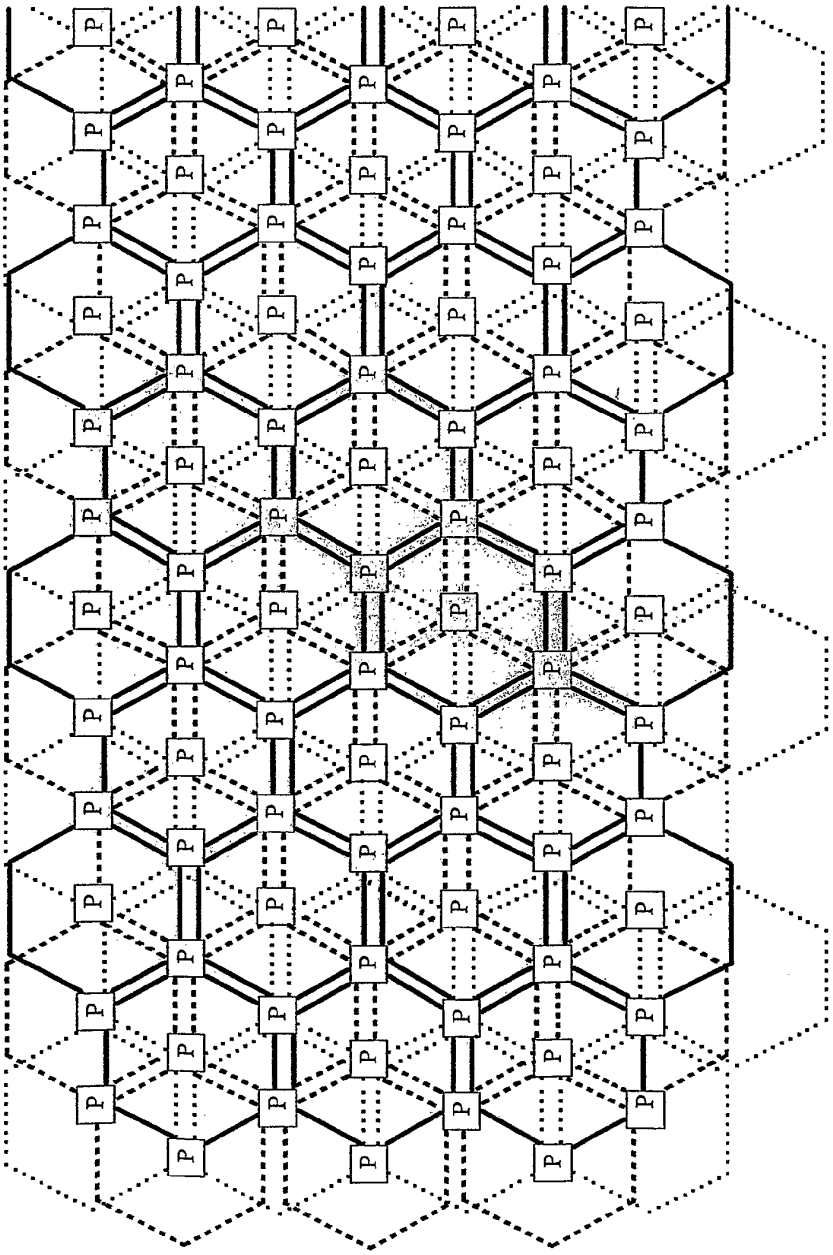


FIG.32

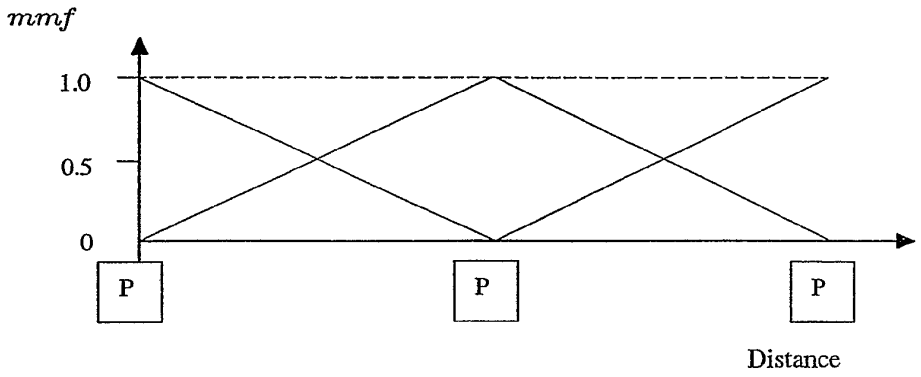


FIG.33

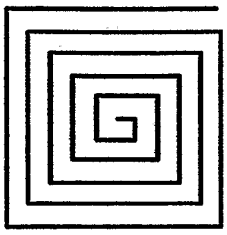


FIG.34

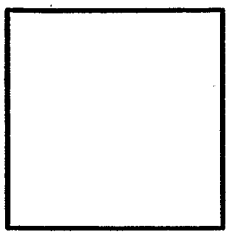


FIG.35

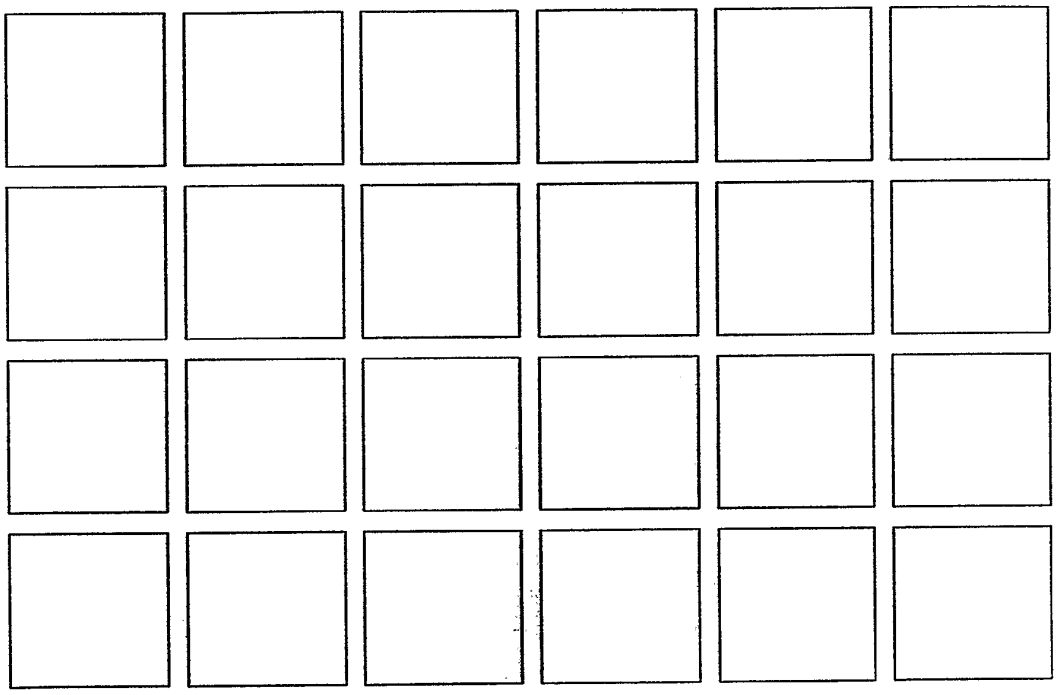


FIG.36

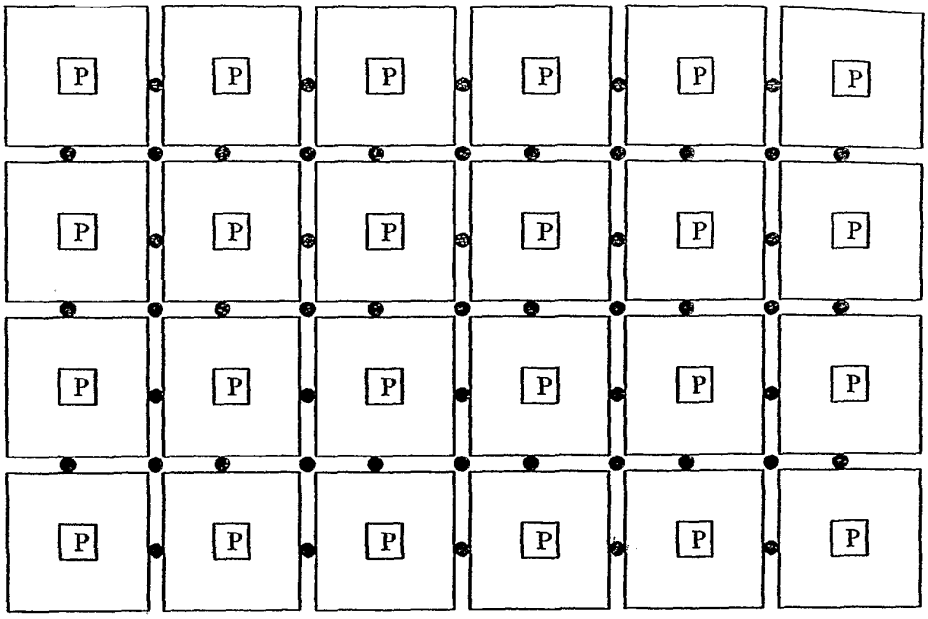


FIG.37

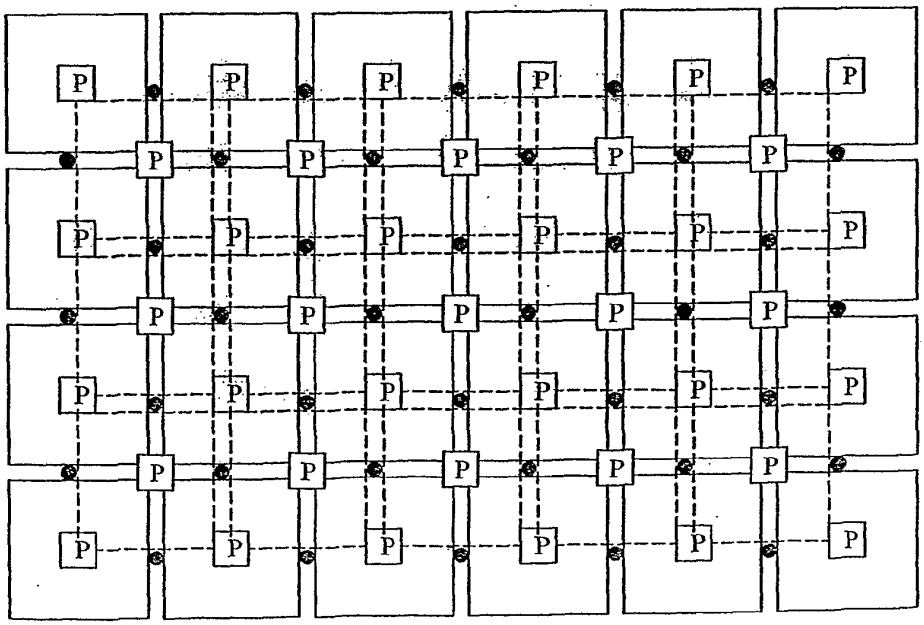


FIG.38

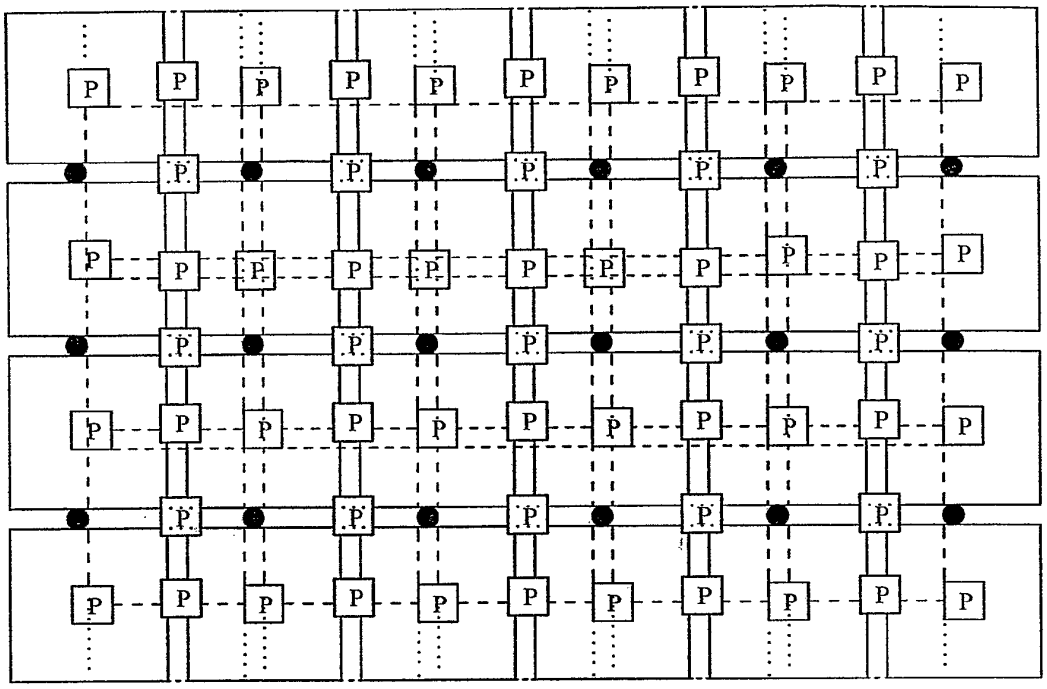


FIG.39

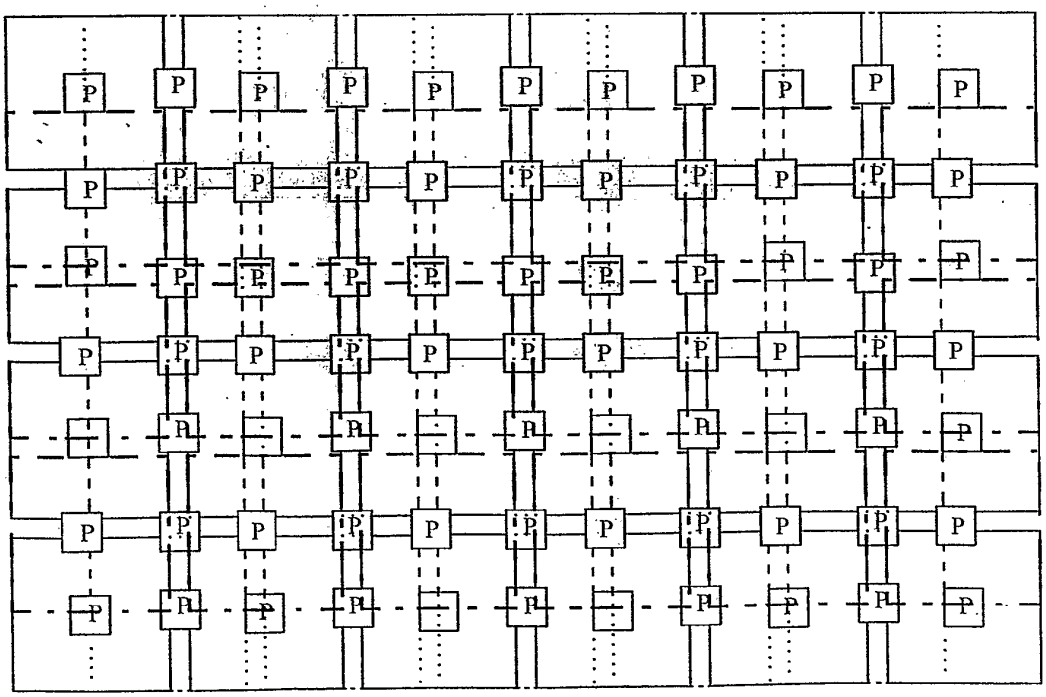


FIG.40

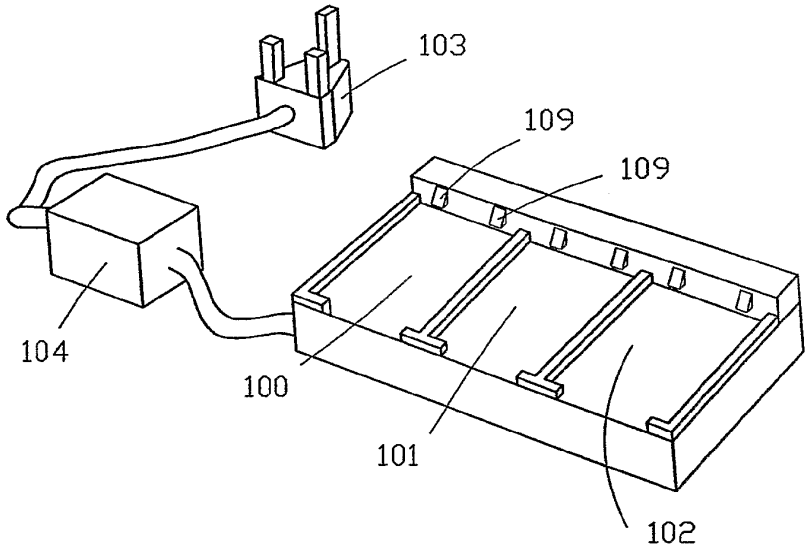


FIG.41

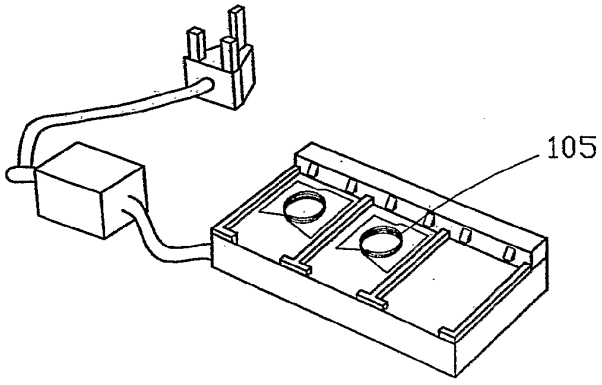


FIG.42

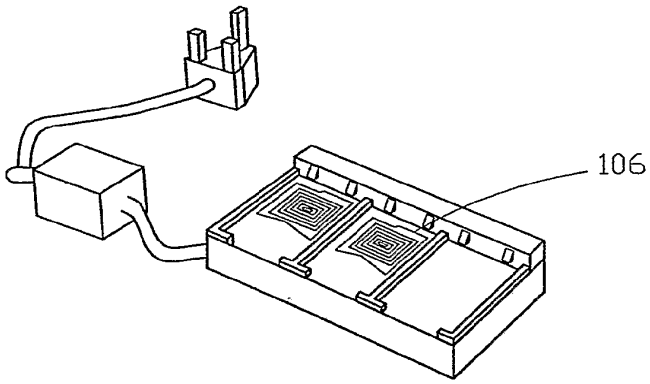


FIG.43

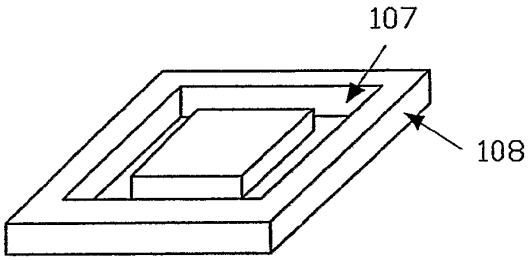


FIG.44(a)

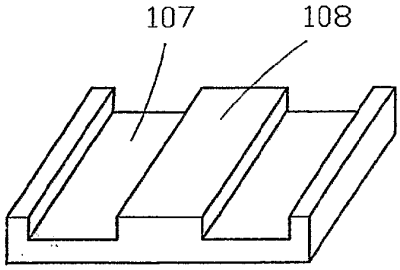


FIG.44(b)

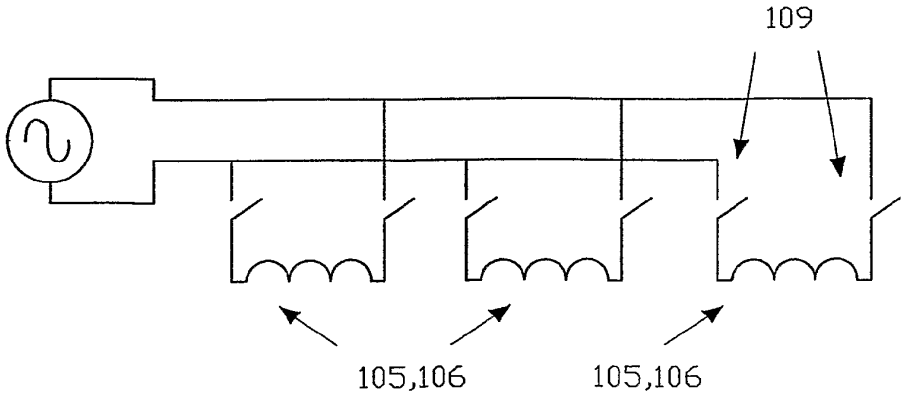


FIG.45

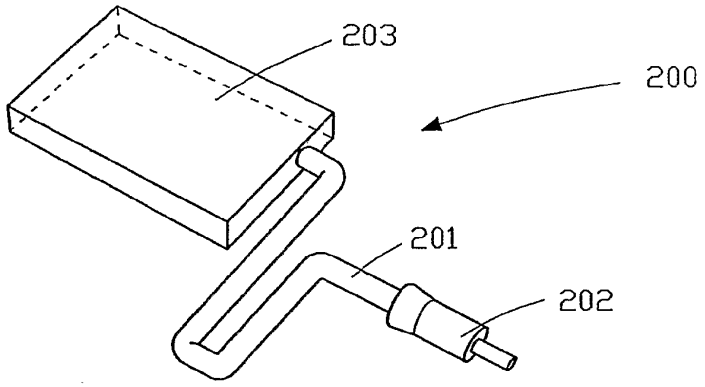


FIG.46

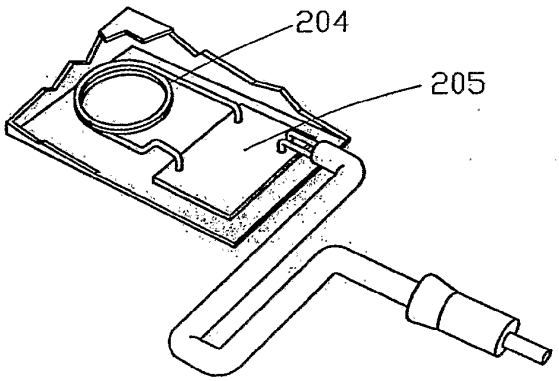


FIG.47

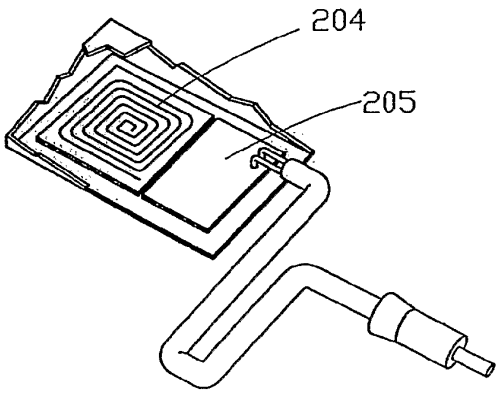


FIG.48

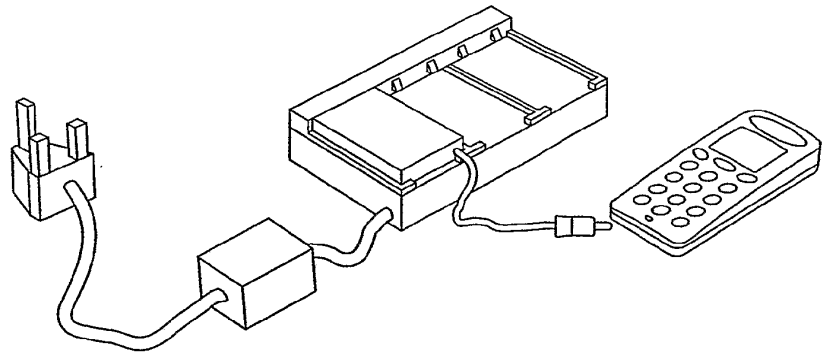


FIG.49

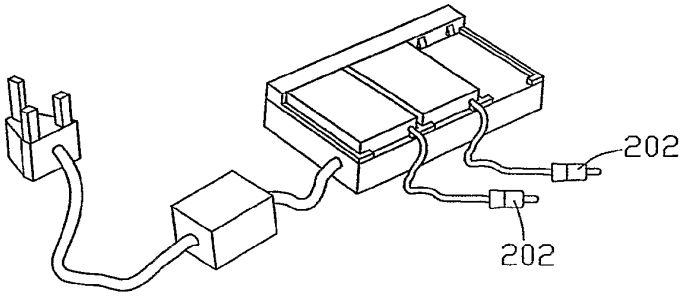


FIG.50

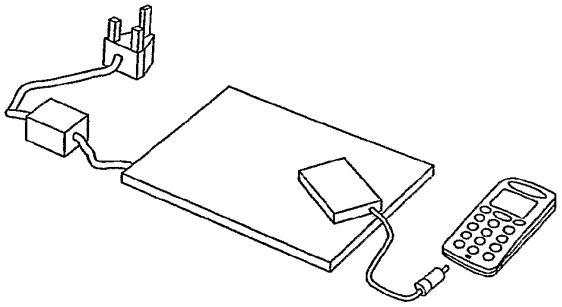


FIG.51

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: H02J 7/00, H01F 38/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI, IEEE (battery, charger, coils, flat, shield)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	HATANAKA, K. et al. "Power Transmission of a desk with a cord-free power supply" IEEE Transactions on Magnetics Volume: 38, Issue: 5, September 2002 Pages 3329-3331	18-21,31
X	HATANAKA, K. et al. "Characteristics of the desk with cord-free power supply" INTERMAG 2002, DIGEST OF TECHNICAL PAPERS 28 April-2 May 2002 Abstract, whole document	18
X Y	EP 298707 B (SEIKO EPSON CORPORATION) 28 September 1994 Whole document Column 4 line17-22, column 3 lines 11-26	1,4,11,32 2,3

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

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

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

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

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

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

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

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2003	- 9 JUL 2003
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **DALE E. SIVER** Telephone No : (02) 6283 2196

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6008622 A (NAKAWATASE) 28 December 1999 Column 1 lines 39-43, column 2 lines 5-17, 21-23, 49-55	1,4,11,32
Y	US 6265789 B (HONDA et al.) 24 July 2001 Abstract, figures, claim 8, column 7 lines 8-23, column 11 lines 62-66	2,3
Y	WO 00/02212 A (ABIOMED, INC.) 13 January 2000 Abstract, Figure 1,7, page 2 lines 5-9	1,11,32,33
A	US 6172884 B (LANNI) 9 January 2001 Abstract, figures, column 18 line 63 to column 19 line 60	35-36,42,48

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU03/00721

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	298707	JP	62260735	EP	245999	ES	2003287
		US	5246734				
US	6008622	JP	11103531				
US	6265789	EP	977297	WO	9927603		
WO	200002212	AU	48613/99	CA	2336725	EP	1095384
		US	6324430	US	2002055763	US	6389318
		US	2002058971				
US	6172884	US	5479331	US	5636110	US	5838554
		US	5949213	US	6091611	US	6266261
		US	2003042881	AU	200153089	CA	2403856
		EP	1273093	WO	200176051		

END OF ANNEX

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

(19) World Intellectual Property Organization
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PCT/GB2005/001833

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(75) Inventors/Applicants *(for US only)*: **STEVENS, Michael, Craig** [AU/GB]; 90 Mill Road, Cambridge CB1 2BD (GB). **KNILL, Alexander, Charles** [GB/GB]; 53 Blackthorn Close, Cambridge CB 1FZ (GB). **DUNTON, John, Robert** [GB/GB]; 19 Chivers Road, Haverhill, Suffolk CB9 9DS (GB).

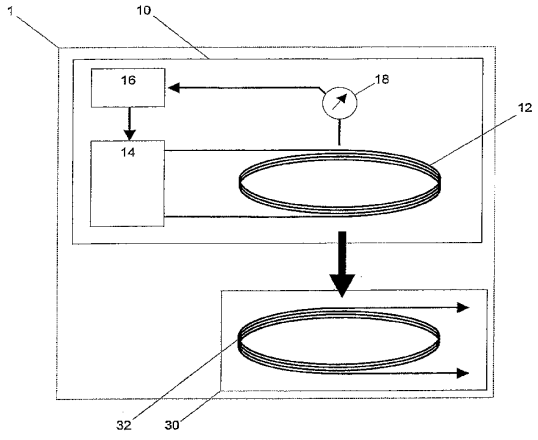
(74) Agent: **HITCHING, Peter, Matthew**; Haseltine Lake, 5th Floor, Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO,

[Continued on next page]

(54) Title: CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS



(57) Abstract: An inductive power transfer system comprises a primary unit (10), having a primary coil (12) and an electrical drive unit (14) which applies electrical drive signals to the primary coil so as to generate an electromagnetic field. The system also comprises at least one secondary device (30), separable from the primary unit and having a secondary coil (32) which couples with the field when the secondary device is in proximity to the primary unit. A control unit (16) causes a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition. In this condition the application of the drive signals to the primary coil by the electrical drive unit is suspended so that energy stored in the circuit decays over the course of the period. A decay measurement unit (18) takes one or more measures of such energy decay during the measurement period. In dependence upon said one or more energy decay measures, the control unit controls the electrical drive unit so as to restrict or stop inductive power transfer from the primary unit.

WO 2005/109598 A1

SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CONTROLLING INDUCTIVE POWER TRANSFER SYSTEMS

The present invention relates to controlling inductive power transfer systems for use, for example, to power portable electrical or electronic devices.

Inductive power transfer systems suitable for powering portable devices may consist of two parts:

- A primary unit having at least one primary coil, through which it drives an alternating current, creating a time-varying magnetic flux.
- A secondary device, separable from the primary unit, containing a secondary coil. When the secondary coil is placed in proximity to the time-varying flux created by the primary coil, the varying flux induces an alternating current in the secondary coil, and thus power may be transferred inductively from the primary unit to the secondary device.

Generally, the secondary device supplies the transferred power to an external load, and the secondary device may be carried in or by a host object which includes the load. For example the host object may be a portable electrical or electronic device having a rechargeable battery or cell. In this case the load may be a battery charger circuit for charging the battery or cell. Alternatively, the secondary device may be incorporated in such a rechargeable cell or battery, together with a suitable battery charger circuit.

A class of such an inductive power transfer systems is described in our United Kingdom patent publication GB-A-2388716. A notable characteristic of this class of systems is the physically "open" nature of the magnetic system of the primary unit – a significant part of the magnetic path is through air. This is necessary in order that the primary unit can supply power to different shapes and sizes of secondary device, and to multiple secondary devices simultaneously. Another example of such an "open" system is described in GB-A-2389720.

Such systems may suffer from some problems. A first problem is that the primary unit cannot be 100% efficient. For example, switching losses in the electronics and I^2R losses in the primary coil dissipate power even when there is no secondary device present, or when no secondary devices that are present require charge. This wastes energy. Preferably the primary unit should enter a low-power "standby mode" in this situation.

A second problem in such systems is that it is not possible to mechanically prevent foreign objects from being placed into proximity with the primary coil, coupling to the coil. Foreign objects made of metal will have eddy-currents induced therein. These eddy currents tend to act to exclude the flux, but because the material has resistance, the flowing eddy currents will suffer I^2R losses which will cause heating of the object. There are two particular cases where this heating may be significant:

- If the resistance of any metal is high, for example if it is impure or thin.
- If the material is ferromagnetic, for example steel. Such materials have high permeability, encouraging a high flux density within the material, causing large eddy currents and therefore large I^2R losses.

In the present application, such foreign objects that cause power drain are termed "parasitic loads". Preferably the primary unit should enter a "shutdown mode" when parasitic loads are present, to avoid heating them.

Various approaches to solve these two problems have been proposed in the prior art.

Solutions to the first problem, of not wasting power when no secondary device requires charge, include:

- In EP0533247 and US 6118249 the secondary device modulates its inductive load during charging, causing a corresponding variation in the power taken from the primary unit. This indicates to the primary unit that it should stay out of the standby state.
- In EP1022840 the primary unit varies the frequency of its drive, and thus the coupling factor to a tuned secondary unit. If the secondary unit is not taking

power, there is no difference in the power taken as the frequency is swept and thus the primary unit goes into a standby state.

- In US5536979 the primary unit simply measures the power flowing in the primary coil, and enters a pulsing standby state if this is below a threshold.
- In US5896278 the primary unit contains detecting coils which have power coupled back into them according to the position of the secondary device. If the device is not present the primary unit enters a standby mode.
- In US5952814 the secondary device has a mechanical protrusion which fits a slot in the primary unit, activating it.
- In US6028413 the primary unit drives two coils, and there are a corresponding two power receiving secondary coils in the secondary unit. The primary unit measures the power delivered from each primary coil and enters standby mode if it is below a threshold.

Solutions to the second problem, of parasitic loads, include:

- As mentioned above, in EP1022840 the primary unit varies the frequency of its drive. In this system, the secondary device is tuned, so this frequency variation will result in a variation of the power taken from the primary unit. If the load is instead a piece of metal, then varying the frequency will not have as much effect and the primary unit will enter a shutdown state.
- As mentioned above, in US5952814 a key in the secondary device activates the primary unit. The assumption is that if a secondary device is present then this will physically exclude any foreign objects.
- As mentioned above, in US6028413 the primary unit supplies power to the secondary device by driving two primary coils. If the amount of power supplied by the two coils is different, the primary unit assumes that the load is not a valid secondary device and enters shutdown mode.

These approaches all assume a 1:1 relationship between the primary unit and the secondary device. Therefore they are not sufficient for systems such as those described in GB-A-2388716 where more than one secondary device at a time may be present. For

example, they would not work when there are two secondary devices present, one requiring charge and the other not.

Some of these approaches also assume that the physical or electrical presence of a valid secondary device implies that all foreign objects are physically excluded by the secondary device. This is not necessarily the case, particularly when the secondary devices may be positioned arbitrarily in respect of the primary unit, as in those described in GB-A-2388716.

According to a first aspect of the present invention, there is provided an inductive power transfer system comprising a primary unit, having a primary coil and electrical drive means connected to the primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field, and the system also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, wherein the primary unit further comprises: control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over a course of said period; and decay measurement means operable to take one or more measures of such energy decay during said period; said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

Such a system is advantageous because it can address either or both the standby problem and the parasitic load detection problem listed above, in a robust and cost-effective manner, and is particularly advantageous in systems which may have multiple secondary devices present in different charge states, and/or whose open magnetic nature makes it easy for parasitic objects to couple to the primary coil.

In the present application, the term "ring-down" will be used to mean causing the circuit ("resonant tank") including the primary coil to operate in this undriven resonating condition.

During a ring-down, no energy is being supplied to the primary coil, and so the decay of energy in the resonant tank is a measure of how much energy is being removed from it. The principal causes of energy loss are:

- Energy coupled into the secondary coil of any secondary device present. This energy may be stored in a storage unit of the secondary device (if provided) and/or delivered to a load connected to the secondary device.
- Losses to any parasitic loads (foreign objects other than valid secondary devices) present.
- Other losses in the primary unit or any secondary devices/host objects present. These other losses include inefficiencies in the primary coil itself and any other components of the resonant tank (e.g. I^2R losses in the copper of the coil or effective series resistance of any resonating capacitor). They also include any magnetic losses in the primary and secondary units, for example magnetic hysteretic loop losses in any cores associated with the primary unit and/or secondary device.

In a preferred embodiment the or one energy decay measure is a measure of a rate of such energy decay. In this case, the rate of energy decay is a measure of the rate at which energy is being removed from the resonant tank.

The control means may employ the energy decay measures to detect when a substantial parasitic load is present in proximity to said primary unit, and restrict or stop inductive power transfer from the primary unit following the detection of such a substantial parasitic load. For example, the energy decay rate may be compared with a shutdown threshold, and if the rate exceeds the threshold the power transfer is shut down.

Alternatively, or in addition, the control means may employ the energy decay measures to detect when there is no secondary device present in proximity to the primary unit, and restrict or stop inductive power transfer from the primary unit when no such secondary device is detected.

When carrying out such detection the control means may employ first compensation information relating to a load imposed on the primary unit by losses in the primary unit itself so as to compensate for said losses of said primary unit. This prevents the detection from being affected by the inefficiencies in the primary coil itself and any other components of the resonant tank, as mentioned above.

The primary unit may further comprise calibration means for deriving part or all of the first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation.

As noted above, depending on its construction, the secondary device, and/or any host object which carries it, may suffer magnetic losses intrinsic to its construction, for example in magnetic core material, and other metal used in its construction. These so-called "friendly parasitics" will be accounted for by the primary unit as a further parasitic loss, and if they sum to more than the threshold, the control means will shut the primary unit down. This may be avoided by providing a method of communicating the friendly parasitics of a device to the primary unit so that they may be accounted for and added to the shutdown threshold.

Accordingly, when carrying out such detection said control means may employ second compensation information relating to a parasitic load imposed on the primary unit by the secondary device so as to compensate for the parasitic load of the secondary device.

In this case, preferably the or each secondary device is operable to communicate its second compensation information directly to the primary unit or to communicate to the

primary unit other information from which the primary unit can derive the second compensation information.

The secondary device may modulate a dummy load to communicate this other information, and the primary unit may derive the second compensation information by measuring the dummy load modulation.

This way of communicating the second compensation information also still works if multiple secondary devices are present. For example, assuming the secondary devices apply their dummy loads at the same time, the primary unit will see a total dummy load equal to the sum of the individual dummy loads of the secondary devices. This is all that the primary unit needs to know for compensating for the parasitic loads of the secondary devices.

One way of doing this is to have a feedback resistor, whose value is proportional to the value of the friendly parasitics of the secondary device, which can be switched across the secondary coil, creating a dummy parasitic load. If this feedback resistor is always applied during certain ring-downs (for example during the third ring-down of a set), the primary unit can then measure the sum of the incremental loads resulting from the feedback resistors in each secondary device present (whether its load is drawing power or not) and adjust its threshold accordingly. As described below, the same feedback resistor may be used as a binary on/off signalling means to control standby mode.

Part or all of the first compensation information and/or part or all of the second compensation information may be information stored in the primary unit during manufacture and/or testing of the primary unit.

The system may have information varying means for varying one or both of the first and second compensation information when one or more operating conditions (for example, temperature) of the primary unit vary.

The decay measurement means may take one or more first such energy decay measures in a first such measurement period and take one or more second such energy decay measures in a second measurement period. In this case the secondary device may comprise decay varying means which cause the secondary device to consume more energy in the first measurement period than in the second measurement period. The control means in said primary unit can then employ the first and second energy decay measures to detect when a secondary device of the system is present in proximity to the primary unit. For example, if the control means detects a substantial difference between the first energy measures and the second energy measures, it may conclude that a secondary device must be present.

The decay varying means may cause the secondary device to impose a first dummy load on the primary unit in the first measurement period and to impose a second dummy load, different from the first dummy load, on said primary unit in the second measurement period. One of the first and second dummy loads may be zero.

In this way, the secondary device may apply an additional dummy (or "feedback") load only during some ring-downs and not during others, or only during some part of the ring-down but not others. This may be done for example by switching the feedback resistor mentioned above across the secondary coil, creating a dummy parasitic load, as measured by the primary unit, which varies with time. In contrast, true parasitic loads (for example a piece of steel) will appear to be a constant parasitic load. If the primary unit control means takes similar load measurements between different ring-downs, or different parts of the same ring-down, it may put the drive means into a power-saving "standby" mode. This mode will be entered when no valid secondary device is present.

The decay varying means may be disabled when an actual load of the secondary device requires no power. If the secondary device only presents a time-varying load during ring-down when it requires power, then the primary unit will enter a standby mode even when there are secondary devices present, if they don't require power.

A difference between the first dummy load and the second dummy load may be set in dependence upon said parasitic load imposed on said primary unit by said secondary device. This is a convenient way to communicate the second compensation information to the primary unit.

The secondary device may be adapted to supply the power it receives inductively from the primary unit to an actual load external to the secondary device. The load may be physically separable from the rest of the secondary device, for example it may be connected by a removable plug and socket arrangement. Of course, the secondary device will generally include its own circuitry which will need some of the received power too. In some cases the load could be internal to the secondary device.

The secondary device preferably comprises a storage means for storing energy received from the primary unit. The storage means, where provided, supplies stored energy to the actual load and/or circuitry of the secondary device when the circuit is operating in the undriven resonating condition. This is not essential in all embodiments. Any load which can cope with short power reductions or interruptions will not require the storage means.

The secondary device may comprise load isolation means operable during the measurement period to prevent the supply to an actual load of the secondary device of any of the power being received inductively by the secondary device from the primary unit. Ideally during a ring-down the storage means of the secondary device is of sufficient capacity, and sufficiently well-charged before the ring-down commences, that the decay of energy in the storage means happens more slowly than the decay of energy in the primary coil. If this cannot be guaranteed to be the case under all conditions, for example if the load is separable and with unknown characteristics, then the load isolation means can be included in the secondary device to disconnect the secondary device's storage means, and load, during the ring down, to ensure that its electrical load is not measured by the primary unit.

When the inductive power transfer from the primary unit has been set to such a restricted or stopped state, for example because the parasitic load became too high, the control means may cause the circuit to operate in the undriven resonating condition during a series of intermittent probing periods. In this case the decay measurement means takes one or more such energy decay measures during each said probing period. The control means employ the energy decay measures taken during the probing periods to determine when to end the restricted or stopped state. For example, the control means may periodically allow the drive to run for a short while in order to conduct a ring-down to measure the parasitic load and, if it is now below a threshold, resume the drive.

Alternatively, when the inductive power transfer from the primary unit has been set into such a restricted or stopped state, the control means may maintain that state until the primary unit is reset by a user of the primary unit.

It may be advantageous to provide a clear means of synchronising the behaviour of the secondary device with that of the primary unit. For example, if the secondary device must isolate the load during ring-down, it may need a clear signal that such a ring-down is about to happen, since opening it once a ring-down is in process may be too late. There are many possible means of such synchronisation using a variety of communications means, but one convenient and reliable method is to use the power transfer channel between primary unit and secondary device by putting onto the primary coil a signal which does not occur during normal operation. For example, the primary unit may change the amplitude, frequency or phase of its drive.

The primary unit may comprise synchronising means operable to transmit a predetermined synchronising signal to the secondary device to synchronise operation of the secondary device with that of the primary unit.

The synchronising means may send the predetermined synchronising signal prior to causing the circuit to operate in said undriven resonating condition.

The primary unit may further comprise snubber means. In this case, the synchronising means may switch the snubber means into the circuit after suspending the application of electrical drive signals to said primary coil, so as to send the synchronising signal to the secondary device. In this way the primary coil is stopped very quickly by switching in the snubber, which provides a very easily detectable synchronising signal.

The storage means (e.g. capacitor) of the secondary device may be of significant size and cost if it is to provide sufficient capacity to supply the load during a ring-down. Therefore it is advantageous for the ring-down to occur as quickly as possible. Measuring fewer cycles of the primary coil is one way to achieve this. This will reduce the accuracy of the system but this may be compensated for by averaging the results of several ring-downs.

The primary unit may further comprise resonant frequency increasing means for temporarily increasing a resonant frequency of the circuit during operation thereof in the undriven resonating condition. This is another way to shorten the ring-down time, because by increasing the resonant frequency of the primary coil during a ring-down, more cycles occur in less time.

The control means preferably cause the electrical drive means to resume application of the drive signals to the primary coil in phase with any residual resonating energy within the circuit. After a ring-down is complete, the primary unit must resume normal operation as quickly as possible to prevent the secondary device storage means from discharging to the point where the supply to the load becomes inadequate. Restarting the drive to the primary coil in-phase with any residual resonating energy within the primary coil can ensure that the coil returns to nominal operating conditions as quickly as possible.

The control means may cause the electrical drive means to temporarily boost the electrical drive signals prior to causing the circuit to operate in the undriven resonating condition. This can enhance the hold-up of the secondary device storage means, for any given such means, keeping the size and cost of such means to a minimum. Before a ring-

down, the control means may cause a boost in the current in the primary coil for one or more cycles, thus temporarily raising the voltage in the secondary device storage means. This stores more energy in that means, enabling it to power the load for longer during ring-down.

The control means may measure a natural resonant frequency of the circuit during the measurement period and employ the measured frequency to compensate for an influence of changes in the natural resonant frequency on the energy decay measures. Because the resonant tank is not being actively driven during ring-down, the primary coil resonates at the natural resonant frequency of the system. Measuring the natural resonant frequency during ring-down allows a calculation of the inductance to be made, leading to a direct calculation of total power loss. The inductance may change due to the presence of secondary devices and/or parasitic loads.

The control means may cause the circuit to operate in the undriven resonating condition during a series of different such measurement periods. In this case, the decay measurement means may take one or more such energy decay measures in each said measurement period. The control means can then employ the energy decay measures taken in two or more different measurement periods to control said electrical drive means. For example, the control means can employ an average of the energy decay measures taken in different measurement periods.

Two or more successive measurement periods may be part of the same ring-down. This can give fast results. Alternatively, there may be just one measurement period in each ring-down. This gives slower results but it is possible to resume application of drive signals to the primary coil between measurement periods, making the power interruption to the secondary devices shorter. Also, the circuit conditions can be replicated at the start of each measurement period. The duration of each ring-down is preferably short compared to an interval between successive ring-downs.

In some systems, the primary coil may not driven continuously. It may, for example, be driven in pulses, for example in a pulse-width-modulated manner. In such systems, a partial "ring-down" is effectively happening whenever the primary coil is not being actively driven, perhaps once or more per cycle. Measurement of the natural resonant frequency and decay of the primary coil during these un-driven periods can provide the same functionality as that from the multiple-cycle ring-downs described above.

The secondary device may have a timing means capable of changing the behaviour of the secondary device over time. For example, the timing means may detect when a second ring-down has happened shortly after a first ring-down, and, for example, switch in a conditional dummy (feedback) load only on such a shortly-following second ring-down. This may be useful for example in making interactions between the primary unit and secondary device more deterministic. For example such a means could be used to make the standby detection scheme described above more reliable. For example, if the primary unit always conducts ring-downs in pairs a few milliseconds apart but repeated once every second, and the secondary device applies the feedback load only on the second of the two ring-downs of a pair, the primary unit may average several "first ring downs", and separately average several "second ring-downs", to improve the accuracy of measurement.

The invention can operate even in systems which have more than one primary coil. An example is systems which allow complete freedom of position or orientation of the secondary device by having two orthogonal coils, driven in quadrature, as in GB-A-2388716. In such systems there will be some coupling between the two primary coils, which may make it awkward to analyse a "ring-down" occurring simultaneously on both coils. In this case, the coils can be tested alternately. At the start of a test, both coils are halted, but then only the first coil is allowed to ring-down while the second coil is held in a halted state to prevent it from affecting the measurements on the first coil. During the next test the first coil is held halted while the second coil is allowed to ring-down.

Accordingly, in a preferred embodiment the primary unit may have first and second such primary coils. A first such electrical drive means is connected to the first primary coil for applying electrical drive signals thereto so as to generate a first electromagnetic field, and a second such electrical drive means is connected to the second primary coil for applying electrical drive signals thereto so as to generate a second electromagnetic field. The control means causes the second electrical drive means to suspend application of electrical drive signals to the second primary coil whilst a first such circuit including the first primary coil is in the undriven resonating condition and the decay measurement means are taking one or more such measures of energy decay in the first circuit. Similarly the control means causes the first electrical drive means to suspend application of electrical drive signals to the first primary coil whilst a second such circuit including said second primary coil is in the undriven resonating condition and the decay measurement means are taking one or more such measures of energy decay in the second circuit.

The operating conditions of the primary unit after the ring-down is complete are likely to be identical to those before the ring-down started. If the primary unit contains any control loops (for example to maintain the strength of the magnetic flux), these control loops may be frozen during the ring-down, so that they do not respond to the ring-down and can resume normal operation immediately.

At least one secondary device may be carried in or by an object requiring power. The secondary device can receive power inductively from the primary unit when the object carrying the secondary device is placed on or in proximity to the primary unit. The object may be a portable electrical or electronic device, for example a mobile communication device.

The system may have an "open" construction with a power transfer surface, the field generated by said primary unit being distributed over a power transfer area of the surface such that, when such a secondary device is placed on or in proximity to the power transfer area, the device can receive power inductively from the primary unit.

The power transfer area may be large enough that two or more such secondary devices can be placed on or in proximity to the power transfer area to receive power simultaneously from the primary unit.

According to a second aspect of the present invention there is provided a primary unit, for use in an inductive power transfer system, the primary unit comprising: a primary coil; electrical drive means connected to said primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field; control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and decay measurement means operable to take one or more measures of such energy decay during said period; said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

According to a third aspect of the present invention there is provided a secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising: a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween; load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and communication means operable to communicate to the primary unit information relating to a parasitic load imposed on the primary unit by the secondary device.

The communication means may communicate the information by imposing a dummy load on said primary unit.

The communication means may impose a first dummy load on the primary unit at a first time and a second dummy load, different from the first dummy load, at a second time, a difference between the first and second dummy loads being set in dependence upon the parasitic load. One of the first and second dummy loads may be zero.

This way of communicating the information still works if multiple secondary devices are present. For example, assuming the secondary devices apply their dummy loads at the same time, the primary unit will see a total load equal to the sum of the individual dummy loads of the secondary devices. In this way, the total parasitic load from multiple secondary devices can be communicated very efficiently and reliably.

Alternatively, the communication means may set a time period in which a dummy load is imposed on the primary unit in dependence upon the parasitic load imposed on the primary unit by the secondary device. The primary unit can then measure the duration of the period to obtain information relating to the parasitic load.

According to a fourth aspect of the present invention there is provided a portable electrical or electronic device comprising: a load which at least at times requires power from said primary unit; and a secondary device embodying the aforesaid third aspect of the present invention, said load connection means of said secondary device being connected to said load for supplying such inductively-received power to the load at said times.

According to a fifth aspect of the present invention there is provided a method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit, having a primary coil to which electrical drive signals are applied to generate an electromagnetic field, and also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said

field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, which method comprises: causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil is suspended so that energy stored in the circuit decays over the course of said period; taking one or more measures of such energy decay during said period; and restricting or stopping inductive power transfer from the primary unit in dependence upon said one or more energy decay measures.

Reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a block diagram showing parts of an inductive power transfer system embodying the present invention;

Figures 2(A) and (B) show example waveforms generated in the Figure 1 system;

Figure 3 is a graph illustrating how energy decays in different parts of the system of Figure 1;

Figure 4 is a block diagram showing parts of an inductive power transfer system according to a preferred embodiment of the present invention;

Figure 5 shows different operating states of a circuit in the Figure 4 system when the circuit is in an undriven resonating condition;

Figure 6 is a graph illustrating a variation over time of current flowing through a primary coil in each of the Figure 5 states;

Figure 7 is a diagram illustrating waveforms generated in operation of the Figure 4 system;

Figure 8 is a diagram for illustrating different modes of operation in the Figure 4 system; and

Figures 9(A) to (E) illustrate the conditions under which the modes of Figure 8 are selected in the Figure 4 system.

Figure 1 illustrates parts of an inductive power transfer system embodying the present invention. The system 1 comprises a primary unit 10 and at least one secondary device 30. The primary unit 10 has a primary coil 12 and an electrical drive unit 14 connected to the primary coil 12 for applying electrical drive signals thereto so as to generate an electromagnetic field.

The primary unit may have any suitable form but one preferred form is a flat platform having a power transfer surface on or in proximity to which each secondary device can be placed. In this case, the field may be distributed over a power transfer area of the surface, as described in GB-A-2388716.

The secondary device 30 is separable from the primary unit 10 and has a secondary coil 32 which couples with the electromagnetic field generated by the primary unit when the secondary device is in proximity to the primary unit. In this way, power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween.

The primary and secondary coils can have any suitable forms, but may for example be copper wire wound around a high-permeability former such as ferrite or amorphous metal.

The secondary device is usually connected to an external load (not shown) and supplies the inductively-received power to the external load. The secondary device may be carried in or by an object requiring power such as a portable electrical or electronic device or a rechargeable battery or cell. Further information regarding designs of secondary device and the objects which can be powered using the secondary devices can be found in GB-A-2388716.

The primary unit 10 in the Figure 1 system also comprises a control unit 16 and a decay measurement unit 18. The control unit causes a circuit (referred to hereinafter as a "resonant tank") including the primary coil to operate in an undriven resonating condition

during a measurement period. In this undriven resonating condition ("ring-down") the application of electrical drive signals to the primary coil by the electrical drive unit 14 is suspended so that energy stored in the resonant tank decays over the course of the measurement period.

Typically a resonant tank is formed by a circuit comprising at least an inductor and a capacitor. The resonant tank stores electrical energy. When brought into the undriven resonating condition, the stored electrical energy flows or oscillates within the tank at a natural resonant frequency of the tank.

The resonant tank includes not only the electrical circuit within the primary unit of which the primary coil is a part, but also the electrical circuit(s) within the at least one secondary units, which is or are coupled to the primary coil via the magnetic circuit formed by the primary and secondary coil(s).

The primary coil may be made resonant with a capacitor in series or parallel, or both series and parallel, and/or may be resonant due to its self-capacitance. It may or may not be driven at its resonant frequency in normal operation, but once a ring-down occurs will naturally oscillate at its resonant frequency.

During a ring-down, no energy is being supplied to the primary coil, and so the rate of decay of energy in the resonant tank is a measure of the rate at which energy is being removed from it. The principal causes of energy loss are:

- Energy coupled into the secondary coil of any secondary device present. This energy may be stored in a storage unit of the secondary device and/or delivered to a load connected to the secondary device.
- Losses to any parasitic loads (foreign objects) present.
- Other losses in the primary unit or any secondary devices/host objects present. These other losses include inefficiencies in the primary coil itself and any other components of the resonant tank (e.g. I^2R losses in the copper of the coil or effective series resistance of any resonating capacitor). They also include any

magnetic losses in the primary and secondary units, for example magnetic hysteretic loop losses in any cores associated with the primary unit and/or secondary device.

Figures 2(A) and 2(B) show two possible examples of energy decay during a ring-down. If the losses are small (Fig. 2(A)) then during a ring-down the energy in the resonant tank will decay slowly. Conversely if the losses are large (Fig. 2(B)) then during a ring-down the energy in the resonant tank will decay rapidly.

The decay measurement unit 18 takes one or more measures of the energy decay in the resonant tank during the measurement period.

The decay measurement unit 18 may take the energy decay measures in any suitable way, for example by measuring the voltage across, or current through, the primary coil or by measuring some other quantity associated with the primary coil, for example the magnetic flux generated thereby. The measurement may be taken over part of a cycle, or over one or more cycles. The measure may be, for example, the ratio of one peak to a subsequent peak. Alternatively, the measure may be derived by curve-fitting several data points. The measure is a rate of energy decay in the resonant tank in one preferred embodiment.

The control unit 16 controls the electrical drive unit 14 so as to restrict or stop inductive power transfer from the primary unit in dependence upon the energy decay measures produced by the decay measurement unit 18.

The energy decay measures may be used by the control unit to restrict or stop inductive power transfer from the primary unit following the detection of certain conditions.

One such condition is the presence of a substantial parasitic load in the vicinity of the primary unit. In this case, the control unit 16 may enter a shutdown mode in which the drive to the primary coil is reduced or stopped, preventing heating of the parasitic load.

Another such condition is when no secondary device of the system is present in the vicinity of the primary unit. Another such condition is when there is at least one secondary device present but none of the devices has a load currently requiring power. A load does not require power, for example, when turned off or when, in the case of a rechargeable battery or cell, the battery or cell is fully charged. Under both these conditions the control unit 16 may enter a standby mode in which the drive to the primary coil is reduced or stopped, preventing unnecessary power consumption in the primary unit.

Compared to other possible methods of measuring the power delivered to the primary coil - for example by measuring the supply power to the primary unit drive electronics - the method used in the present invention is quick and accurate. This accuracy is due at least to the following aspects:

- The drive electronics may be inactive and largely out of circuit during the ring-down, therefore their noise and tolerances do not affect the measurement accuracy.
- Since the method directly measures power taken, it is very hard to "trick" – it works reliably regardless of how power is being taken out, in contrast to other indirect techniques such as measuring inductance shift which make assumptions between the quality they measure and the parasitic load, which may not always be true.

Figure 4 shows parts of an inductive power transfer system according to a preferred embodiment of the present invention. The system 1 has a primary unit 10 and a secondary device 30. Figure 4 also shows a parasitic load 500 on the primary unit, caused for example by a foreign object placed in the vicinity of the primary unit. The secondary device 30 in this case is assumed to be carried in or by a host object such as a portable electrical or electronic device. As explained hereinbefore the secondary device and/or host object also inevitably impose a "friendly" parasitic load 501 on the primary unit.

As described earlier with reference to Figure 1, the primary unit 10 comprises a primary coil 12, an electrical drive unit 14, a control unit 16 and a decay measurement unit 18.

The electrical drive unit 14 in this embodiment has a conventional half bridge configuration in which a first switch 20 is connected between a first power supply line of the primary unit and an output node of the electrical drive unit, and a second switch 21 is connected between the output node and a second power supply line of the primary unit. The first and second switches 20 and 21 may, for example, be field-effect transistors (FETs). The electrical drive unit 14 also comprises a drive controller 19 which applies control signals to the switches 21 and 22 to turn them on and off. The drive controller 19 has a control input connected to an output of the control unit 16

The output node of the electrical drive unit 14 is connected via a capacitor 17 to one side of the primary coil 12.

The control unit 16 is a microprocessor in this embodiment. Alternatively, an ASIC could be used to implement the control unit 16, as well as some or all of the other circuit elements of the primary unit.

The decay measurement unit 18 in this embodiment comprises a resistor 25 which has a first node connected to one side of a switch 28 and a second node connected to the second power supply line. The resistor 25 is a low-value resistor. The decay measurement unit 18 further comprises an operational amplifier 26 having an input connected to the first node of the resistor 25. The decay measurement unit 18 also comprises an analog-to-digital converter (ADC) 27 connected to an output of the operational amplifier 26. An output of the ADC 27 is connected to a measurement input of the control unit 16.

The other side of the switch 28 is connected to the other side of the primary coil 12. A snubber unit 22 is connected in parallel with the switch 28. The snubber unit 22 comprises a capacitor 23 and a resistor 24 connected in series with one another.

The primary unit 10 further comprises a calibration unit 29 in this embodiment. The calibration unit 29 stores first compensation information about the losses in the primary unit (e.g. electrical or magnetic losses). By design, at manufacture, and/or periodically thereafter, the losses in the primary unit may be calibrated and stored within the calibration unit 29. The calibration unit supplies the stored information to the control unit 16 to enable the control unit 16 to subtract the losses from the total measurement, thus calculating a number for the loss due to parasitic loads alone. This calibration unit 29 may vary the first compensation information to cope with variable losses in the primary unit, for example losses which vary with temperature.

The secondary device 30 comprises a secondary coil 32, a rectifier 34, a secondary control unit 36, a dummy load switch 38, a dummy load 40, a load switch 42, a storage unit 44 and an actual load 46. The dummy load switch 38 and the load switch 42 may each be an FET, for example. The dummy load 40 is, for example, a resistor. The storage unit 44 is a capacitor in this embodiment but an inductor could be used instead. The actual load 46 is external to the secondary device in this embodiment and is part of the host object. It could be a battery charge controller for a Lithium-ion cell.

Operation of the system of Figure 4 will now be described.

In an "operating mode" of the system, the host object incorporating the secondary device 30 is placed on or in proximity to the primary unit 10. The drive controller 19 applies control signals to the switches 20 and 21 alternately, so that electrical drive signals are applied to the primary coil 12 via the capacitor 17. The switch 28 is closed. The primary coil 12, capacitor 17, switch 28 and resistor 25 and parts of the secondary device 30 together form a resonant tank. The resonant tank is preferably driven by the electrical drive unit 14 at or near resonance so as to maximise power transfer to the secondary device, but this is not essential in the present invention. In its driven condition, the resonant tank could be driven at some frequency other than its resonant frequency.

In the operating mode, the primary coil 12 generates an electromagnetic field in the vicinity of the primary unit. The secondary coil 32 couples with this field and an alternating current is induced in the coil by the field. The dummy load switch 38 is open and the load switch 42 is closed. The alternating current induced in the secondary coil 32 is rectified by the rectifier 34 and the rectified current is supplied via the load switch 42 to the storage unit 44 and the actual load 46. In this way, power is transferred inductively from the primary unit to the secondary device 30 and from there to the load. The storage unit 44 stores energy in the operating mode.

Whilst in the operating mode, from time to time the control unit 16 in the primary unit initiates a series of three ring-downs in quick succession. Such a series of three ring-downs is shown in Figure 7. The interval between successive series of ring-downs may be, for example, one second. The duration of each ring-down is, for example, one millisecond. Each ring-down of a series has a sequence of three states as shown in Figure 5.

Initially, the system has a normal state in which the control unit 16 causes the electrical drive unit 14 to apply drive signals to the primary coil 12 to cause it to oscillate. It will be appreciated that in the operating mode as described above, the system is in this state for almost all the time.

The next state is a "snub" state. The application of drive signals to the primary coil 12 by the electrical drive unit 14 is suspended under the control of the control unit 16. The drive controller 19 closes the switch 21. The control unit 16 also opens the switch 28 at a time when most of the energy in the resonant tank resides in the capacitor 17. The opening of the switch 28 brings the snubber unit 22 in series with the resonant tank. The snubber unit 22 quickly dissipates any energy which remains in the primary coil 12, stopping it from resonating within one cycle or so. Most of the energy stored in the resonant tank is left in the capacitor 17.

The sudden cessation of cycles is detected by the secondary control unit 36 in the secondary device 30. The secondary control unit 36 opens the load switch 42. The system then enters the decay state from the snub state.

The control unit 16 closes the switch 28, removing the snubber unit 22 from the resonant tank, and thus allowing the energy in capacitor 17 to flow again within the resonant tank. In the decay state, the resonant tank operates in an undriven resonating condition. Energy stored in the resonant tank decays over the course of time in the decay state. In this embodiment, the decay measurement unit 18 measures the energy decay in the resonant tank by measuring the current flowing through the primary coil 12. The same current flows through the resistor 25 and generates a voltage at the first node of that resistor. This voltage is buffered by the operational amplifier 26 and converted into a digital signal by the ADC 27. The resulting digital signal is applied to the measurement input of the control unit 16.

The secondary device uses the storage unit 44 to store energy from the primary unit during normal operation. During the decay state, the energy stored in the storage unit 44 of the secondary device gradually decays as energy is delivered to the load. Provided that the storage unit has sufficient capacity, and is sufficiently well-charged before ring-down commences, the storage unit can deliver continuous power to the secondary device load throughout the ring-down, so the actual load 46 is not interrupted. In Figure 3 a solid line 411 shows the decay of energy in the primary coil 12 and a dotted line 410 represents the decay of energy in the storage unit 44 of the secondary device during the decay state.

The secondary device load will not take any power from the primary coil, and will thus be "invisible" to the primary unit, during the decay state. This is possible in this embodiment because the rectifier 34 between the secondary coil and the storage unit allows current to flow only from the former to the latter. It can be arranged in other ways that the secondary device load will not take any power from the primary coil during the ring-down.

As long as this is the case, the decay measurement will not include losses due to power supplied to the secondary load, i.e. will only measure losses in the primary unit and losses due to parasitic loads.

Figure 6 shows how the current flowing through the primary coil 12 varies in the normal, snub and decay states which occur during a ring-down. In this embodiment, the digital signals representing the current flowing in the primary coil within a measurement period are received and processed within the control unit 16 to calculate a measure of the rate of energy decay in the resonant tank.

An equation describing the energy stored in the resonant tank, at resonance, is:

$$E = \frac{1}{2} L\hat{I}^2 = \frac{1}{2} C\hat{V}^2$$

where E is the energy, L the inductance, $\hat{I}$ is the peak current, C is the capacitance and $\hat{V}$ is the peak voltage.

Therefore the energy stored in the resonant tank of the primary at any given moment can be calculated if the inductance and peak current are known, or if the capacitance and peak voltage are known, or combinations thereof. Typically the capacitance is known by design, the peak current and voltage can be measured by suitable circuitry, and the inductance can be deduced by observing the natural resonant frequency during ring-down and applying the formula:

$$L = \frac{1}{4\pi^2 f^2 C}$$

The rate of decay of energy (and thus the loss) from the resonant tank can be calculated by measuring E_1 at time T_1 and E_2 at another time T_2, and calculating

$$\frac{E_2 - E_1}{T_2 - T_1}$$

Since at resonance the voltage and current in the resonant tank will be 90 degrees out of phase with one another, a convenient method of reading the peak voltage of one is to trigger the measurement on the zero-crossing of the other.

The control unit 16 employs the first compensation information stored in the calibration unit 29 when processing the digital signals to measure the energy decay rate. In this way, the control unit 16 compensates for the losses arising in the primary unit itself.

The behaviour of the primary unit and the secondary device is slightly different in each of the three ring-downs of a series.

During the first ring-down, the secondary control unit 36 has the dummy load switch 38 open so that the dummy load 40 is not connected to the secondary coil 32. As a result, the energy decay measure produced during the first ring-down is a measure of the energy decay due to any parasitic loads 500 from foreign objects in the vicinity of the primary unit and any parasitic load 501 imposed by losses in the secondary device and/or its host object .

During the second ring-down, the secondary control unit 36 selectively closes the dummy load switch 38. The secondary control unit 36 decides whether to have the dummy load switch 38 open or closed during the second ring-down based on the power requirement of the actual load 46. If the load 46 does not require any power at the present time, for example, because it has a rechargeable battery which is presently fully charged, then the dummy load switch 38 is kept open during the second ring-down. If, on the other hand, the load 46 does require power at the present time, then the dummy load switch 38 is closed so that the dummy load 40 is connected to the primary coil 32.

The control unit 16 produces another measure of the energy decay rate during a measurement period within the second ring-down. If the energy decay rate during the second ring-down is substantially different from the energy decay rate during the first ring-down, the control unit 16 detects that a secondary device requiring power may be present in the vicinity of the primary unit.

During the third ring-down, the secondary control unit 36 always closes the dummy load switch 38 so that the dummy load 40 is connected to the secondary coil 32. Another measure of the energy decay rate is taken by the control unit 16 in the primary unit. In this case, the energy decay rate is a measure of the sum of the parasitic loads 500, the parasitic load 501 of the secondary device and/or host object, and the dummy load 40. Based on the difference between the energy decay rates in the first and third ring-downs, the control unit calculates the value of the total of the dummy loads 40 in all of the secondary devices present in the vicinity of the primary unit.

Each dummy load 40 in a secondary device 30 in the system of this embodiment is set to a particular value (at manufacture or during calibration or testing) so that the value represents the parasitic load 501 imposed by the secondary device concerned and/or by its host object.

Thus, the total dummy load for all secondary devices present, as calculated by the control unit 16, can be used by the control unit 16 as second compensation information to compensate for the parasitic loads 501 of the secondary devices present. For example, if the control unit 16 detects that a substantial parasitic load 500 is present in the vicinity of the primary unit when the energy decay rate exceeds some threshold, the threshold may be increased by an amount dependent on the total parasitic load 501 of all the secondary devices present, so that the detection of parasitic loads 500 from foreign objects is not influenced by the number of secondary devices present.

A system embodying the present invention is capable of measuring loads imposed on the primary unit sensitively, for example to within 50mW or so. With this degree of

sensitivity, it is possible to ensure that very little power is coupled into parasitic loads 500 such as foreign objects.

Figure 8 is a diagram illustrating the different modes of operation in the Figure 4 system and the conditions for switching between these different modes. The three modes of operation are an operating mode, a shutdown mode and a standby mode.

In the operating mode, the primary unit is in the normal state (driven condition) most of the time, but periodically does a series of three ring-downs as described above. If the result of the ring-downs is that no secondary device requires power, the primary unit goes into a standby mode. If the result of the ring-downs is that a significant parasitic load 500 is present, the primary unit goes into a shutdown mode.

In the standby mode, the electrical drive unit 14 is stopped for most of the time, thus consuming little power. Periodically the primary unit enters the normal state then does a series of ring-downs in respective probing periods, to check whether it should enter either the operating mode or the shutdown mode. Otherwise it remains in the standby mode.

The shutdown mode is functionally identical to standby mode. However, the two modes may be distinguished by some user-interface feature such as an LED to prompt the user to remove any substantial parasitic load 500.

Figures 9(A) to 9(E) illustrate the conditions under which the modes of Figure 8 are selected in the Figure 4 system. In Figure 9(A) there is no secondary device present in the vicinity of the primary unit. In this case, the primary unit is in the standby mode. In Figure 9(B) no secondary device is present but a substantial parasitic load is present in the vicinity of the primary unit. In this case, the primary unit is in the shutdown mode. In Figure 9(C) a secondary device and a substantial parasitic load are both present at the same time in the vicinity of the primary unit. In this case, the primary unit is in the shutdown mode. In Figure 9(D) a secondary device is present in the vicinity of the primary unit, but the load connected to the secondary device does not need any power at

the current time. In this case, the primary unit is in the standby mode. Finally, in Figure 9(E) a secondary device is present and its load needs power to charge or operate. Thus, the primary unit is in the operating mode.

CLAIMS:

1. An inductive power transfer system comprising a primary unit, having a primary coil and electrical drive means connected to the primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field, and the system also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, wherein the primary unit further comprises:

control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and

decay measurement means operable to take one or more measures of such energy decay during said period; and

said control means are further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

2. A system as claimed in claim 1, wherein the or one said energy decay measure is a measure of a rate of such energy decay.

3. A system as claimed in claim 1 or 2, wherein said control means are operable to employ said one or more energy decay measures to detect when a substantial parasitic load is present in proximity to said primary unit, and are operable to restrict or stop inductive power transfer from the primary unit following the detection of such a substantial parasitic load.

4. A system as claimed in any preceding claim, wherein said control means are operable to employ said one or more energy decay measures to detect when there is no said secondary device present in proximity to said primary unit, and are operable to restrict or stop inductive power transfer from the primary unit when no such secondary device is detected.

5. A system as claimed in claim 3 or 4, wherein when carrying out such detection the control means are also operable to employ first compensation information relating to losses in the primary unit itself so as to compensate for said losses.

6. A system as claimed in claim 5, wherein the primary unit further comprises calibration means for deriving part or all of said first compensation information from measurements taken by the primary unit when it is effectively in electromagnetic isolation.

7. A system as claimed in any one of claims 3 to 6, wherein when carrying out such detection said control means are also operable to employ second compensation information relating to a parasitic load imposed on the primary unit by the secondary device so as to compensate for said parasitic load of said secondary device.

8. A system as claimed in claim 7, wherein the or each said secondary device is operable to communicate its said second compensation information directly to said primary unit or to communicate to said primary unit other information from which the primary unit can derive said second compensation information.

9. A system as claimed in claim 8, wherein said secondary device is operable to modulate a dummy load to communicate said other information, and the primary unit is operable to derive said second compensation information by measuring the dummy load modulation.

10. A system as claimed in any one of claims 5 to 9, wherein part or all of said first compensation information and/or part or all of said second compensation information is information stored in the primary unit during manufacture and/or testing of the primary unit.

11. A system as claimed in any one of claims 3 to 10, further comprising information varying means for varying one or both of said first and second compensation information when one or more operating conditions of the primary unit varies.

12. A system as claimed in any preceding claim, wherein:

said decay measurement means are operable to take one or more first such energy decay measures in a first such measurement period and to take one or more second such energy decay measures in a second measurement period;

the secondary device comprises decay varying means operable to cause the secondary device to consume more energy in said first measurement period than in said second measurement period; and

the control means in said primary unit are operable to employ the first and second energy decay measures to detect when a secondary device of the system is present in proximity to said primary unit.

13. A system as claimed in claim 12, wherein said decay varying means are operable to cause the secondary device to impose a first dummy load on the primary unit in said first measurement period and to impose a second dummy load, different from said first dummy load, on said primary unit in said second measurement period.

14. A system as claimed in claim 13, wherein one of the first and second dummy loads is zero.

15. A system as claimed in claim 13 or 14, wherein said decay varying means are disabled when an actual load of the secondary device requires no power.

16. A system as claimed in claim 13, 14 or 15 when read as appended to claim 9, wherein a difference between said first dummy load and said second dummy load is set in dependence upon said parasitic load imposed on said primary unit by said secondary device.

17. A system as claimed in any preceding claim, wherein said secondary device is adapted to supply the power it receives inductively from the primary unit to an actual load external to the secondary device.

18. A system as claimed in any preceding claim, wherein said secondary device comprises a storage means for storing energy received from the primary unit, said storage means being operable to supply such stored energy to an actual load and/or circuitry of the secondary device when said circuit is operating in said undriven resonating condition.

19. A system as claimed in any preceding claim, wherein said secondary device comprises load isolation means operable during said measurement period to prevent the supply to an actual load of the secondary device of any of the power being received inductively by the secondary device from the primary unit.

20. A system as claimed in any preceding claim, wherein:

said control means are operable, following such restriction or stopping of the inductive power transfer from the primary unit, to cause said circuit to operate in said undriven resonating condition during a series of intermittent probing periods;

the decay measurement means are operable to take one or more such energy decay measures during each said probing period; and

the control means are operable to employ the energy decay measures taken during the probing periods to determine when to end the restricted or stopped state.

21. A system as claimed in any one of claims 1 to 19, wherein said control means are operable, when the inductive power transfer from the primary unit has been set into such a restricted or stopped state, to maintain that state until the primary unit is reset by a user of the primary unit.

22. A system as claimed in any preceding claim, wherein the primary unit comprises synchronising means operable to transmit a predetermined synchronising signal to the secondary device to synchronise operation of the secondary device with that of the primary unit.

23. A system as claimed in claim 22, wherein said synchronising means are operable to send said predetermined synchronising signal prior to causing said circuit to operate in said undriven resonating condition.

24. A system as claimed in claim 22 or 23, wherein said primary unit further comprises snubber means, and said synchronising means are operable to switch said snubber means into said circuit after suspending the application of said electrical drive signals to said primary coil, so as to send said synchronising signal to said secondary device.

25. A system as claimed in any preceding claim, wherein said primary unit further comprises resonant frequency increasing means for temporarily increasing a resonant frequency of said circuit during operation thereof in said undriven resonating condition.

26. A system as claimed in any preceding claim, wherein said control means are operable to cause said electrical drive means to resume application of said drive signals to said primary coil in phase with any residual resonating energy within said circuit.

27. A system as claimed in any preceding claim, wherein said control means are operable to cause said electrical drive means to temporarily boost said electrical drive signals prior to causing said circuit to operate in said undriven resonating condition.

28. A system as claimed in any preceding claim, wherein said control means are operable to measure a natural resonant frequency of said circuit during said measurement period and to employ the measured frequency to compensate for an influence of changes in the natural resonant frequency on said one or more energy decay measures.

29. A system as claimed in any preceding claim, wherein:

said control means are operable to cause said circuit to operate in said undriven resonating condition during a series of different such measurement periods;

said decay measurement means are operable to take one or more such energy decay measures in each said measurement period; and

said control means are operable to employ the energy decay measures taken in two or more different measurement periods to control said electrical drive means.

30. A system as claimed in any preceding claim, wherein:

said primary unit has first and second such primary coils, a first such electrical drive means connected to said first primary coil for applying electrical drive signals thereto so as to generate a first electromagnetic field, and a second such electrical drive means connected to said second primary coil for applying electrical drive signals thereto so as to generate a second electromagnetic field; and

said control means are operable to cause said second electrical drive means to suspend application of said electrical drive signals to said second primary coil whilst a first such circuit including said first primary coil is in said undriven resonating condition and said decay measurement means are taking one or more such measures of energy decay in said first circuit, and are also operable to cause said first electrical drive means to suspend application of said electrical drive signals to said first primary coil whilst a second such circuit including said second primary coil is in said undriven resonating condition and said decay measurement means are taking one or more such measures of energy decay in said second circuit.

31. A system as claimed in any preceding claim, wherein at least one said secondary device is carried in or by an object requiring power and can receive power inductively from the primary unit when the object carrying the secondary device is placed on or in proximity to the primary unit.

32. A system as claimed in claim 31, wherein said object is a portable electrical or electronic device.

33. A system as claimed in claim 31 or 32, wherein said object is a mobile communication device.

34. A system as claimed in any preceding claim, having a power transfer surface, said field generated by said primary unit being distributed over a power transfer area of the surface such that, when such a secondary device is placed on or in proximity to the power transfer area, the device can receive power inductively from the primary unit.

35. A system as claimed in any preceding claim, wherein said power transfer area is large enough that two or more such secondary devices can be placed on or in proximity to the power transfer area to receive power simultaneously from the primary unit.

36. A primary unit, for use in an inductive power transfer system, the primary unit comprising:

a primary coil;

electrical drive means connected to said primary coil for applying electrical drive signals thereto so as to generate an electromagnetic field;

control means operable to cause a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil by said electrical drive means is suspended so that energy stored in said circuit decays over the course of said period; and

decay measurement means operable to take one or more measures of such energy decay during said period;

said control means being further operable, in dependence upon said one or more energy decay measures, to control the electrical drive means so as to restrict or stop inductive power transfer from the primary unit.

37. A secondary device, for use in an inductive power transfer system that comprises a primary unit which generates an electromagnetic field, the secondary device comprising:

a secondary coil adapted to couple with said field generated by said primary unit when the secondary device is in proximity to the primary unit so that power can be received inductively by the secondary device from the primary unit without direct electrical conductive contacts therebetween;

load connection means, connected to said secondary coil and adapted to be connected when the secondary device is in use to a load requiring power from the primary unit, for supplying such inductively-received power to the load; and

communication means operable to communicate to the primary unit information relating to a parasitic load imposed on the primary unit by the secondary device.

38. A secondary device as claimed in claim 37, wherein said communication means are operable to communicate said information by imposing a dummy load on said primary unit.

39. A secondary device as claimed in claim 38, wherein said communication means are operable to impose a first dummy load on the primary unit at a first time and a second dummy load, different from said first dummy load, at a second time, a difference between said first and second dummy loads being set in dependence upon said parasitic load.

40. A secondary device as claimed in claim 39, wherein one of said first and second dummy loads is zero.

41. A portable electrical or electronic device comprising:

a load which at least at times requires power from said primary unit; and

a secondary device as claimed in any one of claims 37 to 40, said load connection means of said secondary device being connected to said load for supplying such inductively-received power to the load at said times.

42. A method of controlling inductive power transfer in an inductive power transfer system comprising a primary unit, having a primary coil to which electrical drive signals are applied to generate an electromagnetic field, and also comprising at least one secondary device, separable from the primary unit and having a secondary coil adapted to

couple with said field when the secondary device is in proximity to the primary unit so that power can be transferred inductively from the primary unit to the secondary device without direct electrical conductive contacts therebetween, which method comprises:

causing a circuit including said primary coil to operate, during a measurement period, in an undriven resonating condition in which the application of said drive signals to said primary coil is suspended so that energy stored in the circuit decays over the course of said period;

taking one or more measures of such energy decay during said period; and

restricting or stopping inductive power transfer from the primary unit in dependence upon said one or more energy decay measures.

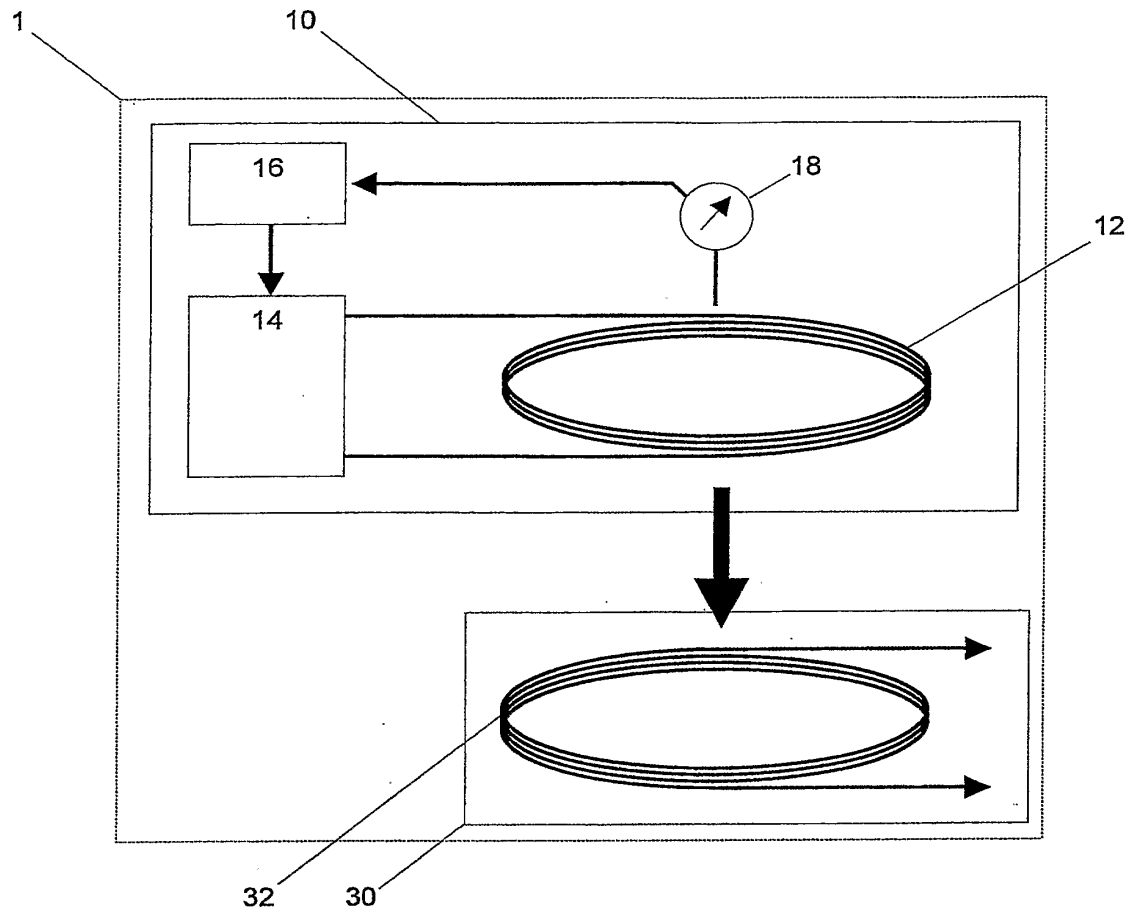


Figure 1

Figure 2(A)

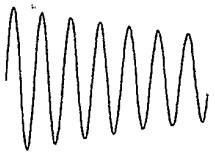
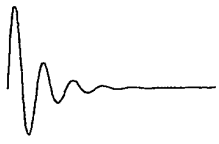


Figure 2(B)



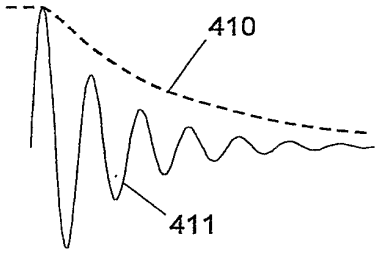


Figure 3

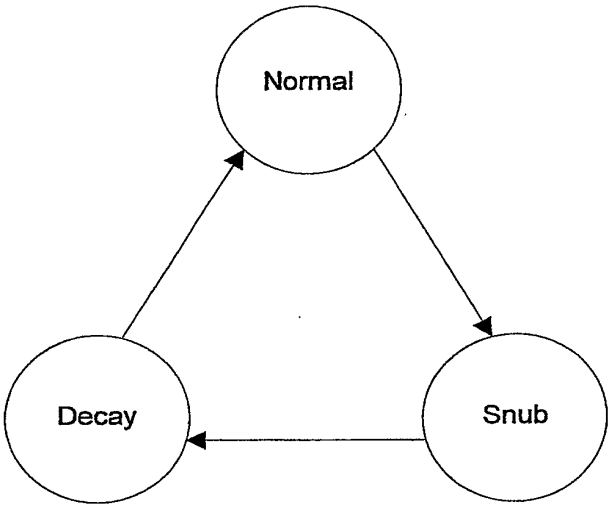


Figure 5

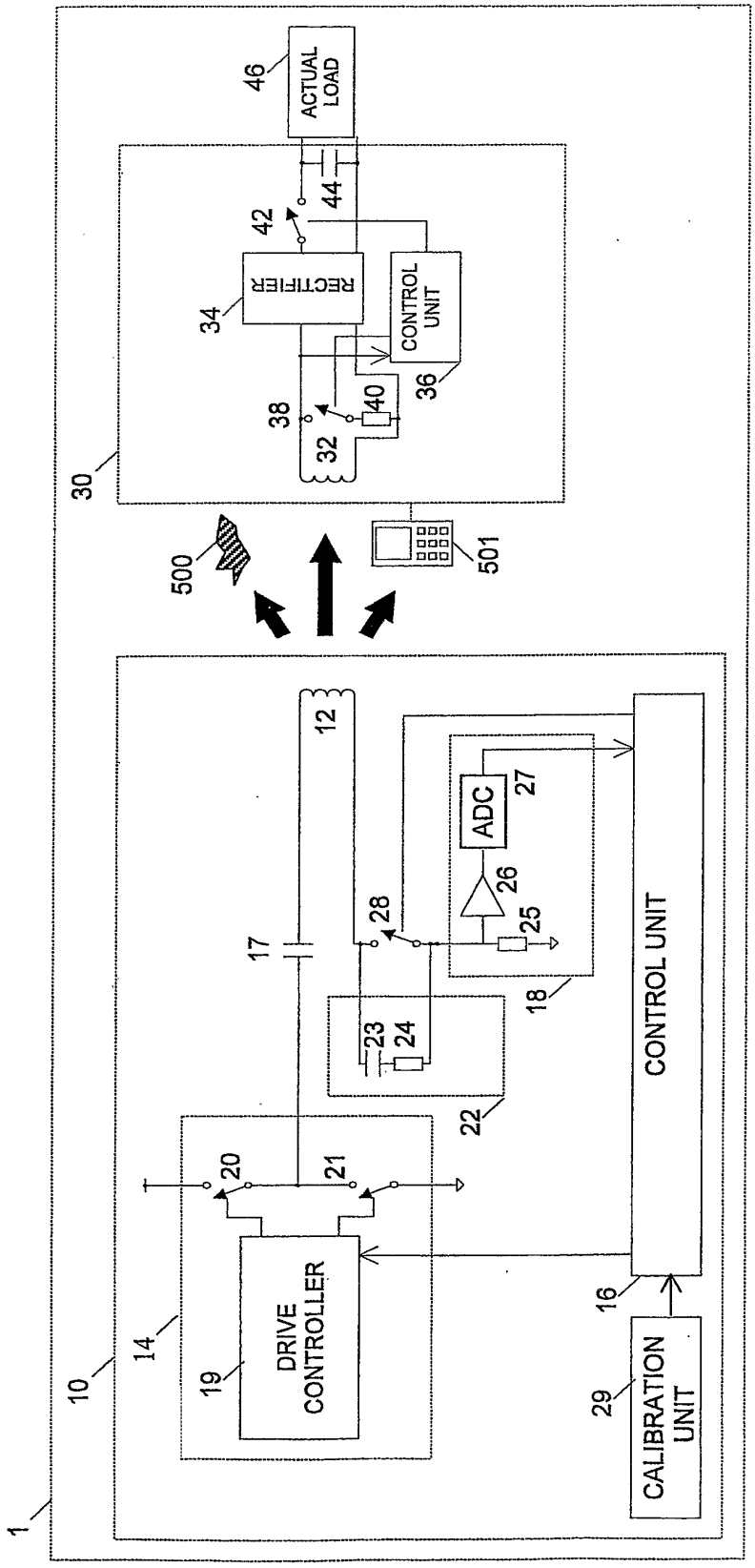

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ACTUAL LOAD
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CONTROL UNIT
ADC
DRIVE CONTROLLER
CONTROL UNIT
CALIBRATION UNIT

Figure 4

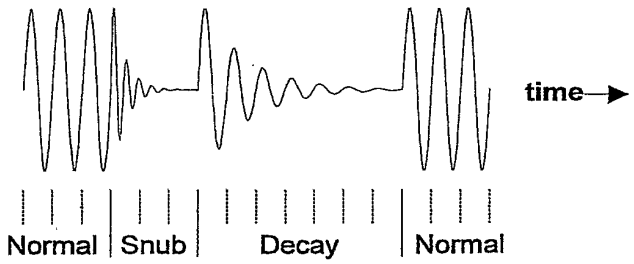


Figure 6



Figure 7

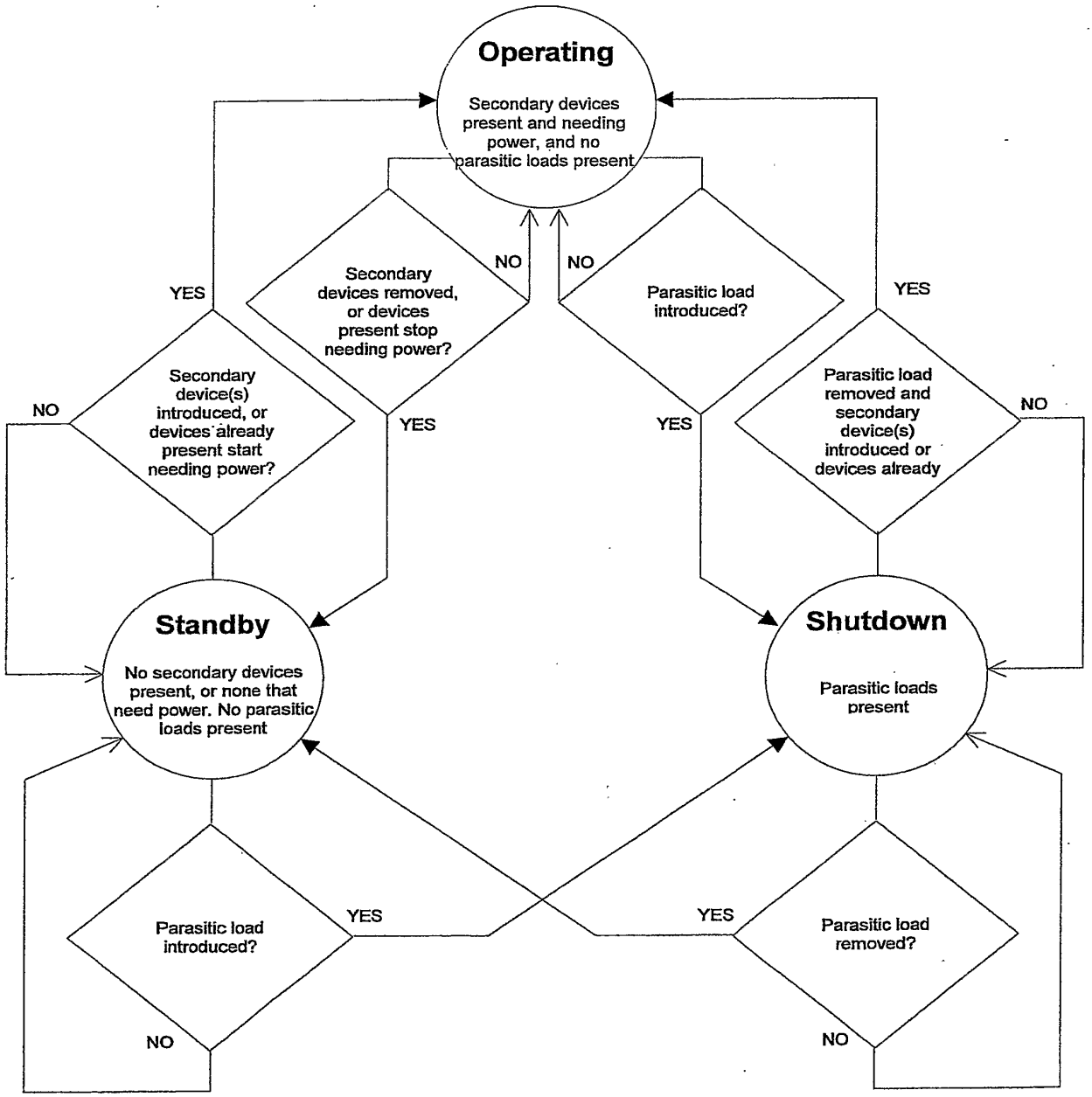

Operating
Secondary devices present and needing power, and no parasitic loads present
Secondary devices removed, or devices present stop needing power?
NO
YES
Parasitic load introduced?
NO
YES
Secondary device(s) introduced, or devices already present start needing power?
NO
YES
Parasitic load removed and secondary device(s) introduced or devices already
YES
NO
Standby
No secondary devices present, or none that need power. No parasitic loads present
Shutdown
Parasitic loads present
Parasitic load introduced?
YES
NO
Parasitic load removed?
YES
NO

Figure 8

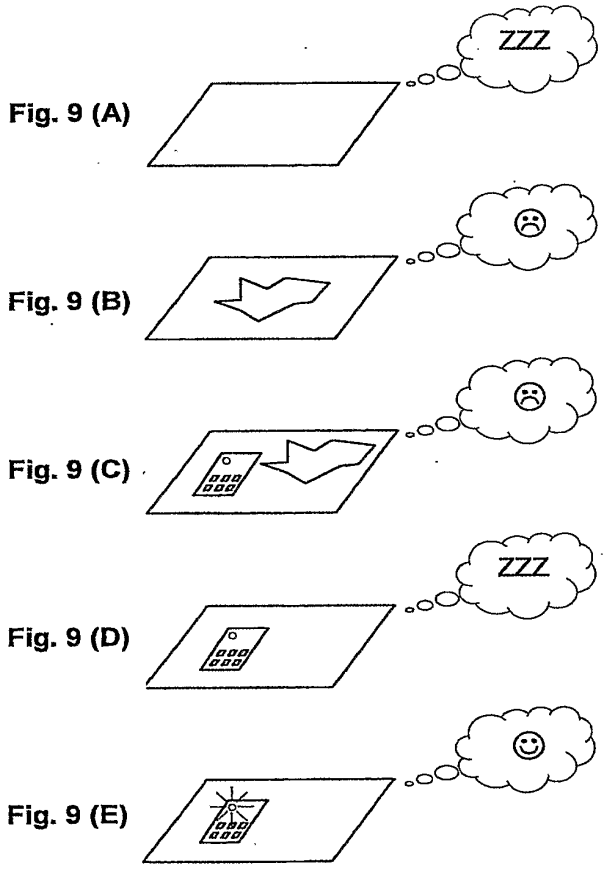


Figure 9

INTERNATIONAL SEARCH REPORT

Int Application No
PCT/GB2005/001833

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 057 668 A (CHAO ET AL) 2 May 2000 (2000-05-02) claims 1-5; figure 2	37-41
A	US 6 263 247 B1 (MUELLER JEFFREY S ET AL) 17 July 2001 (2001-07-17) column 1 - column 9; claims 1-4; figure 8	1-36,42
A	US 5 619 078 A (BOYS ET AL) 8 April 1997 (1997-04-08) column 10, line 60 - column 12, line 55; figures 9,10	1-36,42

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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

"E" earlier document but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2005	03/08/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mapp, G

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

mation on patent family members

Inter il Application No
PCT/GB2005/001833

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6057668 A	02-05-2000	DE 29816725 U1	14-01-1999
US 6263247 B1	17-07-2001	US 6047214 A	04-04-2000
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US 5619078 A	08-04-1997	AU 4093493 A	13-12-1993
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		DE 69326762 T2	20-04-2000
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		EP 0640254 A1	01-03-1995
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		WO 9323908 A1	25-11-1993
		WO 9323909 A1	25-11-1993
		US 5898579 A	27-04-1999

Form PCT/ISA/210 (patent family annex) (January 2004)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)
(PCT Rule 44bis.1(c))

To:

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NOV 10 2011

KENNA, Karl, F.
Fliesler Meyer LLP
650 California Street, Fourteenth Floor
San Francisco, California 94108
ETATS-UNIS D'AMERIQUE

FLIESLER MEYER LLP

Date of mailing *(day/month/year)* 10 November 2011 (10.11.2011)	
Applicant's or agent's file reference AFPA1026WO0 ✓	IMPORTANT NOTICE

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2010/032845 /	28 April 2010 (28.04.2010) ✓	28 April 2009 (28.04.2009) ✓

Applicant
MOJO MOBILITY, INC. et al ✓

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

Docket No: AFPA-01026WO4
Atty: KFK
Docketed By: mpx
Verified By: ✓
Notes

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Athina Nickitas-Etienne
Facsimile No. +41 22 338 82 70	e-mail: pt04.pct@wipo.int

Form PCT/IB/326 (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference AFPA1026WO0	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2010/032845	International filing date *(day/month/year)* 28 April 2010 (28.04.2010)	Priority date *(day/month/year)* 28 April 2009 (28.04.2009)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant MOJO MOBILITY, INC.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 01 November 2011 (01.11.2011)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Athina Nickitas-Etienne e-mail: pt04.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KENNA KARL F.

FLIESLER MEYER LLP 650 CALIFORNIA STREET,
FOURTEENTH FLOOR SAN FRANCISCO CA 94108 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**13 DECEMBER 2010 (13.12.2010)**
Applicant's or agent's file reference AFPA1026WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2010/032845	**28 APRIL 2010 (28.04.2010)**	28 APRIL 2009 (28.04.2009)

International Patent Classification (IPC) or both national classification and IPC

H02J 7/00(2006.01)i, H02J 17/00(2006.01)i, H01F 38/14(2006.01)i

Applicant

MOJO MOBILITY, INC. et al

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA 220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302 -701, Republic of Korea Facsimile No. 82-42-472-7140	10 DECEMBER 2010 (10.12.2010)	KOO, Young Hoi Telephone No.0424818376

Form PCT/ISA/237 (cover sheet) (July 2009)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/032845

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

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

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

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/032845

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-60	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-60	NO
Industrial applicability (IA)	Claims	1-60	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: WO 2008-137966 A1 (MOJO MOBILITY, INC. et al) 13 NOVEMBER 2008.
D2: US 2008-0258679 A1 (Manico Joseph A. et al) 23 OCTOBER 2008.

The present invention relates to systems and methods for inductive charging.

D1 discloses system and method for inductive charging of portable device.
D2 discloses a charging display system.

1. Novelty and Inventive Step

1.1 Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, includes additional functionality such as communication of data(Page 5), heat removal, reducing any potential EMI issues, and shielding the outside environment from any potential radiative fields([00308]). Claim 1 differs from D1 in that includes activation of applications. However, it is well known in that includes charging display system determining whether activation of a particular wireless charging element in D2([0056]). Claim 1 would have been obvious over D1 in view of D2. Therefore, claim 1 lacks an inventive step under PCT Article 33(3).

1.2 Claim 2

The subject matter of claim 2 relates a method claim corresponding to a system for use with a charging device for charging or powering another device of claim 1. Therefore, Claim 2 lacks an inventive step under PCT Article 33(3), because the subject matter of claim 1 is considered to lack an inventive step under PCT Article 33(3).

1.3 Independent Claim 15

D1, which is considered to be the closest prior art to the subject matter of claim 15, includes wireless or wired charger, the basic concepts for the control, verification, and data transmission implemented in a similar manner([00208]) and determining the appropriate charging/powering condition([00107]). Claim 15 differs from D1 in that includes determining the best method for charging by wireless and/or wired power transfer. However, it would be obvious to a person skilled in the art to apply the feature of determining the appropriate charging/powering condition in D1([00107]). Claim 15 would have been obvious over D1. Therefore, claim 15 lacks an inventive step under PCT Article 33(3).

1.4 Dependent Claims 3, 5, 6-14, 16-27, 29-34, 36-42, 44-60

The subject matter of claim 3 dependent on claim 1 is identical to base unit, charger or power

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Box V

supply, and a device or batteries in D1(Claims 1-2). Therefore, claim 3 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 5 dependent on claim 3 is considered to be a minor difference over data communication between a device and a charger or power supply in D1(Page 45). Therefore, claim 5 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 6 dependent on claim 3 is considered to be a minor difference over a device including cellular telephones, PDAs, notebook, radios in D1([0003]). Therefore, claim 6 lacks an inventive step under PCT Article 33(3).

The subject matter of claim 7 dependent on claim 3 is identical to inductive power transfer in D1([00105]). Therefore, claim 7 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 8-10 dependent on claim 3 is considered to be a minor difference over the same coil or wires as antenna for data transfer in D1([00130]). Therefore, claims 8-10 lack an inventive step under PCT Article 33(3).

The subject matter of claim 11 dependent on claim 3 is considered to be a minor difference over pre-programmed manner in D1([154]). Therefore, claim 11 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 12-13 dependent on claim 3 is considered to be a minor difference over device identification and verification in D1([00182]). Therefore, claims 12-13 lack an inventive step under PCT Article 33(3).

The subject matter of claim 14 dependent on claim 1 is considered to be a minor difference over alignment magnets in D1([00341]). Therefore, claim 14 lacks an inventive step under PCT Article 33(3).

The subject matter of claims 16-23 dependent on claim 1 is considered to be a minor difference over a base unit and/or receiver, inductive coil, magnet, metal layer, reducing eddy current, coil layer, conductive layer in D1. Therefore, claims 16-23 lack an inventive step under PCT Article 33(3).

The subject matter of claims 24-27 dependent on claim 1 is considered to be a minor difference over a base unit and/or receiver, inductive coil, several devices, rechargeable batteries, ferromagnetic layers, heat reduction, magnet, metal layer, reducing eddy current in D1. Therefore, claims 24-27 lack an inventive step under PCT Article 33(3).

The subject matter of claims 29-34 dependent on claim 1 is considered to be a minor difference over a receiver coil, connector, battery pack, some contact points, bidirectional communication, and cylindrical battery in D1. Therefore, claims 29-34 lack an inventive step under PCT Article 33(3).

The subject matter of claims 36-42 dependent on claim 1 is considered to be a minor difference over charging for laptop computer and USB outlet of a laptop in D1, speaker and monitor in D2, mouse pad in D1. Therefore, claims 36-42 lack an inventive step under PCT Article 33(3).

The subject matter of claim 44 dependent on claim 1 is considered to be a minor difference over flatness in D1 (Fig. 35) and coil shape in D1. Therefore, claim 44 lacks an inventive step under PCT Article 33(3).

Continued on Supplemental Box

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of :

Previous Supplemental Box

The subject matter of claims 45-50 dependent on claim 1 is considered to be a minor difference over CD, DVD player, receiver coil, magnet, shield layer, battery identification, protection against reverse voltage, temperature sensor, and alignment magnets in D1. Therefore, claims 45-50 lack an inventive step under PCT Article 33(3).

The subject matter of claims 51-54 dependent on claim 1 is considered to be a minor difference over metal layer, battery, case, skin, RFID, temperature sensor, and switching circuit in D1. Therefore, claims 51-54 lack an inventive step under PCT Article 33(3).

The subject matter of claims 55-60 dependent on claim 52 is considered to be a minor difference over battery, case, skin, coil layer, reducing any potential EMI issues, wireless charging, wired power supply, RFID, termperature sensor, and alignment magnets in D1. Therefore, claims 55-60 lack an inventive step under PCT Article 33(3).

1.5 Claim 4, 28, 35, 43

The subject matter of claims 4, 28, 35, 43 relates a method claim corresponding to a system for use with a charging device for charging or powering another device of claims 3, 16, 30, 36. Therefore, Claims 4, 28, 35, 43 lack an inventive step under PCT Article 33(3), because the subject matter of claims 3, 16, 30, 36 is considered to lack an inventive step under PCT Article 33(3).

2. Industrial Applicability

Claims 1-60 are considered to be industrially applicable under PCT Article 33(4).

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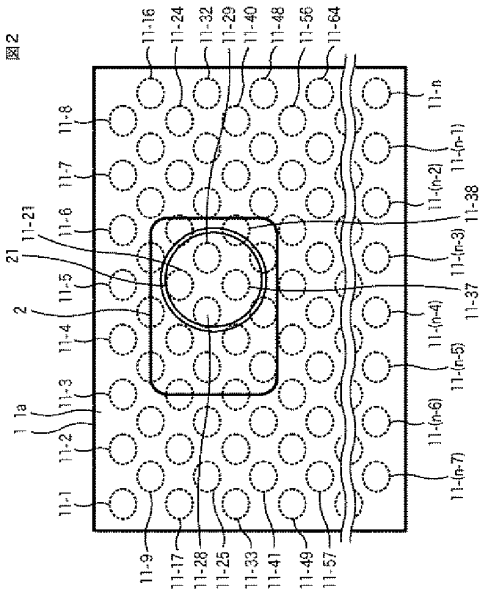
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最終頁に続く

(54)【発明の名称】電力供給システム、電力供給装置および方法、受電装置および方法、記録媒体、並びにプログラム

(57)【要約】
【課題】より迅速に、受電装置に電力を供給するようにする。
【解決手段】電磁誘導により電力を供給する電力供給部１１－１乃至１１－ｎを有する電力供給装置１において、電力供給装置１が、電力供給部１１－１乃至１１－ｎのうちから、電力供給装置１の設置面１ａに載せられた、受電装置２の受電部２１の位置に対応する電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７を選択する。その後、選択された電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７が、受電装置２の受電部２１に対して電磁誘導により電力を供給する。本発明は、携帯電話機等に電力を供給する電力供給装置に適用することができる。
【選択図】図２

図2



【特許請求の範囲】
【請求項1】
少なくとも１個の受電装置と、前記受電装置に電力を供給する電力供給装置とからなる電力供給システムにおいて、
前記電力供給装置は、
前記受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、
複数の前記電力供給手段のうちの、前記受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、
前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段と、
前記制御情報に基づいて、選択された複数の前記電力供給手段により前記受電装置へ電力を供給するように制御する制御手段と
を備え、
前記受電装置は、
選択された複数の前記電力供給手段から前記電磁誘導により電力の供給をうける１つの受電手段と、
選択された前記電力供給手段から前記電磁誘導により電力の供給をうけた場合、前記制御情報を無線で送信する送信手段と
を備える
ことを特徴とする電力供給システム。
【請求項2】
少なくとも１個の受電装置に電力を供給する電力供給装置において、
前記受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、
複数の前記電力供給手段のうちの、前記受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、
前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段と、
前記制御情報に基づいて、選択された複数の前記電力供給手段により前記受電装置へ電力を供給するように制御する制御手段と
を備えることを特徴とする電力供給装置。
【請求項3】
前記制御手段は、前記通信手段を介して情報の授受を行い、前記受電装置との認証処理を行う
ことを特徴とする請求項２に記載の電力供給装置。
【請求項4】
前記選択手段は、複数の前記電力供給手段が順に磁界を発生することに基づいて、前記通信手段が、前記受電装置から送信されてくる、電力が供給されたことを示す情報を受信した場合、そのとき前記磁界を発生している前記電力供給手段を、前記受電装置が載せられた前記位置に対応する電力供給手段として選択する
ことを特徴とする請求項２に記載の電力供給装置。
【請求項5】
前記電力供給手段が前記磁界を発生した場合に、前記電力供給手段に過電流が流れたことを検出する検出手段をさらに備え、
前記選択手段は、前記通信手段が電力が供給されたことを示す情報を受信する前に、前記検出手段により過電流が検出された場合、過電流が検出された前記電力供給手段を選択しない
ことを特徴とする請求項４に記載の電力供給装置。
【請求項6】
受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の

載せされた受電装置に前記電力供給部から電力を供給する電力供給装置の電力供給方法において、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とする電力供給方法。
【請求項7】
　受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の載せされた受電装置に前記電力供給部から電力を供給する電力供給装置の電力供給処理用のプログラムにおいて、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とするコンピュータが読み取り可能なプログラムが記録されている記録媒体。
【請求項8】
　受電装置に電磁誘導により電力を供給する複数の電力供給部を備え、少なくとも１個の載せされた受電装置に前記電力供給部から電力を供給する電力供給装置のコンピュータに電力供給処理を行わせるプログラムにおいて、
　複数の前記電力供給部のうちの、前記受電装置が載せられた位置に対応する複数の前記電力供給部を選択する選択ステップと、
　前記受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、
　前記制御情報に基づいて、選択された複数の前記電力供給部により前記受電装置へ電力を供給するように制御する制御ステップと
　を含むことを特徴とするプログラム。
【請求項9】
　電磁誘導により電力を供給する複数の電力供給部を備える電力供給装置から電力の供給をうける受電装置において、
　複数の前記電力供給部から前記電磁誘導により電力の供給をうける少なくとも１つの受電手段と、
　前記電力供給部から前記電磁誘導により電力の供給をうけた場合、前記電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段と
　を備えることを特徴とする受電装置。
【請求項10】
　電磁誘導により電力を供給する複数の電力供給部を備える電力供給装置から電力の供給をうける受電装置の受電方法において、
　複数の前記電力供給部から前記電磁誘導により電力の供給をうける受電ステップと、
　前記電力供給部から前記電磁誘導により電力の供給をうけた場合、前記電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップと
　を含むことを特徴とする受電方法。

【発明の詳細な説明】
【技術分野】
【0001】
　本発明は、電力供給システム、電力供給装置および方法、受電装置および方法、記録媒

体、並びにプログラムに関し、特に、受電装置への電力の供給に好適な電力供給システム、電力供給装置および方法、受電装置および方法、記録媒体、並びにプログラムに関する。

【背景技術】

【0002】

従来、PDA（Personal Digital Assistance）やデジタル携帯電話機などの電子機器は、交流電源から、ACアダプタを介し、ACアダプタから延びるプラグと接続されることで、電力が供給され、バッテリの充電を行っていた。すなわち、電源から、電力供給用の配線を介して（有線で）、電子機器に電力が供給されていた。

【0003】

これに対して、電源から電力供給用の配線を用いずに（無線で）、電子機器に電力を供給する電力供給装置が提案されている。

【0004】

例えば、特許文献１には、マスタシステムの１個の電磁誘導コイルからパワーレシーバシステムの１個の電磁誘導コイルに、電磁誘導により電力を供給することが開示されている。

【0005】

特許文献２では、複数の給電コイルを有する給電装置が、複数の給電コイルの内の１つを順次選択して通電する。給電装置の設置面に載置された受電機器においては、その１個の受電コイルおよび１個の認識タグ用コイルが、給電コイルの発生する電磁波を受け、誘電起電力を得る。認識タグ用コイルから給電装置にＩＤが送信され、給電装置は受信したＩＤを、そのとき通電していた給電コイルのインデックスとともに記憶する。以後、記憶された情報を基に、給電コイルの通電時間が制御される。

【特許文献1】特開平６－１３３４７６号公報

【特許文献2】特開２００３－２２４９３７号公報

【発明の開示】

【発明が解決しようとする課題】

【0006】

しかしながら、これら従来の装置においては、電力供給装置における給電コイルと受電装置における受電コイルとが１対１に対応していた。その結果、充電完了までに時間がかかっていた。

【0007】

本発明は、このような状況に鑑みてなされたものであり、より迅速に、受電装置に電力を供給することができるようにするものである。

【課題を解決するための手段】

【0008】

本発明の電力供給システムは、電力供給装置が、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段とを備え、受電装置が、選択された複数の電力供給手段から電磁誘導により電力の供給をうける１つの受電手段と、選択された電力供給手段から電磁誘導により電力の供給をうけた場合、制御情報を無線で送信する送信手段とを備えることを特徴とする。

【0009】

本発明の電力供給装置は、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段とを備えることを

特徴とする。

【0010】

制御手段は、通信手段を介して情報の授受を行い、受電装置との認証処理を行うようにすることができる。

【0011】

選択手段は、複数の電力供給手段が順に磁界を発生することに基づいて、通信手段が、受電装置から送信されてくる、電力が供給されたことを示す情報を受信した場合、そのとき磁界を発生している電力供給手段を、受電装置が載せられた位置に対応する電力供給手段として選択するようにすることができる。

【0012】

電力供給装置は、電力供給手段が磁界を発生した場合に、電力供給手段に過電流が流れたことを検出する検出手段をさらに備え、選択手段は、通信手段が電力が供給されたことを示す情報を受信する前に、検出手段により過電流が検出された場合、過電流が検出された電力供給手段を選択しないようにすることができる。

【0013】

本発明の電力供給方法は、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとを含むことを特徴とする。

【0014】

本発明の記録媒体のプログラムは、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとを含むことを特徴とする。

【0015】

本発明のプログラムは、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップと、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップと、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力を供給するように制御する制御ステップとをコンピュータに実行させることを特徴とする。

【0016】

本発明の受電装置は、複数の電力供給部から電磁誘導により電力の供給をうける少なくとも１つの受電手段と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段とを備えることを特徴とする。

【0017】

本発明の受電方法は、複数の電力供給部から電磁誘導により電力の供給をうける受電ステップと、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップとを含むことを特徴とする。

【0018】

本発明の電力供給システムにおいては、電力供給装置において、複数の電力供給手段により受電装置に対して電磁誘導により電力が供給され、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段が選択され、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報が受信され、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力が供給されるように制御され、受電装置において、１つの受電手段に、選択された複数の電力供給手段から電磁誘導により電力が供給され、選択された電力供給手段から電磁誘導により電力が供給された場合、制御情報が無線で送信される。

【0019】
本発明の電力供給装置、電力供給方法、記録媒体のプログラム、およびプログラムにおいては、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部が選択され、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報が受信され、制御情報に基づいて、選択された複数の電力供給部により受電装置へ電力が供給されるように制御される。
【0020】
本発明の受電装置および受電方法においては、複数の電力供給部から電磁誘導により電力が供給され、電力供給部から電磁誘導により電力が供給された場合、電力供給装置に、電力の供給を制御する制御情報が無線で送信される。
【発明の効果】
【0021】
本発明によれば、受電装置に電力を供給することができる。また、本発明によれば、より迅速に、受電装置に電力を供給することができる。
【発明を実施するための最良の形態】
【0022】
以下に本発明の実施の形態を説明するが、請求項に記載の構成要件と、発明の実施の形態における具体例との対応関係を例示すると、次のようになる。この記載は、請求項に記載されている発明をサポートする具体例が、発明の実施の形態に記載されていることを確認するためのものである。従って、発明の実施の形態中には記載されているが、構成要件に対応するものとして、ここには記載されていない具体例があったとしても、そのことは、その具体例が、その構成要件に対応するものではないことを意味するものではない。逆に、具体例が構成要件に対応するものとしてここに記載されていたとしても、そのことは、その具体例が、その構成要件以外の構成要件には対応しないものであることを意味するものでもない。
【0023】
さらに、この記載は、発明の実施の形態に記載されている具体例に対応する発明が、請求項に全て記載されていることを意味するものではない。換言すれば、この記載は、発明の実施の形態に記載されている具体例に対応する発明であって、この出願の請求項には記載されていない発明の存在、すなわち、将来、分割出願されたり、補正により追加される発明の存在を否定するものではない。
【0024】
請求項１に記載の電力供給システムは、少なくとも１個の受電装置と、受電装置に電力を供給する電力供給装置とからなる電力供給システムであって、電力供給装置（例えば、図１の電力供給装置１）は、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段（例えば、図３の電力供給部１１）と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択手段（例えば、図３のセレクタ７２）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信手段（例えば、図３の通信部７３）と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段（例えば、図３の電力供給制御部７１）とを備え、受電装置（例えば、図１の受電装置２）は、選択された電力供給手段から電磁誘導により電力の供給をうける受電手段（例えば、図４の受電部２１）と、選択された電力供給手段から電磁誘導により電力の供給をうけた場合、制御情報を無線で送信する送信手段（例えば、図４の通信部１０７）とを備えることを特徴とする。
【0025】
請求項２に記載の電力供給装置は、少なくとも１個の受電装置に電力を供給する電力供給装置（例えば、図１の電力供給装置１）であって、受電装置に対して電磁誘導により電力を供給する複数の電力供給手段（例えば、図３の電力供給部１１）と、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する複数の電力供給手段を選択する選択

手段（例えば、図３のセレクタ７２）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する通信手段（例えば、図３の通信部７３）と、制御情報に基づいて、選択された複数の電力供給手段により受電装置へ電力を供給するように制御する制御手段（例えば、図３の電力供給制御部７１）とを備えることを特徴とする。

【0026】

請求項５に記載の電力供給装置は、電力供給手段が、磁界を発生した場合に、電力供給手段に過電流が流れたことを検出する検出手段（例えば、図３の電流検出器５３）をさらに備え、選択手段は、通信手段が電力が供給されたことを示す情報を受信する前に、検出手段により過電流が検出された場合、過電流が検出された電力供給手段を選択しない（例えば、図５のステップＳ４９の処理）ようにすることができる。

【0027】

請求項６に記載の電力供給装置は、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）の電力供給方法において、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを含むことを特徴とする。

【0028】

請求項７に記載の記録媒体のプログラムは、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）の電力供給処理用のプログラムであって、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを含むことを特徴とする。

【0029】

請求項８に記載のプログラムは、受電装置に電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備え、少なくとも１個の載せされた受電装置（例えば、図１の受電装置２）に電力供給部から電力を供給する電力供給装置（例えば、図１の電力供給装置１）のコンピュータに、電力供給処理を行わせるプログラムにおいて、複数の電力供給部のうちの、受電装置が載せられた位置に対応する複数の電力供給部を選択する選択ステップ（例えば、図５のステップＳ５１の処理）と、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信する受信ステップ（例えば、図８のステップＳ８９の処理）と、制御情報に基づいて、選択された電力供給部により受電装置へ電力を供給するように制御する制御ステップ（例えば、図９のステップＳ１１１）とを実行させる。

【0030】

請求項９に記載の受電装置は、電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備える電力供給装置（例えば、図１の電力供給装置１）から電力の供給をうける受電装置（例えば、図１の受電装置２）であって、複数の電力供給部から電磁誘導により電力の供給をうけるすくなくとも１つの受電手段（例えば、図４の受電部２１）と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信手段（例えば、図４の通信部１０７）とを備えることを特徴とする。

【0031】
請求項１０に記載の受電方法は、電磁誘導により電力を供給する複数の電力供給部（例えば、図２の電力供給部１１）を備える電力供給装置（例えば、図１の電力供給装置１）から電力の供給をうける受電装置（例えば、図１の受電装置２）の受電方法であって、複数の電力供給部から電磁誘導により電力の供給をうける受電ステップ（例えば、図１０のステップＳ１５１の処理）と、電力供給部から電磁誘導により電力の供給をうけた場合、電力供給装置に、電力の供給を制御する制御情報を無線で送信する送信ステップ（例えば、図１０のステップＳ１５５）とを含むことを特徴とする。
【0032】
以下に、本発明の実施の形態について図面を参照して説明する。
【0033】
図１は、本発明の一実施の形態に係る電力供給システムの構成の例を示す斜視図である。
【0034】
このシステムは、電力供給装置１と受電装置２とで構成される。電力供給装置１の表面には、電磁波を透過させる材質のシートで形成される設置面１ａが設けられている。電力供給装置１は、この設置面１ａに、受電装置２が載せられた場合、受電装置２に無線で、必要な電力を供給する。すなわち、電力供給装置１は、電力供給用の配線無しで、受電装置２に電力を供給する。
【0035】
受電装置２は、例えば、ノート型パーソナルコンピュータ、PDA、携帯電話機、もしくはPHS（Personal Handyphone System）などの機器、または各種機器から取り外すことが可能なバッテリである。
【0036】
図２は、電力供給装置１の設置面１ａ上に受電装置２が載せられた状態を上方向から見た透過図である。
【0037】
電力供給装置１には、電磁誘導により受電装置２に電力を供給するｎ個の電力供給部１１－１乃至１１－ｎが設けられている。電力供給部１１－１乃至１１－ｎは、設置面１ａの下部（図２の紙面と垂直な下方向）に、例えば、市松状に設けられている。
【0038】
以下、電力供給部１１－１乃至１１－ｎを個々に区別する必要のないとき、単に、電力供給部１１と称する。
【0039】
受電装置２には、その下面側（設置面１ａと接触している面側）に、１個の受電部２１が設けられている。１個の受電部２１は、複数の電力供給部１１が発生する磁界による電磁誘導により電力の供給をうける。
【0040】
すなわち、図２に示されるように、１個の受電部２１（より詳細には後述する図４の受電アンテナ１０１）は、その大きさ（面積）が１個の電力供給部１１の大きさ（面積）より、大きくなるように形成されている。図２の例では、受電装置２の１個の受電部２１は、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個の電力供給部１１を含む大きさになされている。
【0041】
図３は、電力供給装置１の構成の例を示すブロック図である。電力供給装置１は、ｎ個の電力供給部１１（図３には１個のみが示されている）、制御部４１、メモリ４２、リアルタイムクロック４３、および電源回路４４により構成されている。
【0042】
電力供給部１１は、スイッチ５１、電力供給アンテナ５２、および電流検出器５３により構成される。

【0043】
スイッチ５１は、制御部４１のセレクタ７２から供給される制御信号に基づいて、オンまたはオフされる。スイッチ５１がオンの場合、電力供給アンテナ５２には、電源回路４４から交流電流が流れる。このとき、電力供給アンテナ５２は、電流が流れることで磁界を発生する。すなわち、電力供給アンテナ５２は、電流が流れることで磁界を発生するコイルである。
【0044】
電流検出器５３はグランドに接続されており、スイッチ５１がオンである場合、電力供給アンテナ５２に流れる電流の大きさを検出する。また、電流検出器５３は検出した電流の大きさに対応する電流検出信号を、制御部４１のセレクタ７２に供給する。
【0045】
制御部４１は、電力供給制御部７１、セレクタ７２、通信部７３、および温度センサ７４により構成される。
【0046】
電力供給制御部７１は、汎用のCPU（Central Processing Unit）やMPU（Micro Processing Unit）などにより構成される。電力供給制御部７１は、必要に応じて、フラッシュメモリなどで構成されるメモリ４２にデータを記憶したり、メモリ４２に記憶してあるデータまたはプログラム、もしくはクロックパルスを発生するリアルタイムクロック４３から供給されるクロックパルスを基に、充電動作を制御する。
【0047】
セレクタ７２は、電力供給制御部７１の制御の基に、スイッチ５１のオンまたはオフを指示する制御信号を電力供給部１１に供給する。また、セレクタ７２には、電流検出器５３から、電力供給アンテナ５２に流れている電流値を示す電流検出信号が供給される。セレクタ７２は、その電流検出信号を電力供給制御部７１に供給する。
【0048】
アンテナなどより構成される通信部７３は、電力供給制御部７１の制御に基づいて、電波や赤外線を用いることにより、受電装置２と情報の授受を行う。
【0049】
温度センサ７４は、電力供給部１１－１乃至１１－ｎのそれぞれ、または設置面１ａの一部（例えば、電力供給部１１－１乃至１１－３２が配置されている部分、電力供給部１１－３３乃至１１－６４が配置されている部分、電力供給部１１－６５乃至１１－ｎが配置されている部分の３つの部分）の温度を測定し、その測定結果を電力供給制御部７１に供給する。これにより、電力供給制御部７１は、電力供給部１１における回路異常や漏電などを認識し、必要に応じて全てのスイッチ５１をオフにすることができる。
【0050】
電源回路４４は、電源ケーブルを介して供給される交流電流をそのまま、あるいは所定の周波数の交流電流を生成して、電力供給部１１に供給する。
【0051】
電力供給制御部７１には、必要に応じて、ドライブ８１が接続され、磁気ディスク、光ディスク、光磁気ディスク、或いは半導体メモリなどのリムーバブルメディア８２が適宜装着され、それらから読み出されたコンピュータプログラムが、必要に応じてメモリ４２にインストールされる。
【0052】
図４は、受電装置２の構成の例を示すブロック図である。受電装置２は、受電部２１、メモリ１２１、リアルタイムクロック１２２、およびバッテリ１２３により構成される。
【0053】
受電部２１は、受電アンテナ１０１、整流器１０２、受電制御部１０３、端子１０４、端子１０５、スイッチ１０６、および通信部１０７から構成される。
【0054】
受電アンテナ１０１には、上述した電力供給部１１の電力供給アンテナ５２に電流が流

れることにより発生した磁界によって、交流電流が流れる。すなわち、受電アンテナ１０１は、電力供給アンテナ５２が発生した磁界による電磁誘導により電流が流れるコイルである。

【0055】

受電アンテナ１０１の大きさは電力供給アンテナ５２の大きさより大きく形成されている。

【0056】

受電アンテナ１０１に流れる電流は整流器１０２に供給される。整流器１０２は、受電アンテナ１０１から流れる交流電流を整流し、直流電流を生成する。整流器１０２は、生成した直流電流を受電制御部１０３に動作電源として供給する。また、整流器１０２は、端子１０４、端子１０５、およびスイッチ１０６を介して、バッテリ１２３に電流を流し、バッテリ１２３を充電させる。

【0057】

受電制御部１０３は、汎用のCPUやMPUなどにより構成される。すなわち、例えば、受電部２１およびバッテリ１２３は、スマートバッテリの規格に準ずるインテリジェントバッテリである。

【0058】

受電制御部１０３は、整流器１０２から電流が供給されることで起動する。受電制御部１０３は、起動後、通信部１０７を介し、電力供給装置１と情報の通信を行う。また、受電制御部１０３は、スイッチ１０６をオンにし、バッテリ１２３に充電電力を供給する。

【0059】

受電制御部１０３は、必要に応じて、フラッシュメモリなどで構成されるメモリ１２１にデータを記憶したり、メモリ１２１に記憶してある受電装置２を識別する識別情報を取得したり、またはメモリ１２１に記憶されているプログラムを基づいて、充電動作を制御する。

【0060】

また、受電制御部１０３は、バッテリ１２３の充電が完了した場合、すなわち、端子１０４および端子１０５にかかる電圧が、バッテリ１２３の充電の完了を示す電圧に達した場合、スイッチ１０６をオフにする。

【0061】

従って、バッテリ１２３の充電が完了した場合、整流器１０２、端子１０４、バッテリ１２３、端子１０５、およびスイッチ１０６の経路での充電電流が流れなくなる。

【0062】

次に、図５のフローチャートを参照して、受電装置２が載せられた設置面１ａ上の位置、すなわち、設置面１ａにおける受電部２１の位置に対応する電力供給部１１の選択の処理について説明する。この処理は、電力供給装置１の電源がオンされたとき、あるいは受電装置２に対する充電が完了したとき再び開始される。

【0063】

ステップＳ４１において、電力供給制御部７１は、変数Ｎに１を設定する。

【0064】

ステップＳ４２において、セレクタ７２は、電力供給制御部７１の制御の基に、Ｎ番目の電力供給部１１に微弱な磁界を発生させる。すなわち、セレクタ７２は、Ｎ番目の電力供給部１１のスイッチ５１に対しオンの制御信号を供給し、電力供給アンテナ５２に電流を流し、弱い磁界を発生させる。

【0065】

ここで、Ｎ番目の電力供給部１１とは、図２で示される電力供給部１１－１乃至１１－ｎのいずれか１つを意味する。例えば、１（＝Ｎ）番目の電力供給部１１は、電力供給部１１－１を意味し、２（＝Ｎ）番目の電力供給部１１は、電力供給部１１－２を意味し、ｎ（＝Ｎ）番目の電力供給部１１は、電力供給部１１－ｎを意味する。

【0066】

ステップＳ４３において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0067】

ステップＳ４４において、電流検出器５３は、Ｎ番目の電力供給部１１における、電力供給アンテナ５２に流れている電流の値を検出する。

【0068】

ステップＳ４５において、電力供給制御部７１は、ステップＳ４４の処理により検出された電流の値が、閾値THａ以上であるか否かを判定する。すなわち、電力供給制御部７１は、電流検出器５３から供給される電流検出信号が示す電流の値が、閾値THａ以上であるかを判定する。

【0069】

ここで、ステップＳ４５において、電力供給アンテナ５２に流れる電流の値が閾値THa以上であるか否かを判定する理由を説明する。

【0070】

図６は、設置面１ａに異物２０１が載せられている状態を示す図である。図６で示される例では、異物２０１は、電力供給装置１において、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７に対応する位置に載せられている。

【0071】

異物２０１が金属である場合、例えば、Ｎ番目の電力供給部１１が電力供給部１１－２１であるとき、異物２０１には、電力供給部１１－２１が発生している磁界によって、異物２０１には渦電流が発生する。この異物２０１は金属であるため抵抗が少ない。これにより、この渦電流によって、電力供給部１１－２１の電力供給アンテナ５２には、過剰な電流（過電流）が流れてしまう。また、異物２０１も渦電流によって発熱してしまう恐れがある。

【0072】

以上のように、ステップＳ４５の処理は、電力供給アンテナ５２に、許容量以上の大きな電流が流れてしまうことを防ぐための処理である（後述するステップＳ４９の処理参照）。

【0073】

ステップＳ４５において、ステップＳ４４の処理により検出された電流の値が、閾値THa以上ではないと判定された場合、ステップＳ４６において、電力供給制御部７１は、通信部７３を介し、後述する図１０のステップＳ１５１の処理により、受電装置２から送信されてくる、電流情報および識別情報を受信したか否かを判定する。

【0074】

ここで、電流情報とは、Ｎ番目の電力供給アンテナ５２に発生した磁界による電磁誘導により、受電アンテナ１０１に流れた電流の値や電圧を示す情報である。また、識別情報とは、受電装置２を識別（特定）するための情報である。

【0075】

ステップＳ４６において、受電装置２から電流情報および識別情報を受信していないと判定された場合、ステップＳ４７において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、ステップＳ４３の処理により計測が開始した時間が、予め設定してある一定の時間、例えば、１秒が経過したか否かを判定する。

【0076】

ステップＳ４７において、所定の時間が経過していないと判定された場合、処理は、ステップＳ４６に戻り、上述した処理が繰り返される。

【0077】

ステップＳ４７において、所定の時間が経過したと判定された場合、受電装置２から電流情報が送信されていないことになる。すなわち、電力供給装置１に受電装置２が載せら

れていないことになるので、ステップＳ４８において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が無いことを示すフラグを設定する。すなわち、例えば、電力供給制御部７１はメモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が無いことを示すフラグとして、“０１”を記憶させる。

【0078】

ステップＳ４８の処理の後、処理は、ステップＳ５２に進む。

【0079】

ステップＳ４５において、電流の値が、閾値THa以上であると判定された場合、上述したように、Ｎ番目の電力供給部１１の電力供給アンテナ５２に過電流が流れているので、ステップＳ４９において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、異物２０１が在ることを示すフラグを設定する。すなわち、例えば、メモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、異物２０１が在ることを示すフラグ、“１０”が記憶される。

【0080】

ステップＳ４９の処理の後、処理は、ステップＳ５２に進む。

【0081】

ステップＳ４６において、受電装置２から電流情報および識別情報を受信したと判定された場合、ステップＳ５０において、電力供給制御部７１は、電流情報における電流値が閾値THb以上であるかを判定する。

【0082】

ステップＳ５０において、電流情報における電流値が閾値THb以上であると判定された場合、受電装置２の受電部２１（受電アンテナ１０１）の範囲にある電力供給部１１から電力が供給されているので、ステップＳ５１において、電力供給制御部７１は、設置面１ａのＮ番目の電力供給部１１に対応する位置に、受電装置２の受電部２１が在ることを示すフラグと識別情報を設定する。すなわち、メモリ４２に、Ｎ番目の電力供給部１１に対応する位置に、受電部２１が在ることを示すフラグ、例えば、“１１”が記憶されるとともに、その受電部２１（受電装置２）の識別情報が記憶される。

【0083】

ステップＳ５２において、電力供給制御部７１は、ステップＳ４２の処理により発生させた、Ｎ番目の電力供給部１１における微弱な磁界の発生を停止させる。すなわち、電力供給制御部７１はセレクタ７２を介して、制御信号を供給し、スイッチ５１をオフさせる。

【0084】

ステップＳ５３において、電力供給制御部７１は、変数Ｎに設定されている数値を１だけインクリメントする。例えば、電力供給制御部７１は、変数Ｎに“１”が設定されている場合、変数Ｎを“２”に設定する。

【0085】

ステップＳ５４において、電力供給制御部７１は、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下であるかを判定する。すなわち、電力供給制御部７１は、変数Ｎに設定されている値が、全ての電力供給部１１の数以下であるか否か（ｎ≦Ｎであるか否か）を判定する。

【0086】

ステップＳ５４において、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下であると判定された場合、すなわち、ｎ≦Ｎである場合、処理は、ステップＳ４２に戻り、同様の処理が次の電力供給部１１に対して実行される。

【0087】

ステップＳ５４において、変数Ｎに設定されている数値は、全ての電力供給部１１の数以下ではないと判定された場合、すなわち、ｎ＞Ｎである場合、処理は終了する。

【0088】

ステップＳ５０において、電流情報における電流値が閾値THb以上ではないと判定された場合、受電装置２の受電部２１に少量の電力が供給されている。すなわち、例えば、図２に示されるように、受電部２１にその一部のみがかかるように配置されている電力供給部１１－３８による磁界によって、受電部２１の受電アンテナ１０１に少量の電流が流れていることが想定される。そこでこの場合、ステップ４８において、上述した処理が実行される。

【0089】

ステップＳ５０の処理により、例えば、図２で示されるように、受電装置２の受電部２１は、受電部２１（受電アンテナ１０１）の範囲内にその大半が含まれる電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７のみから電力の供給をうける。すなわち、受電部２１（受電アンテナ１０１）の範囲内にその大半が含まれる電力供給部１１のみから電力の供給をうけることで、無駄な磁界の発生を防ぎ、効率的に電力を供給することができる。

【0090】

以上の処理により、例えば、図２で示される受電装置２に対して、電力を供給する電力供給部１１として、電力供給部１１－２１，１１－２８，１１－２９、および１１－３７が選択されることになる。

【0091】

図７は、複数の受電装置や異物が同時に載せられた電力供給装置１を説明する図である。例えば、図７に示されるように、今、電力供給装置１には、受電装置２、受電装置２２０、および異物２３１が同時に載せられているとする。

【0092】

ここで、受電装置２２０および受電部２２１のそれぞれは、受電装置２および受電部２１のそれぞれと同様の構成であるため、その説明は省略する。また、異物２３１は、例えば金属板である。

【0093】

図７の例の場合、図５のフローチャートを参照して上述した電力供給部１１の選択の処理において、受電装置２に電力を供給する電力供給部１１としては、電力供給部１１－２１，１１－２８，１１－２９、および１１－３７が選択される。また、受電装置２２０に電力を供給する電力供給部１１としては、電力供給部１１－４０，１１－４７，１１－４８、および１１－５６が選択され、金属である異物２３１に対しては、電力供給部１１が選択されないことになる。

【0094】

次に、図８のフローチャートを参照して、受電装置との認証の処理について説明する。この処理は、図５のフローチャートを参照して上述した電力供給部１１の選択の処理において、電力供給部１１が選択され、メモリ４２に受電装置の受電部が在ることを示すフラグが記憶された場合に開始される。

【0095】

また、この受電装置との認証の処理は、例えば、図２に示されるように、電力供給装置１に１個の受電装置２のみが載せられている場合、電力供給装置１においては、受電装置２と以下に説明する認証処理が実行される。

【0096】

また、例えば、図７に示されるように、電力供給装置１に受電装置２および受電装置２２０が載せられている場合、電力供給装置１においては、受電装置２と以下に説明する認証処理が実行され、その後、受電装置２２０と以下に説明する認証処理が実行されるようにしてもよいし、受電装置２との認証処理と受電装置２２０との認証処理が同時に実行されるようにしてもよい。

【0097】

電力供給装置１において、複数の受電装置との認証処理が実行される場合、図５のステップＳ５１において受電装置の識別情報をメモリ４２に記憶しているため、以下に説明す

るように、受電装置が電力供給装置１にデータを送信する際に、受電装置の識別情報も送信するようにすることで、電力供給装置１は、どの受電装置と通信を行っているのかを認識することができる。

【0098】

ステップＳ８１において、電力供給制御部７１は、通信部７３に、受電装置に対し、受電装置を認証するための情報としてのID（IDentification）を要求する信号を送信する。このIDの要求先としての受電装置は識別番号を付することで指定される。

【0099】

受電装置のIDは識別情報と、同じ情報であってもよいし、異なるものであってもよい。受電装置のIDと識別情報とが同じである場合、ステップＳ８１乃至Ｓ８４の処理は省略することができる。両者が異なる場合、ステップＳ８１乃至Ｓ８４の処理が実行される。

【0100】

ステップＳ８２において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0101】

ステップＳ８３において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１５３の処理により、識別番号で指定された受電装置から送信されてくる、受電装置のIDおよび識別情報を受信したかを判定する。

【0102】

ステップＳ８３において、受電装置のIDおよび識別情報を受信していないと判定された場合、ステップＳ８４において、電力供給制御部７１は、ステップＳ８２の処理により計測を開始した所定の時間（例えば、１秒）が経過したかを判定する。

【0103】

ステップＳ８４において、所定の時間が経過していないと判定された場合、処理はステップＳ８３に戻り、上述した処理が繰り返される。

【0104】

ステップＳ８３において、受電装置のIDおよび識別情報を受信したと判定された場合、ステップＳ８５において、電力供給制御部７１は、受信した受電装置のIDが、電力供給装置１と対応しているIDであるかを判定する。すなわち、電力供給制御部７１は、メモリ４２に記憶されているIDを参照し、受電装置のIDが予め登録されている装置（規格上充電が許容される装置）のものであるか否かを判定する。

【0105】

ステップＳ８５において、受信した受電装置のIDが、電力供給装置１と対応しているIDであると判定された場合、ステップＳ８６において、電力供給制御部７１は、受電装置に、受電装置の電力情報を要求する信号を送信する。この場合にも信号の送信先が識別番号で指定される。ここで、電力情報とは、受電装置に電力を供給するのに必要な情報、すなわち、受電部２１おいて許容される電圧の大きさや受電部２１に流れる電流の値、現在、受電部２１において端子１０４および端子１０５における電圧を意味する。

【0106】

ステップＳ８７において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0107】

ステップＳ８８において、電力供給制御部７１は、ステップＳ８７の処理により測定を開始した所定の時間（例えば、１秒）が経過したかを判定する。

【0108】

ステップＳ８８において、所定の時間がまだ経過していないと判定された場合、ステップＳ８９において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１５５の処理により、受電装置から送信されてくる、電力情報および識別情報を受信したかを判定する。

【0109】

ステップＳ８９において、受電装置から電力情報および識別情報を受信していないと判定された場合、処理は、ステップＳ８８に戻り、上述した処理が繰り返される。

【0110】

ステップＳ８９において、受電装置から電力情報および識別情報を受信したと判定された場合、ステップＳ９０において、電力供給制御部７１は、受信した電力情報に示されている電力は、供給可能であるかを判定する。すなわち、電力供給制御部７１は、メモリ４２に記憶されている情報を基に、その受電装置へ指定された電力を供給することが規格上許容されているか否かを判定する。

【0111】

ステップＳ９０において、受信した電力情報における電力が、受電装置に供給可能であると判定された場合、ステップＳ９１において、電力供給制御部７１は、受電装置が電力供給装置１に対応している機器であることを示すフラグを設定する。すなわち、電力供給制御部７１は、メモリ４２に、その識別番号の受電装置が電力供給装置１に対応している機器であることを示すフラグ、例えば、“００１”を記憶させる。

【0112】

ステップＳ８４において、所定の時間が経過したと判定された場合（受電装置が電力供給装置１の設置面１aから取り除かれたことが推測される場合）、ステップＳ８５において、受電装置のIDが電力供給装置１と対応しているIDではないと判定された場合、ステップＳ８８において、所定の時間が経過したと判定された場合（受電装置が電力供給装置１の設置面１aから取り除かれたことが推測される場合）、並びにステップＳ９０において、受信した電力情報における電力が、受電装置に供給可能ではないと判定された場合、ステップＳ９２において、電力供給制御部７１は、受電装置が電力供給装置１に対応している機器ではないことを示すフラグを設定する。すなわち、電力供給制御部７１は、メモリ４２に、その識別番号の受電装置が電力供給装置１に対応している機器ではないことを示すフラグ、例えば、“０１１”を記憶させる。

【0113】

ステップＳ９１またはステップＳ９２の処理の後、処理は終了する。

【0114】

以上のように、受電装置のIDおよび電力情報が電力供給装置１と対応しているか否かを判定することにより、受電装置２との認証の精度をより向上させることができる。

【0115】

図９のフローチャートを参照して、受電装置への電力の供給の処理について説明する。この処理は、図８のフローチャートを参照して上述した受電装置との認証の処理において、ステップＳ９１の処理により、受電装置が電力供給装置１に対応していることを示すフラグが設定された場合に開始される。

【0116】

また、この受電装置への電力の供給の処理は、例えば、図２に示されるように、電力供給装置１に受電装置２のみが載せられている場合、電力供給装置１において、受電装置２のみに対し、以下に説明する電力の供給の処理が実行される。

【0117】

さらに、図７に示されるように、電力供給装置１に受電装置２および受電装置２２０が載せられている場合、電力供給装置１において、受電装置２への電力の供給の処理が実行され、その後、受電装置２２０への電力の供給の処理が実行されるようにしてもよいし、電力供給装置１において、受電装置２および受電装置２２０への電力の供給の処理が同時に実行されてもよい。

【0118】

電力供給装置１において、複数の受電装置に対して、電力の供給の処理が実行される場合、図５のステップＳ５１において受電装置の識別情報をメモリ４２に記憶しているため、以下に説明するように、受電装置が電力供給装置１に所定のデータを送信する際に、受電装置の識別情報も送信するようにすることで、電力供給装置１は、どの受電装置と通信

を行っているのか認識することができる。

【0119】

ステップＳ１１１において、電力供給制御部７１は、図８のステップＳ８９の処理により受信した受電装置の電力情報を基に、電力供給部１１に対し、受電装置への電力の供給のための磁界を発生させる。すなわち、電力供給制御部７１は、セレクタ７２を介し、その識別情報に対応して選択されている電力供給部１１のスイッチ５１にオンの制御信号を供給する。これにより、電力供給部１１の電力供給アンテナ５２に、電源回路４４から交流電流が供給される。このとき、電力供給アンテナ５２においては、電流が流れることで、磁界が発生する。

【0120】

ステップＳ１１１の処理において、磁界を発生させる電力供給部１１は、図５のステップＳ５１の処理により、同じ識別情報が記憶されている電力供給部１１の全てである。すなわち、例えば、図２で示される電力供給装置１においては、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個である。

【0121】

ステップＳ１１２において、電力供給制御部７１は、リアルタイムクロック４３から供給されるクロックパルスを計数することで、時間の計測を開始する。

【0122】

ステップＳ１１３において、電力供給制御部７１は、通信部７３が、後述する図１０のステップＳ１６０の処理により受電装置から送信されてくる、充電中を示す信号および識別情報を受信したかを判定する。

【0123】

ステップＳ１１３において、受電装置から、充電中を示す信号および識別情報を受信していないと判定された場合、ステップＳ１１４において、電力供給制御部７１は、後述する図１０のステップＳ１６２の処理により受電装置から送信されてくる、充電の完了を示す信号および識別情報を受信したか否かを判定する。

【0124】

ステップＳ１１４において、受電装置から、充電の完了を示す信号および識別情報を受信していないと判定された場合、ステップＳ１１５において、電力供給制御部７１は、ステップＳ１１２の処理において時間の計測を開始してから、所定の時間が経過したかを判定する。すなわち、例えば、電力供給制御部７１は、ステップＳ１１２の処理により時間の計測を開始してから１分３０秒が経過したか否かを判定する。

【0125】

ステップＳ１１５において、所定の時間がまだ経過していないと判定された場合、処理はステップＳ１１３に戻り、それ以降の処理が繰り返される。

【0126】

ステップＳ１１３において、受電装置から充電中を示す信号および識別情報を受信したと判定された場合、ステップＳ１１６において、電力供給制御部７１は、ステップＳ１１２において計測を開始した時間をリセットする。すなわち、電力供給制御部７１は、計測中の時間を０秒にする。

【0127】

ステップＳ１１６の処理の後、処理は、ステップＳ１１２に戻り、受電装置から送信されてくる充電の完了を示す信号を受信するまで、ステップＳ１１２，Ｓ１１３，Ｓ１１６の処理が繰り返し実行される。

【0128】

ステップＳ１１４において、受電装置から、充電の完了を示す信号および識別情報を受信したと判定された場合、ステップＳ１１５の処理は、スキップされ、ステップＳ１１７において、電力供給制御部７１は、ステップＳ１１１の処理により発生させた、受電装置の識別情報に対応づけられている、電力供給部１１における磁界の発生を停止させる。

【0129】
すなわち、電力供給制御部７１は、セレクタ７２を介し、電力供給部１１のスイッチ５１にオフの制御信号を供給する。これにより、電力供給部１１の電力供給アンテナ５２に、電源回路４４から電流が流れなくなり、電力供給アンテナ５２において発生していた磁界が消えることになる。
【0130】
ステップＳ１１４の処理において、磁界の発生を停止させる電力供給部１１は、ステップＳ１１１の処理により、磁界を発生させた電力供給部１１の全てである。すなわち、図５のステップＳ５１の処理により、同じ識別情報が記憶されている電力供給部１１の全てである。例えば、図２で示される電力供給装置１においては、ステップＳ１１７の処理により、電力供給部１１－２１、電力供給部１１－２８、電力供給部１１－２９、および電力供給部１１－３７の４個の磁界の発生が停止する。
【0131】
ステップＳ１１５において、ステップＳ１１２の処理において時間の計測が開始されてから、所定の時間が経過したと判定された場合、例えば、１分３０秒が経過した場合、電力供給装置１の設置面１aから受電装置が取り除かれたことが推測されるため、ステップＳ１１７において、上述した処理が実行される。すなわち、電力を供給する受電装置がないので、ステップＳ１１７の処理により、電力供給部１１が発生した磁界を消す必要がある。
【0132】
図１０のフローチャートを参照して、受電装置の受電の処理について説明する。この処理は、電力供給装置１が、図５のステップＳ４２において、微弱な磁界を発生させることにより、電力供給部１１に対応する位置にある受電部２１の受電アンテナ１０１に、電磁誘導によって電流が流れ、その電流が整流器１０２を介し、受電制御部１０３に供給されることで、受電制御部１０３が起動したとき開始される。
【0133】
ステップＳ１５１において、受電制御部１０３は、通信部１０７に、電力供給装置１に対しメモリ１２１に記憶されている電流情報および識別情報を送信させる。ステップＳ１５２において、受電制御部１０３は、通信部１０７が、受電装置のIDを要求する信号を受信したかを判定する。
【0134】
ステップＳ１５２において、通信部１０７が、受電装置のIDを要求する信号を受信していないと判定された場合、処理はステップＳ１５１に戻り、判定された場合、ステップＳ１５３において、受電制御部１０３は、受電装置のIDおよび識別情報をメモリ１２１から読み出し、電力供給装置１に送信する。
【0135】
ステップＳ１５４において、受電制御部１０３は、通信部１０７が電力情報を要求する信号を受信したかを判定する。ステップＳ１５４において、通信部１０７が、受電装置２のIDを要求する信号を受信していないと判定された場合、受電装置の電力情報を要求する信号を受信するまで待機する。
【0136】
ステップＳ１５４において、通信部１０７が受電装置の電力情報を要求する信号を受信したと判定された場合、ステップＳ１５５において、受電制御部１０３は、電力情報および識別情報を通信部１０７に送信させる。
【0137】
ステップＳ１５６において、受電制御部１０３は、バッテリ１２３の充電を開始させる。すなわち、受電制御部１０３は、スイッチ１０６をオンにすることにより、受電アンテナ１０１から整流器１０２に交流電流が流れ、整流器１０２が整流した直流電流が、端子１０４、バッテリ１２３、端子１０５、およびスイッチ１０６の経路で流れ、バッテリ１２３が充電される。

【0138】
ステップＳ１５７において、受電制御部１０３は、リアルタイムクロック１２２から供給されるクロックパルスを計数することで、時間の計測を開始する。
【0139】
ステップＳ１５８において、受電制御部１０３は、ステップＳ１５７の処理により計測を開始した時間（例えば、１分）が経過したかを判定する。
【0140】
ステップＳ１５８において、時間が、例えば、１分が経過していないと判定された場合、ステップＳ１５９において、受電制御部１０３は、バッテリ１２３の充電が完了したかを判定する。すなわち、受電制御部１０３は、端子１０４および端子１０５にかかる電圧が、バッテリ１２３の充電の完了を示す基準電圧に達したか否かを判定する。
【0141】
ステップＳ１５９において、充電が完了していないと判定された場合、処理はステップＳ１５８に戻り、上述した処理が実行される。
【0142】
ステップＳ１５８において、１分が経過したと判定された場合、ステップＳ１６０において、受電制御部１０３は、通信部１０７に、電力供給装置１に対して、充電中を示す信号および識別情報を送信させる。
【0143】
ステップＳ１６１において、受電制御部１０３は、ステップＳ１５７において計測を開始した時間をリセットする。すなわち、受電制御部１０３は、計測中の時間を０秒にする。
【0144】
ステップＳ１６１の処理の後、処理は、ステップＳ１５７に戻る。
【0145】
ステップＳ１５９において、バッテリ１２３の充電が完了したと判定された場合、ステップＳ１６２において、受電制御部１０３は、通信部１０７に、電力供給装置１に対し、充電の完了を示す信号および識別情報を送信させる。
【0146】
ステップＳ１６３において、受電制御部１０３は、バッテリ１２３の充電を終了させる。すなわち、受電制御部１０３は、スイッチ１０６をオフにする。
【0147】
以上のように、１個の受電部２１に対して、受電部２１の位置に対応する複数の電力供給部１１により電力が供給されるので、迅速に、受電部２１への電力の供給を完了することができる。
【0148】
また、電力供給装置１において、金属である、例えば、異物２０１を検出することにより、異物２０１の発熱や電力供給部１１の電力供給アンテナ５２に流れる過電流を防ぐことができる。これにより、より安全に、受電装置に電力を供給することができる。
【0149】
また、コネクタを使用せず、無線で、受電装置２に電力が供給されるので、電圧や電流などの規格による制限が緩和され、規格の異なる複数の受電装置にも電力を供給することができる。
【0150】
なお、受電装置２が受電部２１（受電アンテナ１０１）の大きさを電力供給装置１に送信することで、図５の電力供給部１１の選択の処理において、全ての電力供給部１１を順に、走査することで、受電部２１の位置に対応する電力供給部１１を検出する必要がなくなる。
【0151】
すなわち、受電部２１の大きさを基に、最初に検出された電力供給部１１の周りの電力

供給部１１のみに微弱な磁界を発生させ、電力供給部１１が受電部２１の位置に対応しているか否かを判定するだけで、電力供給部１１を検出することが可能となる。従って、受電部２１の位置に対応する電力供給部１１をより迅速に検出することができる。

【0152】

図１１は、受電装置２の受電部の他の構成の例を示す図である。受電装置２において、受電部３２１－１および受電部３２１－２は、受電部２１と同様の構成をしている。すなわち、受電部３２１－１および受電部３２１－２は、両方とも受電部２１におけるバッテリ１２３に接続されており、受電部３２１－１および受電部３２１－２の両方から、バッテリ１２３は電力が供給される。

【0153】

また、図１１で示されるように、受電部３２１－１および受電部３２１－２のそれぞれは、１個の電力供給部１１だけを含む大きさに形成されている。

【0154】

受電装置２は、受電部３２１－１および受電部３２１－２のそれぞれが、電力供給部１１－２１および電力供給部１１－３６のそれぞれの位置に対応するように電力供給装置１の設置面１ａに載せられている。従って、受電部３２１－１および受電部３２１－２のそれぞれは、電力供給部１１－２１および電力供給部１１－３６のそれぞれから電力の供給をうけることになる。

【0155】

以下、受電部３２１－１および受電部３２１－２を個々に区別する必要のない場合、単に、受電部３２１と称する。

【0156】

以上のように、複数の受電部３２１を受電装置２に設けることにより、複数の電力供給部１１から電力の供給をうけることができる。従って、図２で示される受電装置２と同様に、より迅速に、図１１で示される受電装置２は、電力の供給を完了することができる。

【0157】

なお、図１１で示される受電装置２が、受電部３２１の数および受電部３２１同士の距離、すなわち、例えば、受電部３２１－１の中心から受電部３２１－２の中心までの距離を電力供給装置１に送信することで、図５の電力供給部１１の選択の処理において、全ての電力供給部１１を順に、走査することで、受電部３２１の位置に対応する電力供給部１１を検出する必要がなくなる。

【0158】

すなわち、例えば、最初に検出された電力供給部１１から、受電部３２１の数および受電部３２１同士の距離を基に、各受電部３２１に電力を供給することが推測される位置にある電力供給部１１を検出し、検出された電力供給部１１に微弱な磁界を発生させ、電力供給部１１が受電部３２１の位置に対応しているか否かを判定するだけで、受電部２３１に電力を供給する電力供給部１１を検出することが可能となる。従って、複数の受電部３２１の位置に対応する電力供給部１１をより迅速に検出することができる。

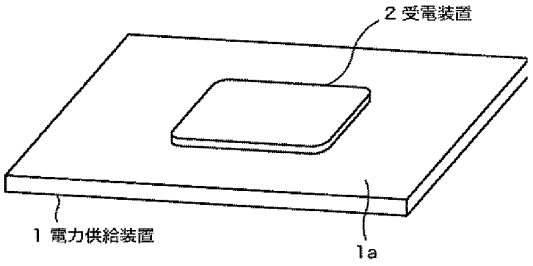
【0159】

このように、電力供給装置において、無線で電力を供給することができるようにした場合、配線を必要としないため、電圧や電流の規格による規制が緩和され、容易に受電装置に電力を供給することができる。電力供給装置において、複数の電力供給手段が受電装置に対して電磁誘導により電力を供給し、選択手段が、複数の電力供給手段のうちの、受電装置が載せられた位置に対応する電力供給手段を選択し、受信手段が、受電装置から無線で送信されてくる、電力の供給を制御するための制御情報を受信し、制御手段が、制御情報に基づいて、選択された電力供給手段による電力の受電装置への供給を制御し、受電装置において、受電手段が、選択された電力供給手段による電磁誘導により電力の供給をうけ、送信手段が、選択された電力供給手段による電磁誘導により電力の供給をうけた場合、制御情報を無線で送信するようにした場合、より容易に受電装置に電力を供給することができる。

【0160】
上述した一連の処理は、ハードウェアにより実行させることもできるが、ソフトウェアにより実行させることもできる。一連の処理をソフトウェアにより実行させる場合には、そのソフトウェアを構成するプログラムが、専用のハードウェアに組み込まれているコンピュータ、または各種のプログラムをインストールすることで、各種の機能を実行することが可能な、例えば汎用のパーソナルコンピュータなどに、記録媒体からインストールされる。
【0161】
この記録媒体は、図３で示されるリムーバブルメディア８２のように、コンピュータとは別に、ユーザにプログラムを提供するために配布される、プログラムが記録されている磁気ディスク（フレキシブルディスクを含む）、光ディスク（CD-ROM（Compact Disk Read-Only Memory），DVDを含む）、光磁気ディスク（MD（Mini Disc）（商標）を含む）、若しくは半導体メモリなどよりなるパッケージメディアにより構成されるだけでなく、コンピュータに予め組み込まれた状態でユーザに提供される、プログラムが記録されているメモリ４２もしくはハードディスクなどで構成される。
【0162】
なお、上述した一連の処理を実行させるプログラムは、必要に応じてルータ、モデムなどのインターフェースを介して、ローカルエリアネットワーク、インターネット、デジタル衛星放送といった、有線または無線の通信媒体を介してコンピュータにインストールされるようにしてもよい。
【0163】
また、本明細書において、記録媒体に格納されるプログラムを記述するステップは、記載された順序に沿って時系列的に行われる処理はもちろん、必ずしも時系列的に処理されなくても、並列的あるいは個別に実行される処理を含むものである。
【0164】
さらに、本明細書において、システムとは、複数の装置により構成される装置全体を表すものである。
【図面の簡単な説明】
【0165】
【図1】本発明の一実施の形態に係る電力供給システムの構成の例を示す斜視図である。
【図2】図１の電力供給装置の設置面上に受電装置が載せられた状態を上方向から見た透過図である。
【図3】図１の電力供給装置の構成の例を示すブロック図である。
【図4】図１の受電装置の構成の例を示すブロック図である。
【図5】電力供給部の選択の処理を説明するフローチャートである。
【図6】設置面に異物が載せられている状態を示す図である。
【図7】複数の受電装置や異物が同時に載せられた電力供給装置を説明する図である。
【図8】受電装置との認証の処理を説明するフローチャートである。
【図9】受電装置への電力の供給の処理を説明するフローチャートである。
【図10】受電装置の受電の処理を説明するフローチャートである。
【図11】受電装置の受電部の他の例を説明する図である。
【符号の説明】
【0166】
１　電力供給装置，　１１、および１１－１乃至１１－ｎ　電力供給部，　２　受電装置，　２１　受電部，　４１　制御部，　５２　電力供給アンテナ，　５３　電流検出器，　７１　電力供給制御部，　７２　セレクタ，　７３　通信部，　８２　リムーバブルメディア，　１０１　受電アンテナ，　１０３　受電制御部，　１２３　バッテリ，　３２１、並びに３２１－１および３２１－２　受電部

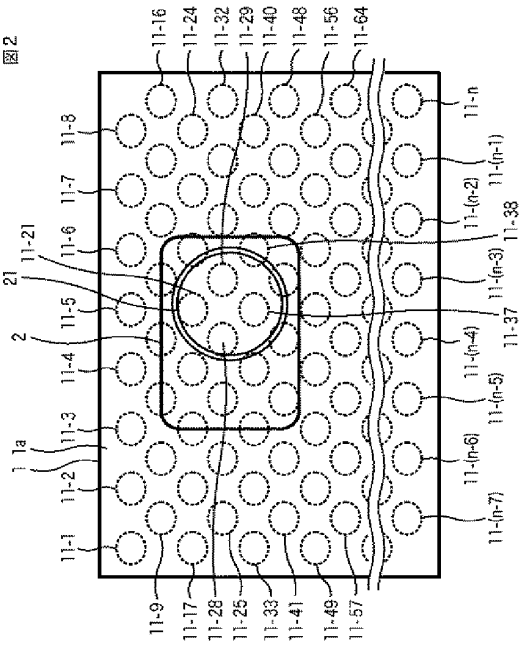
【図1】

図1



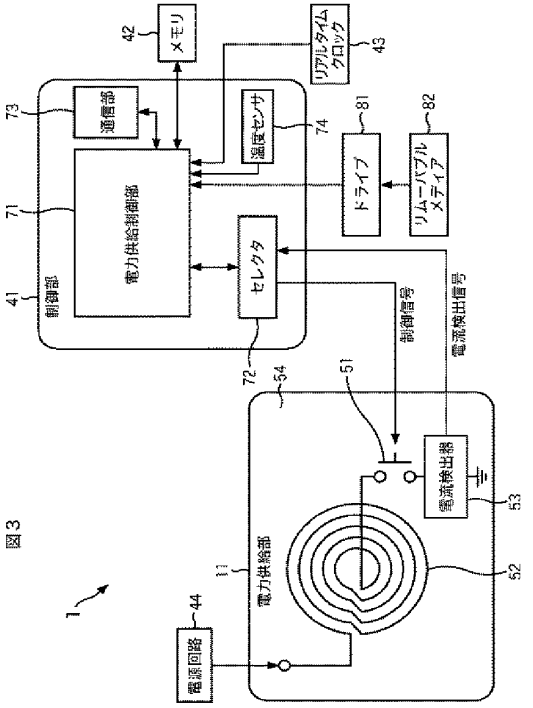
【図2】

図2



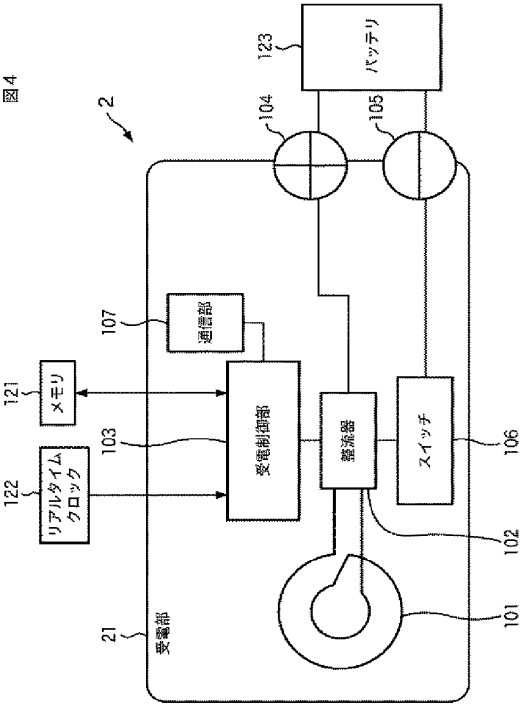
【図3】

図3

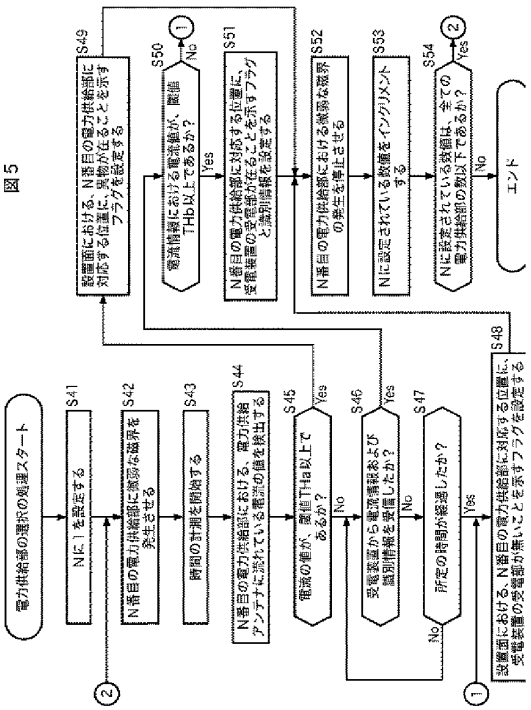


【図4】

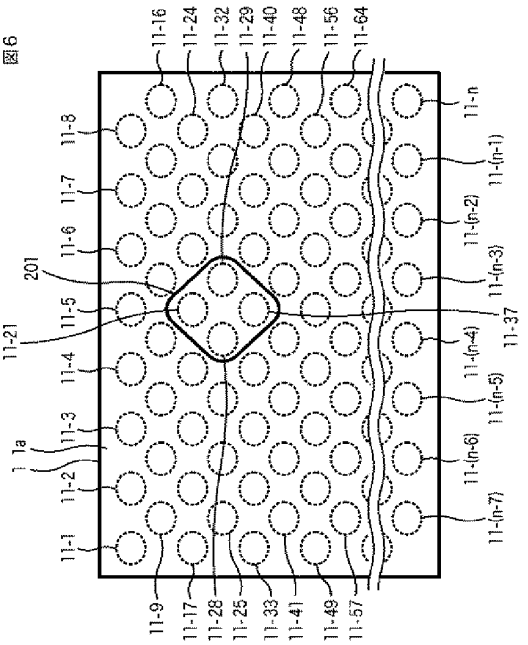
図4



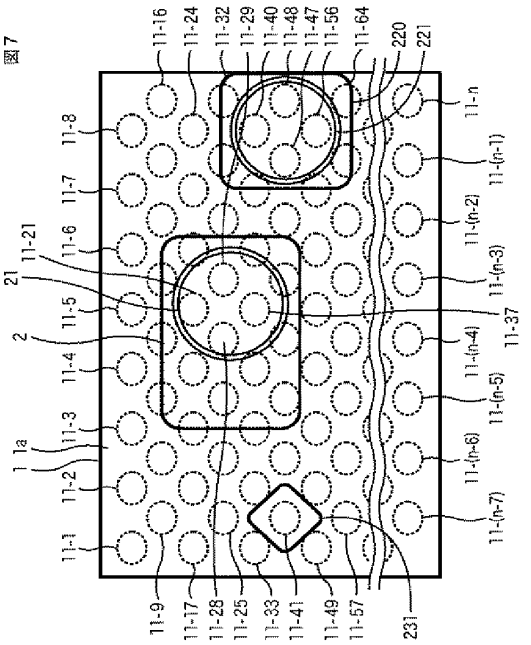
【図5】


図5
電力供給部の運転の処理スタート
N=1 を設定する
N番目の電力供給部に識別情報の発生を停止させる
時間の計測を開始する
N番目の電力供給部において、電力供給アンテナに流れている電流の値を検出する
電流の値が、閾値T1a以上であるか？
受電装置から識別情報および識別情報を受信したか？
所定の時間が経過したか？
設置面における、N番目の電力供給部に対応する位置に、受電装置の受電部が無いことを示すフラグを設定する
設置面における、N番目の電力供給部に対応する位置に、受電装置の受電部が存在することを示すフラグと識別情報を設定する
電流情報における電流値が、閾値T1b以上であるか？
N番目の電力供給部における微弱な磁界の発生を停止させる
Nに設定されている数値をインクリメントする
Nに設定されている数値は、全ての電力供給部の数以下であるか？
エンド
Yes
No

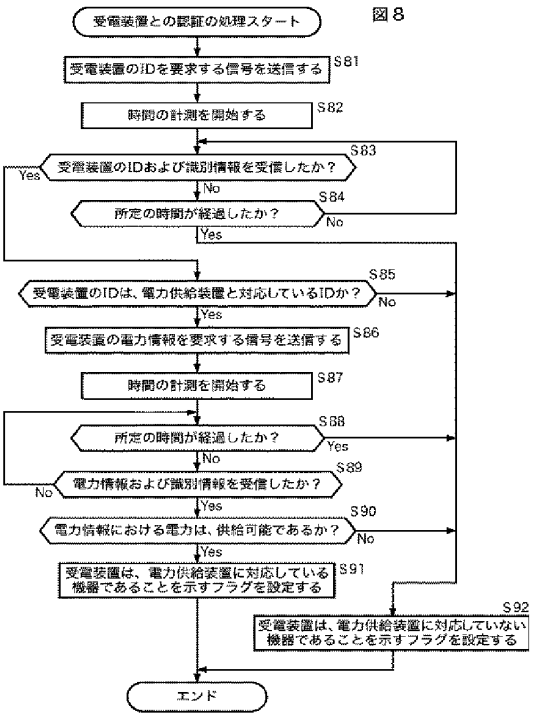
【図6】


図6
11-16
11-24
11-32
11-29
11-40
11-48
11-56
11-64
11-n
11-(n-1)
11-(n-2)
11-(n-3)
11-37
11-(n-4)
11-(n-5)
11-(n-6)
11-(n-7)
11-8
11-7
11-6
201
11-5
11-21
11-4
11-3
1 1a
11-2
11-1
11-9
11-17
11-28
11-25
11-33
11-41
11-49
11-57

【図7】

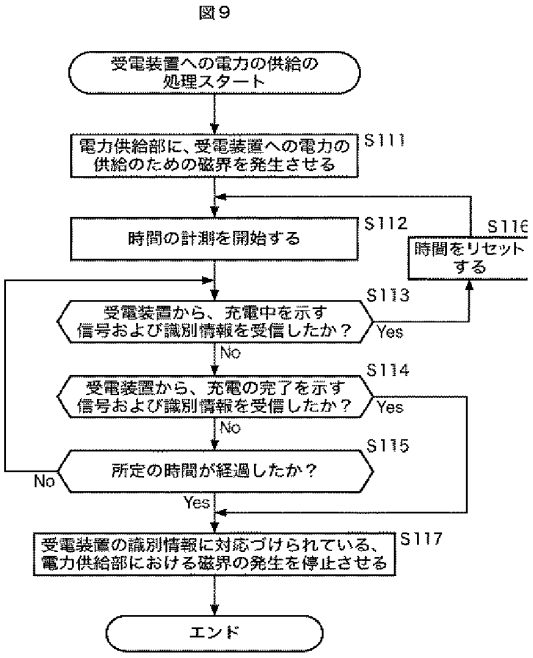

図7
11-16
11-24
11-32
11-29
11-40
11-48
11-47
11-56
11-64
220
221
11-n
11-(n-1)
11-(n-2)
11-(n-3)
11-37
11-(n-4)
11-(n-5)
11-(n-6)
11-(n-7)
11-8
11-7
11-6
11-21
21
11-5
2
11-4
11-3
1 1a
11-2
11-1
11-9
11-17
11-28
11-25
11-33
11-41
11-49
11-57
231

【図8】


図8
受電装置との認証の処理スタート
受電装置のIDを要求する信号を送信する
S81
時間の計測を開始する
S82
受電装置のIDおよび識別情報を受信したか？
S83
所定の時間が経過したか？
S84
受電装置のIDは、電力供給装置と対応しているIDか？
S85
受電装置の電力情報を要求する信号を送信する
S86
時間の計測を開始する
S87
所定の時間が経過したか？
S88
電力情報および識別情報を受信したか？
S89
電力情報における電力は、供給可能であるか？
S90
受電装置は、電力供給装置に対応している機器であることを示すフラグを設定する
S91
受電装置は、電力供給装置に対応していない機器であることを示すフラグを設定する
S92
エンド
Yes
No

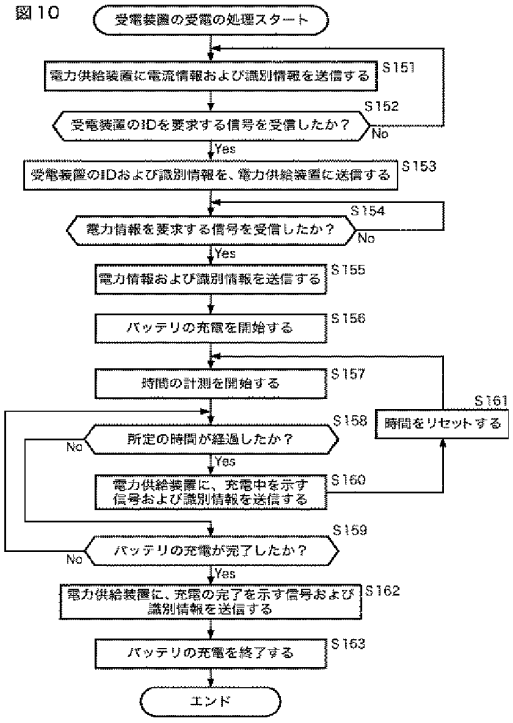
【図9】

図９



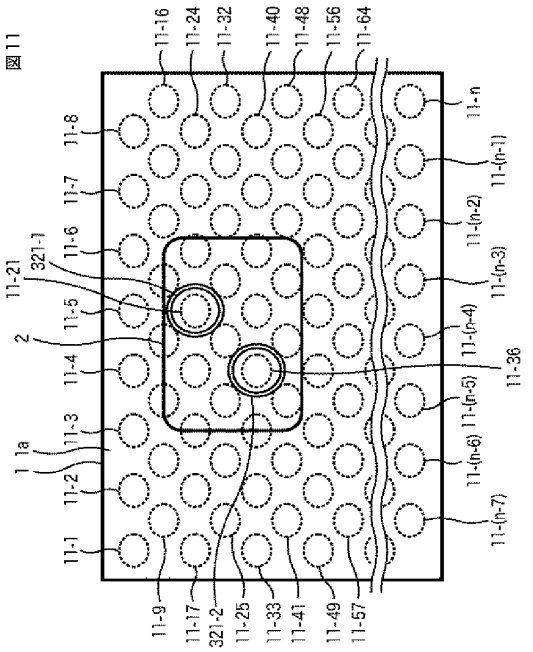
【図10】

図１０



【図11】

図１１



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(54) **Title**: SYSTEM FOR WIRELESS POWER TRANSFER THAT SUPPORTS INTEROPERABILITY, AND MULTI-POLE MAGNETS FOR USE THEREWITH

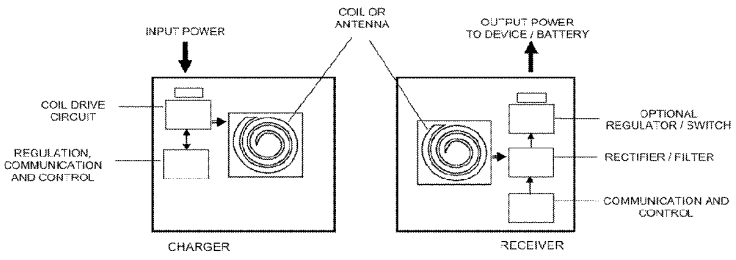


FIGURE 1

(57) **Abstract**: In the field of wireless power, to enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and receiver) can communicate in a manner that allows operation. With the proliferation of different communication schemes, a multi-protocol system that can adapt and interoperate with different communication protocols allows maximum interoperability. Described herein are systems and methods for providing such multi-protocol operation and maximum interoperability. Also described herein are methods for use of magnets in or around magnetically sensitive devices such that the operation of such a device is not impaired. Applications in various devices and systems are described. In particular, applications for fastening mobile devices to their cases or other surfaces, and also alignment or attachment for power transfer or charging are described. Also described herein are systems and methods for the use of multi-pole and other magnets, in electronic and other articles, devices, components, or parts thereof.

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SYSTEM FOR WIRELESS POWER TRANSFER THAT SUPPORTS INTEROPERABILITY, AND MULTI-POLE MAGNETS FOR USE THEREWITH

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Claim of Priority:

[0001] This application claims the benefit of priority to U.S. Provisional Patent Applications "IMPROVED MAGNETS FOR USE IN PROXIMITY TO MAGNETICALLY SENSITIVE PARTS OR DEVICES", Application No. 61/354,114, filed June 11, 2010; "SYSTEM AND METHOD FOR PROVIDING A UNIVERSAL-COMPATIBLE WIRELESS POWER SYSTEM", Application No. 61/387,895, filed September 29, 2010; and "SYSTEM AND METHOD FOR PROVIDING A UNIVERSAL-COMPATIBLE WIRELESS POWER SYSTEM", Application No. 61/478,015, filed April 21, 2011, each of which applications are hereby incorporated by reference herein.

Field of Invention:

[0002] The invention is generally related to inductive charging, including applications for use in mobile or other devices and vehicles, and improved compatibility and transfer of wireless power; and is also related to the use of magnets in electronic devices, and in particular to devices or parts having proximity to magnetic sensors.

Cross-Reference to Related Applications:

[0003] This application is related to U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by

reference herein.

Background:

[0004] Wireless technologies for powering and charging mobile and other electronic devices and vehicles have been developed. These systems generally use a wireless charger or transmitter system and a wireless receiver in combination to provide a means for transfer of power across a distance. For safe and efficient operation the two parts of the system often communicate with each other to verify the presence of receivers and/or initiate charging and continued power transfer. To enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and the receiver) can communicate in a manner that allows such operation.

[0005] Additionally, many mobile, industrial, automotive, medical devices, etc. contain compasses or other components that are sensitive to magnetic field. At the same time, it is often desired to use magnets for fastening or attachment, or alignment purposes near such devices without affecting the operation of such sensitive material. One application may be fastening of a mobile device or phone to a surface in a car or other vehicle to avoid movement during transport.

[0006] These are the general areas that embodiments of the invention are intended to address.

Summary:

[0007] As described above, to enable interoperability between chargers and receivers, it is important that the two parts of the system (the charger and receiver) can communicate in a manner that allows operation. With the proliferation of different communication schemes, a multi-protocol system that can adapt and interoperate with different communication protocols allows maximum interoperability. Described herein are systems and methods for providing such multi-protocol operation and maximum interoperability. Also described herein are methods for use of magnets in or around magnetically sensitive devices such that the operation of such a device is not impaired. Applications in various devices and systems are described. In particular, applications for fastening mobile devices to their cases or other surfaces, and also alignment or attachment for power transfer or charging are described. Also described herein are systems and methods for the use of multi-pole and other magnets, in electronic and other articles, devices, components, or parts thereof.

Brief Description of the Figures:

[0008] **Figure 1** illustrates an example of a wireless charger or power system that comprises a charger or transmitter part, and a receiver part, in accordance with an embodiment.

[0009] **Figure 2** shows a more detailed view of the wireless charger system with a resonant

converter geometry, in accordance with an embodiment.

[0010] **Figure 3** illustrates a system wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes, in accordance with an embodiment.

[0011] **Figure 4** illustrates the use a center-tapped receiver wherein during each cycle current passes only through one part of the coil and one diode in the receiver and therefore halves the rectification losses, in accordance with an embodiment.

[0012] **Figure 5** illustrates that the charger and receiver coils can be represented by their respective inductances by themselves and the mutual inductance between, in accordance with an embodiment.

[0013] **Figure 6** shows a wirelessly powered battery pack and receiver, in accordance with an embodiment.

[0014] **Figure 7** illustrates the use of a battery cell connected through a protection circuit comprising a battery protection IC that protects a battery from over-current and under or over voltage, in accordance with an embodiment.

[0015] **Figure 8** illustrates a typical charge cycle for a Lithium Ion battery, in accordance with an embodiment.

[0016] **Figure 9** illustrates how the charger periodically activates the charger coil driver and powers the charger coil with a drive signal of appropriate frequency, in accordance with an embodiment.

[0017] **Figure 10** illustrates an example of the communication process and regulation of power and/or other functions, in accordance with an embodiment.

[0018] **Figure 11** shows a Notebook-style portfolio case and a mobile phone or camera pouch, where magnets are used to secure a closing clasp or flap, in accordance with an embodiment.

[0019] **Figure 12** illustrates several commercially available mounts for devices, in accordance with an embodiment.

[0020] **Figure 13** shows an example of a power plug for an electronic device, in accordance with an embodiment.

[0021] **Figure 14** shows an inductive wireless charger and/or power supply with multiple charging stations, in accordance with an embodiment.

[0022] **Figure 15** illustrates several different placements and shapes for magnets, in accordance with an embodiment.

[0023] **Figure 16** shows a measured z-component along the axial direction of magnetization of a magnet, in accordance with an embodiment.

[0024] **Figure 17** illustrates the performance of a 50 x 50 x 1 mm^3 magnet with one of 10 x

10 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part, in accordance with an embodiment.

[0025] **Figure 18** illustrates how the same shape part can be periodically poled in a multi-pole pattern, in accordance with an embodiment.

[0026] **Figure 19** shows the drop off of maximum flux density value for a 10 x 10 x 1 mm^3 magnet magnetized periodically with a periodicity of 1 and 2 mm, in accordance with an embodiment.

[0027] **Figure 20** shows several magnet types that are magnetized perpendicular to the magnet surface (axially), in accordance with various embodiments.

[0028] **Figure 21** shows an example of various ring or arc multi-pole magnets, as may be used to with a coil to provide alignment, in accordance with an embodiment.

[0029] **Figure 22** illustrates a ring magnet that includes a discontinuity, in accordance with an embodiment.

[0030] **Figure 23** illustrates a multi-pole ring magnet with radially magnetized sections, in accordance with an embodiment.

Detailed Description:

[0031] With the proliferation of electrical and electronic devices and vehicles (which are considered devices herein), simple and universal methods of providing power and or charging of these devices is becoming increasingly important. To enable a user to easily charge or power these devices, a simple non-contact method such as wireless power transfer is increasingly important.

[0032] Many of these devices contain internal batteries, and the device may or may not be operating during receipt of power. Depending on the degree of charge status of the battery or its presence and the system design, the applied power may provide power to the device, charge its battery or a combination of the above. The terms charging and/or power are used interchangeably herein to indicate that the received power can be used for either of these cases or a combination thereof. Unless specifically described, these terms are therefore used interchangeably.

[0033] As shown in **Figure 1**, a wireless charger or power system comprises a charger or transmitter part, and a receiver part. The charger or transmitter can generate a repetitive power signal pattern (such as a sinusoid or square wave from 10's of Hz to several MHz or even higher but typically in the 100 kHz to several MHz range) with its coil drive circuit and a coil or antenna for transmission of the power. The charger or transmitter typically also includes a communication and regulation / control system that detects a receiver and/or turns the applied power on or off and/or modify the amount of applied power by mechanisms such as changing the amplitude, frequency or duty cycle, etc. or a combination thereof of the applied power signal

to the coil or antenna.

[0034] The second part of the system is a receiver that includes a coil or antenna to receive power, a method for change of the received AC voltage to DC voltage such as rectification and smoothing with one or more rectifiers or a bridge or synchronous rectifier, etc. and one or more capacitors and optionally, a method for the receiver to communicate with the charger.

[0035] In accordance with an embodiment, the method of communication between the charger and receiver can be through the same coils as for transfer of power, through a separate coil, through an RF or optical link or combination thereof. In case of communication through the power transfer coil, one method for the communication is to modulate the load in the receiver to affect the voltage in the receiver coil and therefore create a modulation in the charger coil parameters that can be detected through monitoring of its voltage or current. Other methods can include frequency modulation by combining the received frequency with a local oscillator signal or inductive, capacitive, or resistive modulation of the output of the receiver coil.

[0036] In accordance with an embodiment, the communicated information can be the output voltage, current, device or battery status, validation ID for receiver, end of charge or various charge status information, receiver battery, device, or coil temperature, or user data.

[0037] In accordance with an embodiment, the data communicated can be any of the information detailed herein, or the difference between these values and the desired value or simple commands to increase or decrease power or simply one or more signals that would confirm presence of a receiver or a combination of the above. In addition, the receiver can include other elements such as a dc to dc converter or regulator such as a switching, buck, boost, buck / boost, or linear regulator. The receiver may also include a switch between the DC output of the receiver coil and its output to a device or battery or a device case or skin and in cases where the receiver is used to charge a battery, the receiver may also include a battery charger IC or circuitry and/or battery protection circuit and associated transistors, etc. The receiver and/or charger and/or their coils can also include elements such as thermistors, magnetic shields or magnetic cores, magnetic sensors, and input voltage filters, etc. for safety and/or emission compliance reasons. In addition, the charger and or receiver can include means to provide more precise alignment between the charger and receiver coils or antennas. These may include visual, physical, or magnetic means to assist the user in alignment of parts. To implement more positioning freedom of the receiver on the charger, the size of the coils can also be mismatched. For example, the charger can comprise a larger coil size and the receiver a smaller one or vice versa, so that the coils do not have to be precisely aligned for power transfer.

[0038] In accordance with an embodiment, the power section (coil drive circuit and receiver power section) can be a resonant, zero switching, flyback, or any other appropriate topology. **Figure 2** shows a more detailed view of the wireless charger system with a resonant converter

geometry where a pair of transistors Q1 and Q2 (such as FETs) are driven by a half-bridge driver IC and the voltage is applied to the coil L1 through one or more capacitors shown as C1. The receiver includes a coil and an optional capacitor (for added efficiency) shown as C2 that may be in series or in parallel with the receiver coil L2. The charger and/or receiver coils may also include magnetic material layers behind them to increase their inductance or to shield the magnetic field leakage to surrounding area.

[0039] In accordance with an embodiment, the charger also includes a circuit that measures the current through and/or voltage across the charger coil (in this case a current sensor is shown in the figure as an example). Various demodulation methods for detection of the communication signal on the charger current or voltage are available. This demodulation mechanism can be an AM or FM receiver (depending on whether amplitude or frequency modulation is employed in the receiver modulator) similar to a radio receiver tuned to the frequency of the communication or a heterodyne detector, etc.

[0040] In accordance with an embodiment, the microcontroller unit (MCU) in the charger (MCU2) is responsible for understanding the communication signal from the detection / demodulation circuit and, depending on the algorithm used, making appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output. In addition, MCU1 is responsible for processes such as periodic start of the charger to seek a receiver at the start of charge, keeping the charger on when a receiver is found and accepted as a valid receiver, continuing to apply power and making necessary adjustments, and/or monitoring temperature or other environmental factors, providing audio or visual indications to the user on the status of charging or power process, etc. or terminating charging or application of power due to end of charge or customer preference or over temperature, over current, over voltage, or some other fault condition or to launch or start another program or process. For example, the charger can be built into a car and once a valid receiver integrated into or on a mobile device, its case or skin, or battery is found, the charger may activate some other functions such as Bluetooth connectivity to the device, displaying the device identity on a display, etc. Other similar actions can be done in other environments. It may be useful in addition to the communication signal to detect the dc value of the current through the charger coil. For example, faults may be caused by insertion or presence of foreign objects such as metallic materials between the charger and receiver. These materials may be heated by the application of the power and can be detected through detection of the charger current or temperature or comparison of input voltage, current, or power to the charger and output voltage, current, or power from the receiver and concluding that the ratio is out of normal range and extra power loss due to unknown reasons is occurring. In these conditions or other situations such as abnormal charger and/or receiver heating, the charger may be programmed to declare a fault condition and shut down and/or alert the user or take other actions.

[0041] Once the charger MCU has received a signal and decoded this signal, it can take action to provide more or less power to the charger coil. This can be accomplished through known methods of adjusting the frequency, duty cycle or input voltage to the charger coil or a combination of these approaches. Depending on the system and the circuit used, the MCU can directly adjust the bridge driver or an additional circuit such as a frequency oscillator may be necessary to drive the bridge driver or the FETs.

[0042] A typical circuit for the receiver in accordance with an embodiment, is also shown in Figure 2. In accordance with an embodiment, the receiver circuit can include a capacitor C2 in parallel or series with the receiver coil to produce a tuned receiver circuit. This circuit is known to increase the efficiency of a wireless power system. The rectified and smoothed (through a bridge rectifier and capacitors) output of the receiver coil and optional capacitor is either directly or through a switch or regulator applied to the output. A microcontroller is used to measure various values such as output voltage, current, temperature, state of charge, battery full status, end of charge, etc. and to report back to the charger to provide a closed loop system with the charger as described above. In the circuit shown in Figure 2, the receiver MCU communicates back to the charger by modulating the receiver load by rapidly closing and opening a switch in series with a modulation load at a pre-determined speed and coding pattern. This rapid load modulation technique at a frequency distinct from the power transfer frequency can be easily detected by the charger. A capacitor and/or inductor can also be placed in parallel or in series with this load.

[0043] For example, one may assumes that the maximum current output of the receiver is 1000 mA and the output voltage is 5 V for a maximum output of 5W. In this case, the minimum load resistance is 5 ohms. A modulation load resistor of several ohms (20, or 10 ohms or smaller) would be able to provide a large modulation depth signal on the receiver coil voltage. Choosing a 5 ohm resistor would modulate the output between a maximum current of 1 Amp or larger and a smaller value defined by the device load at the output. Such a large modulation can be easily detected at the charger coil current or voltage as described above.

[0044] The receiver in Figure 2 also shows an optional dc regulator that is used to provide constant stable voltage to the receiver MCU. This voltage supply may be necessary to avoid drop out of the receiver MCU during startup conditions where the power is varying largely or during changes in output current and also to enable the MCU to have a stable voltage reference source so it can measure the output voltage accurately.

[0045] In the above description, a uni-directional communication (from the receiver to the charger) is described. However, this communication can also be bi-directional and data can be transferred from the charger to the receiver through modulation of the voltage or current in the charger coil and read back by the microcontroller in the receiver detecting a change in the voltage or current, etc.

[0046] In accordance with an embodiment, in other geometries where position independence on placement of the receiver on the charger surface is achieved by having multiple charger coils in an array or pattern, similar drive and communication circuits in the charger and receiver can be implemented. However, to detect the appropriate coil to activate in the charger, the coils can be activated in a raster or zigzag fashion or other geometry and current drawn from a charger coil, strength of voltage, current, power or signal from the receiver or other methods can be used to determine the closest match between position of one or more of the charger coils and a receiver coil and the appropriate charger coil or coils can be activated and modulated to provide optimum power transfer to the receiver.

[0047] While a system for communication between the charger and receiver through the power transfer coil or antenna is described above, the communication can also be implemented through a separate coil, a radio frequency link (am or fm or other communication method), an optical communication system or a combination of the above. The communication in any of these methods can also be bi-directional rather than uni-directional as described above. As an example, **Figure 3** shows a system in accordance with an embodiment, wherein a dedicated RF channel for uni-directional or bi-directional communication between the charger and receiver is implemented for validation and/or regulation purposes. This system is similar to the system shown in Figure 2, except rather than load modulation being the method of communication, the MCU in the receiver transmits the necessary information over an RF communication path. A similar system with LED or laser transceivers or detectors and light sources can be implemented. Advantages of such system may be that the power received is not modulated and therefore not wasted during communication and/or that no noise due to the modulation is added to the system.

[0048] One of the disadvantages of the circuit shown in Figure 2 is that in the receiver circuit shown therein, the current path passes through 2 diodes and suffers 2 voltage drops resulting in large power dissipation and loss. For example, for Schottky diodes with forward voltage drop of 0.4 V, at a current output of 1 A, each diode would lose 0.4 W of power for a combined power loss of 0.8 W for the two in a bridge rectifier configuration. For a 5 V, 1 A output power (5W), this 0.8 W of power loss presents a significant amount of loss (16%) just due to the rectification system. In accordance with an embodiment, an alternative is to use a center-tapped receiver as shown in **Figure 4** wherein during each cycle current passes only through one part of the coil and one diode in the receiver and therefore halves the rectification losses. Such a center tapped coil can be implemented in a wound wire geometry with 2 sections of a wound wire or a printed circuit board coil or with a double or multi-sided sided PCB coil or a combination or even a stamped, etched or otherwise manufactured coil or winding.

[0049] In any of the systems described above, as shown in **Figure 5**, the charger and receiver coils can be represented by their respective inductances by themselves (L1 and L2) and

the mutual inductance between them M which is dependent on the material between the 2 coils and their position with respect to each other in x, y, and z dimensions. The coupling coefficient between the coils k is given by:

$$k = M / (L1 * L2)^{1/2}$$

[0050] The coupling coefficient is a measure of how closely the 2 coils are coupled and may range from 0 (no coupling) to 1 (very tight coupling). In coils with small overlap, large gap between coils or dissimilar coils (in size, number of turns, coil winding or pattern overlap, etc.), this value can be smaller than 1.

[0051] **Figure 6** shows a wirelessly powered battery pack and receiver in accordance with an embodiment. The components of a typical common battery pack (battery cell and protection circuit, etc.) used in a battery device used in applications such as mobile phone, etc. are shown inside the dashed lines. The components outside the dashed lines are additional components necessary to enable safe wireless and wired charging of a battery pack. A battery pack may have four or more external connector points that interface with a mobile device pins in a battery housing or with an external typical wired charger. In accordance with an embodiment, the battery cell is connected as shown in **Figure 7** to two of these connectors (shown in the figure as Batt+ and Batt-) through a protection circuit comprising a battery protection IC that protects a battery from over-current and under or over voltage. A typical IC may be Seiko 8241 IC that uses 2 external FETs as shown in Figure 7 to prevent current going from or to the battery cell (on the left) from the external battery pack connectors if a fault condition based on over current, or battery cell over or under voltage is detected. This provides safety during charging or discharging of the battery. In addition, a battery pack may include a PTC conductive polymer passive fuse. These devices can sense and shut off current by heating a layer inside the PTC if the amount of current passing exceeds a threshold. The PTC device is reset once this current falls and the device cools.

[0052] In addition, in accordance with an embodiment, the battery pack can contain a thermistor that the mobile device checks through one other connector on the battery pack to monitor the health of the pack, and in some embodiments an ID chip or microcontroller that the mobile device interrogates through another connector to confirm an original battery manufacturer or other information about the battery. Other connectors and functions can be included in a battery pack to provide accurate battery status and/or charging information to a device being powered by a battery pack or a charger charging the battery pack.

[0053] In addition to the components described above, In accordance with an embodiment, the receiver circuit comprises a receiver coil that could be a wound wire or PCB coil as described above, optional electromagnetic shielding between the coil and the metal body of the battery,

optional alignment assisting parts such as magnets, etc., a receiver communication circuit (such as the resistor and FET for load modulation shown in Figures 2 and 4), a wireless power receiver (such as rectifiers and capacitors as discussed above), and an optional Battery charger IC that has a pre-programmed battery charging algorithm. Each type of battery and chemistry requires a pre-determined optimized profile for charging of a battery. A typical charge cycle for a Lithium Ion (Li-Ion) is shown in **Figure 8**. Such a battery may be charged up to a value of 4.2 V at full capacity. The battery should be charged according to the guidelines of the manufacturer. For a battery of capacity C, the cell can typically be charged at the rate 1C. In Stage 1, the maximum available current is applied and the cell voltage increases until the cell voltage reaches the final value (4.2 V). In that case, the charger IC switches to Stage 2 where the charger IC switches to Constant Voltage charging where the cell voltage does not change but current is drawn from the source to further fill up the battery. This second Stage may take 1 or more hours and is necessary to fully charge the battery. Eventually, the battery will draw little (below a threshold) or no current. At this stage, the battery is full and the charger may discontinue charging. The charger IC can periodically seek the condition of the battery and top it off further if the battery has drained due to stand-by, etc.

[0054] Such multiple stages of battery charging may be implemented in firmware with the wireless power charger and receiver microcontrollers monitoring the battery cell voltage, current, etc. and working in tandem and to provide appropriate voltage, current, etc. for safe charging for any type of battery. In another approach as shown in Figure 6, a battery charger IC chip that has specialized battery charging circuitry and algorithm for a particular type of battery can be employed. These charger ICs (with or without fuel gauge capability to accurately measure battery status, etc.) are available for different battery chemistries and are included in most mobile devices with mobile batteries such as mobile phones. They can include such safety features as a temperature sensor, open circuit shut off, etc. and can provide other circuits or microcontrollers such useful information as end of charge signal, signaling for being in constant current or voltage (stage 1 or 2 above, etc.). In addition, some of these ICs allow the user to program and set the maximum output current to the battery cell with an external resistor across 2 pins of the IC.

[0055] In accordance with an embodiment, the wirelessly charged battery pack in addition includes a micro-controller that coordinates and monitors various points and may also include thermal sensors on the wireless power coil, battery cell and/or other points in the battery pack. The microcontroller also may communicate to the charger and can also monitor communication from the charger (in case of bi-directional communication). Typical communication through load modulation is described above.

[0056] Another aspect of a wirelessly charged battery pack is the optional external / internal switch. A battery pack may receive power and be charged wirelessly or through the connectors

of a battery pack. For example when such a battery pack is used in a mobile phone, the user may wish to place the phone on a wireless charger or plug the device in to a wired charger for charging or charge the device as well as synchronize or upload and/or download information. In the second case, it may be important for the battery pack to recognize current incoming to the battery pack and to take some sort of action. This action may include notifying the user, shutting off the wired charger by a switch or simply shutting down the charger IC and sending a signal back through the microcontroller and modulating the current back to the charger that a wired charger is present (in case priority is to be given to the wired charger) or conversely to provide priority to the wireless charger and shut off wired charger access to battery when the wireless charger is charging the battery. At either case, a protocol for dealing with presence of two chargers simultaneously should be pre-established and implemented in hardware and firmware.

[0057] As shown in Figure 6, the wireless charging of battery occurs with current flowing into the battery through the battery contacts from the mobile device. Typically, such current is provided by an external DC supply to the mobile device (such as an AC/DC adaptor for a mobile phone) and the actual charging is handled by a charger IC chip or power management IC inside the mobile device that in addition to charging the battery, measures the battery's state of charge, health, verifies battery authenticity, and displays charge status through LEDs, display, etc. to a user. It may be therefore be advantageous to include a current sense circuit at one of the battery pack contacts to measure and sense the direction of current flow into or out of the battery. In case the current is flowing in (i.e. battery being externally charged through wired charging through a mobile device), the micro-controller may take the actions described above and shut off wireless charging or conversely, provide priority to wireless charging and if it is present, not allow wired charging to occur as preferred by design.

[0058] In accordance with an embodiment, the firmware in the receiver micro-controller is a key element in the operation of this battery pack. The micro-controller can measure voltages and currents, flags, and temperatures at appropriate locations for proper operation. In accordance with one embodiment, by way of example, the micro-controller can measure the value of Vout from the rectifier circuit and attempt to keep this constant throughout the charging cycle thereby providing a stable regulated DC supply to the charger IC chip. The microcontroller can send back the value of this voltage or error from a desired voltage (for example 5V) or simply a code for more or less power back to the charger in a binary or multi-level coding scheme through a load modulation or other scheme (for example RF communication as described earlier) back to the charger. The charger can then take action through adjustment of input voltage to the charger coil, adjustment of the frequency or duty cycle of the ac voltage applied to the charger coil to bring the Vout to within required voltage range. The micro-controller throughout the charging process, in addition, monitors the end of charge and/or other signals from charger and/or protection circuit and the current sense circuit (used to sense battery

pack current direction and value) to take appropriate action. Li-ion batteries for example need to be charged below a certain temperature for safety reasons. It is therefore essential to monitor the cell, wireless power receiver coil or other temperature and take appropriate action such as terminate charging or lower charging current, etc. if a certain maximum temperature is exceeded.

[0059] It is important to realize that during charging, as shown in Figure 8, the battery cell voltage increases from 3 V or lower, to 4.2 V, as it is charged. The V_{out} of the wireless power receiver is input to a charger IC and if this V_{out} is kept constant (for example 5V), a large voltage drop (up to 2 V or more) can occur across this chip especially during Stage 1 where maximum current is applied. With charging currents of up to 1 A, this may translate to up to 2 Watts of wasted power / heat across this IC that may contribute to battery heating. It may be therefore preferable to implement a strategy whereby the V_{out} into the charger IC tracks the battery voltage thereby creating a smaller voltage drop and therefore loss across the charger IC. This can provide a significant improvement in performance since thermal performance of the battery pack is very important.

[0060] The communication between the receiver and charger needs to follow a pre-determined protocol, baud rate, modulation depth, etc. and a pre-determined method for hand-shake, establishment of communication, and signaling, etc. as well as optionally methods for providing closed loop control and regulation of power, voltage, etc. in the receiver.

[0061] In accordance with an embodiment, a typical wireless power system operation can be as follows: As shown in **Figure 9**, the charger periodically activates the charger coil driver and powers the charger coil with a drive signal of appropriate frequency. During this 'ping' process, if a receiver coil is placed on top or close to the charger coil, power is received through the receiver coil and the receiver circuit is energized. The receiver microcontroller is activated by the received power and begins to perform an initiation process whereby the receiver ID, its presence, power or voltage requirements, receiver or battery temperature or state of charge and/or other information is sent back to the charger. If this information is verified and found to be valid, then the charger proceeds to provide continuous power to the receiver. The receiver may alternately send an end of charge, over-temperature, battery full, or other messages that will be handled appropriately by the charger and actions performed. The length of the ping process should be planned to be of sufficient length for the receiver to power up its microcontroller and to respond back and for the response to be received and understood. The length of time between the pings is determined by the designer. If ping process is performed often, the stand-by power use of the charger is higher. Alternately, if the ping is done infrequently, the system will have a delay before the charger discovers a receiver nearby.

[0062] Alternately, the ping operation can be initiated upon discovery of a nearby receiver by other means. This provides a very low stand-by power use by the charger and may be

performed by including a magnet in the receiver and a magnet sensor in the charger or through optical, capacitive, weight or other methods for detection. Alternatively, the system can be designed to be always ON (i.e. the charger coil is powered at an appropriate drive frequency) and presence of the receiver coil brings the coil to resonance with the receiver coil and power transfer occurs. The receiver in this case may not even contain a microcontroller and act autonomously and simply have a regulator to provide regulated output power to a device, its kin or case, or battery.

[0063] In accordance with an embodiment, the protocol for communication can be any of, e.g. common RZ, NRZ, Manchester code, etc. used for communication. An example of the communication process and regulation of power and/or other functions is shown in **Figure 10**. As discussed above, the charger may periodically start and apply a ping voltage of pre-determined frequency and length to the charger coil (bottom figure in Figure 10). The receiver is then activated and may begin to send back communication signals as shown in top of Figure 10. The communication signal can include an optional preamble that is used to synchronize the detection circuit in the charger and prepare it for detection of communication. A communication containing a data packet may then follow, optionally followed by checksum and parity bits, etc. These processes are quite standard in communication systems and similar techniques can be followed. The actual data packet can include information such as an ID code for the receiver, received voltage, power, or current values, status of the battery, amount of power in the battery, battery or circuit temperature, end of charge or battery full signals, presence of external wired charger, or a number of the above. Also this packet may include the actual voltage, power, current, etc. value or the difference between the actual value and the desired value or some encoded value that will be useful for the charger to determine how best to regulate the output.

[0064] Alternatively, the communication signal can be a pre-determined pattern that is repetitive and simply lets the charger know that a receiver is present and/or that the receiver is a valid device within the power range of the charger, etc. Any combination of systems can be designed to provide the required performance.

[0065] In response to the receiver providing information regarding output power or voltage, etc. the charger may modify voltage, frequency, duty cycle of the charger coil signal or a combination of the above. The charger can also use other techniques to modify the power out of the charger coil and to adjust the received power. Alternatively the charger can simply continue to provide power to the receiver if an approved receiver is detected and continues to be present. The charger may also monitor the current into the charger coil and/or its temperature to ensure that no extra-ordinary fault conditions exist. One example of this type of fault may be if instead of a receiver, a metal object is placed on the charger.

[0066] The charger can adjust a parameter to increase or decrease the power or voltage in the receiver and then wait for the receiver to provide further information before changing a

parameter again or it can use more sophisticated Proportional Integral Derivative (PID) or other control mechanisms for closing the loop with the receiver and achieving output power control. Alternatively, as described above, the charger can provide a constant output power, and the receiver can regulate the power through a regulator or a charger IC or a combination of these to provide the required power to a device or battery.

[0067] Various manufacturers may use different coding and also bit rates and protocol. The control process used by different manufacturers may also differ, further causing interoperability problems between various chargers and receivers. A source of interoperability differences may be the size, shape, and number of turns used for the power transfer coils. Furthermore, depending on the input voltage used, the design of a wireless power system may step up or down the voltage in the receiver depending on the voltage required by a device by having appropriate number of turns in the charger and receiver coils. However, a receiver from one manufacturer may then not be able to operate on another manufacturer charger due to these differences in designs employed. It is therefore extremely beneficial to provide a system that can operate with different receivers or chargers and can be universal.

[0068] In accordance with an embodiment, to be able to detect and power / charge various receivers, the charger can be designed such that the initial Ping signal is at such a frequency range to initially be able to power and activate the receiver circuitry in any receiver during the ping process. After this initial power up of the receiver, the charger communication circuit should be able to detect and understand the communication signal from the receiver. Many microcontrollers are able to communicate in multiple formats and may have different input pins that can be configured differently to simultaneously receive the communication signal and synchronize and understand the communication at different baud rates and protocols. The charger firmware can then decide on what type of receiver is present and proceed to regulate or implement what is required (end of charge, shut-off, fault condition, etc.). Depending on the message received, then the charger can decide to change the charger driver voltage amplitude, frequency, or duty cycle or a combination of these to provide the appropriate regulated output.

[0069] In accordance with an embodiment, the charger's behavior can also take into account the difference in the coil geometry, turns ratio, etc. For example, a charger and receiver pair from one or more manufacturers may require operation of the charger drive voltage at 150 kHz. However, if the same receiver is placed on a charger from another manufacturer or driven with different coil / input voltage combination, to achieve the same output power, the charger frequency may need to be 200 kHz. The charger program may detect the type of receiver placed on it and shift the frequency appropriately to achieve a baseline output power and continue regulating from there.

[0070] As shown in Figure 10, after the receiver sends back a communication signal back to the charger, in response to it, the charger adjusts its frequency and then awaits further

information from the receiver. The receiver acknowledges the change and as shown in the second data packet in the receiver signal, has modified its state and communicates back to the charger. This closed loop continues during the charging process.

[0071] For receivers that contain an onboard regulator for the output power, the input voltage to the regulator is not as critical since the regulator performs a smoothing function and keeps the output voltage at the desired level with any load changes. It is however, important not to exceed the maximum rated input voltage of the regulator or to drop below a level required so that the output voltage could no longer be maintained at the required value. However, in general, inclusion of a regulator and/or a charger IC chip (for batteries) reduces the power / voltage regulation requirements at the expense of the additional size and cost of this component.

[0072] While the system above describes a system where the communication is primarily through the coil, as described earlier, communication may be implemented through a separate coil, RF, optical system or a combination of the above. In such circumstances, a multi-protocol system can also be used to interoperate between systems with different communication and/or control protocols or even means of communication.

[0073] Alternately, the receiver may be designed to accommodate different types of chargers. For example, once a receiver is awakened by a charger, it may try to detect the ping frequency used by the charger. This may be done by any number of phase locking or other techniques. Alternately, the receiver may send back a variety of trial communication signals during ping process to establish which type of device is performing the ping. Once the type of the charger is established, the receiver can proceed and communicate with the appropriate communication protocol and frequency with the charger.

[0074] The multi-protocol approach described above is important for development of a universal system that can operate amongst multiple systems and provide user convenience.

[0075] The description for the systems above may use discreet electronics components or some or all of the functions described above may be integrated into an Application Specific Integrated Circuit (ASIC) to achieve smaller footprint, better performance / noise, etc. and/or cost advantages. Such integration is common in the Electronics industry and can provide additional advantages here.

Magnets for use with Magnetically Sensitive Devices and Materials

[0076] Magnetically sensitive devices, materials, or components are used in a variety of applications in industrial, consumer, credit, debit, Identification, or loyalty cards, computer, MP3 players, cameras, medical, satellite, marine, mining, transport, and military applications. Examples of magnetically sensitive components or sensors include traditional or electronic compasses, Hall sensors, magnetometers, disk drives, speakers, rotational or linear encoders, pneumatic sensors, electric motor position sensors, etc. These sensors monitor and/or measure

slight amounts of magnetic field. For example, a traditional or electronic compass (consisting of magnetometer or Hall Effect sensors) responds to the small magnetic field of the earth to provide directional information to the user. Use of a magnet near such a device would alter its performance and reliability. However, there are instances where such a use would be beneficial. As an example, recently, there is interest in incorporation of electronic compasses in mobile devices such as phones, GPS, cameras, electronic tablets, and electronic compasses to provide the user a portable navigation capability. Simultaneously, these devices have often used magnets to secure the device in a holder, case, or holster or to attach the device to a surface such as a holder in a car. One example of use of magnets in mobile phones is in certain phones, such as Blackberry-type phones, where the presence of a device in its holster containing a small magnet is detected by a magnetic sensor in a phone and activates certain actions that may be selectable by the user on the phone. These actions can for example consist of turning the ringer on the phone off or switching to a vibrate mode.

[0077] In cases such as the phone described above, if a magnetic compass is implemented in the phone, the presence of a magnet in a case can interfere with the operation of the compass and/or navigation capabilities of the device. Another example is the often used magnetic discs or clasps in cases or holders for phones or cameras to close a protective cover on a mobile device, phone, computer, GPS device, etc. In these and many other cases, it is desired to have an easy method of fastening two parts together magnetically while not affecting the operation of the device or system.

[0078] **Figure 11** shows a Notebook-style portfolio case (left) and a mobile phone or camera pouch (right), where magnets are used to secure a closing clasp or flap. Magnets have also been used to secure cases or portfolios to Notebook computers or the back of their screens. These devices often incorporate components such as disk drives or magnetically sensitive components such as compasses, etc. that may be affected by use of such magnets. In addition, the existing magnetic sensors in the device (as in the blackberry phone case discussed above) may be affected by such magnets.

[0079] In addition, in many instances, it is desirable to hold or mount various devices securely by use of magnets. These can include having a convenient method for mounting of mobile phones, MP3 players, cameras, radar detectors, GPS units, compass, video screens, TVs, etc. in cars, boats, ships, trains, planes, helicopters, or other transport vehicles or work or home areas. Several commercially available mounts for such devices are shown in **Figure 12**. In these instances, a magnetic or ferromagnetic base unit is coupled with a magnetic or ferromagnetic matching thin sticker or small sheet that can be attached or inserted inside a mobile device or its battery compartment or incorporated into a skin or case for the device such that the device will be attracted to the base and be held firmly during use or for storage. One or the other or both the holder or the mount and the other part incorporated into or on a device can

be magnetic, to provide the necessary attractive force for this operation. Similarly, if the device is sensitive to magnetic fields, such a magnet can interfere with its operation.

[0080] Another area of use of magnets is in design of handbags, bags, backpacks, wallets, money clasps, etc. where magnets are used as a convenient method of closing or fastening parts to close or shut parts together. Use of magnets in such instances where the user may place a magnetically sensitive device, phone, camera, MP3 player with disk drive, GPS unit, compass, or credit cards, etc. may cause problems. In particular, erasure of data in credit cards due to use of magnets in wallets or handbags can be a concern.

[0081] More recently, magnets have been used to provide easy and safe connectivity between power or data cables and mobile devices or Notebook computers. As shown in **Figure 13** and described, for example in U.S. Patent Nos. 7,311,526 and 7,645,143 , a power plug for an electronic device or Notebook computer or deep fryer using a magnetic method for fastening and attachment of the power cable and its plug to the matching connector in the Notebook and a deep fryer. The magnet or ferromagnet material in the part of the plug surrounding the 5 connectors shown is attracted to the matching part in the Notebook and automatically aligns and connects the connectors in the 2 parts. The magnetic element on one or both of the plug and the device connector or receptacle can be a magnet to provide the necessary attractive force. The advantages of this type of connector is that in case a user accidentally trips over such a cable, it would easily pull the cable out of the Notebook computer or deep fryer without damage to either side and pulling the product off to the floor causing damage or injury. This is a considerable advantage over other types of connectors that are mated by force and insertion of one part into another and liable to break in case of such accidents or cause unnecessary damage or injury. However, similar to the situations described above, use of such types of magnets near devices that are sensitive to the magnetic field such as mobile phones with compasses or devices with magnetic sensors or hard drives near the connector is problematic and therefore similar connectors are not used in many devices that can take advantage of this technology.

[0082] Another area of use of magnets is in the area of wireless power. With the proliferation of mobile devices in recent years, the area of powering and charging these devices has attracted more attention. The vast majority of the electronic devices in use today are powered and/or charged through conduction of electricity through wires from a power supply or charger to the device. While this method has proven to be efficient for most stationary devices, recently, there has been an interest in providing wireless methods for powering or charging several mobile devices, batteries, or electronics devices. The advantages include the ability to eliminate a power / charger cord and the possibility of implementing a universal charger / power supply that is able to charge / power multiple devices one at a time or simultaneously. In addition, in many situations, eliminating the connectors for charging and/or power would improve

device and/or battery reliability. The so called "wireless power" methods can also be generally divided into conductive and inductive methods. While the conductive methods use flow of current from a charger into the mobile devices and/or battery to provide power and therefore are not strictly speaking wireless, they offer geometries where a user can place a device on a pad or similar object and receive power through matching contacts on the back of a device and the pad without 'plugging in' the device. The inductive methods utilize coils or wires near the surface of a charger to create a magnetic field in the vicinity of the surface. A coil or wire in a receiver embedded into a device or battery that is in the vicinity of the surface can sense the magnetic field. Power from the charger can be transferred to the receiver without any wired connection through air or other media in between. The inductive method has several advantages over the conductive approach, such as:

- Connectors that are a major failure point in electronics are eliminated.
- Environmentally hermetic devices can be developed that are immune to moisture or liquids.
- The receiver can be built directly on the battery so the battery can be charged through the outside shell of the device by induction. This enables changing the battery of any existing product after-market with a similar sized and shaped battery to enable inductive charging.
- With a properly designed charger pad, the charging is independent of position and does not require placement of device in any particular location or orientation.

[0083] Methods based on an array of connectors (e.g. U.S. Patent No. 6,913,477 B2) or strips of power (e.g. www.pureenergy.com) in a pad that can power mobile devices conductively have been proposed. Sakamoto (H.Sakamoto and K.Harada in PESC'93 Record, pp168-174, Spain, (1992)) has also shown the possibility of recharging a device through a transformer coil with a core where the sections of the transformer can be separated. S. Hui, et al., in Electronics Letters, 34, pp. 1052-1054, (1998) and S. Tang, et al., Electronics Letters, 36, pp 943-944 (2000), describe the use of coreless printed circuit board transformers. Fernandez, et al., in Proc. APECOZ, 2002, pp. 339-345, have described the process of optimization of PCB coils for power transfer. The use of a resonance circuit is described in U.S. Publication No. 2009/0015075 and U.S. Publication No. 2009/0033564.

[0084] As described herein, powering or charging of a mobile or electronic device or battery can be used interchangeably. Many mobile devices incorporate rechargeable batteries and require external DC power to charge these batteries for operation. However, in case of some devices such as a notebook, computer, etc., while the device is connected to DC power to charge its internal battery, the device can also be using the DC power to operate simultaneously. The ratio of power used for charging the internal rechargeable battery to operating the device

depends on the degree to which the battery is discharged, the power necessary to operate the device, and what the device is doing at any given time. In the extreme, a laptop with its battery removed can only use the DC power to operate. In this case no charging occurs and 100% of the provided DC power is used to operate the device.

[0085] In some of the applications described above, magnets can be used to provide alignment or a secure connection for an electrical contact. For example, in some implementations of the inductive charging technology, it may be desirable to provide alignment between the charger and receiver coils by aligning them through use of disk, ring, or other magnets attached to the two coils. When a receiver embedded in a device, battery, battery door, skin, or case is brought close to a charger surface, the corresponding magnets can attract and bring the coils to the necessary alignment for optimum power transfer. Several embodiments for implementing this, for example to provide higher insensitivity to placement of the receiver, better mechanical and smaller volume requirements, minimal impact on power transfer, etc., are described in U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein.

[0086] **Figure 14** shows an Inductive wireless charger and/or power supply with multiple charging stations in accordance with an embodiment. The inductive receiver can be incorporated into a mobile device, its battery door, case or skin, a battery, etc. To align the coil in the charger and the coil in the receiver, magnets that attract the coils into alignment can be incorporated or on around the coils. Many types of magnets such as round discs, square, ring, oval, rectangular, arc, etc. can be used for alignment of coils. In Figure 14, round disc (top) and ring (bottom) magnets are used for this alignment. One or many magnets can be used. Several different placements and shapes for magnets are shown in **Figure 15** by way of example. For example, a single disc or square, or other shaped magnet at the center of each coil can be used. In other implementations, 4 disc or square magnets placed in the corners of a square pattern can be used or other patterns. The patterns shown herein are shown by way of example. In accordance with other embodiments, other numbers and/or shapes of magnets or magnetization direction or strength can be used to achieve the desired alignment. It is possible to incorporate

magnets with attracting magnetic orientation in the two parts to be aligned or alternatively, only one or one set of magnets and a ferromagnetic or magnetically attractable material used in the other part to achieve similar alignment results.

[0087] The advantage of use of a single disc magnet in the center of a charger and one in the center of a receiver is that the receiver can rotate with respect to the charger and still maintain optimum alignment. With 4 magnets placed as shown in Figure 15, the coils can be rotated 90, 180, or 270 degrees with respect to each other and still maintain alignment. Other shapes or number of magnets can be used and patterns in Figure15 are shown only as a way of example. The magnets can be magnetized with the magnet direction perpendicular to the face of the disk or magnet and by using magnet poles in the charger and receiver such that the pole is In the same direction in both, for example as south pole out of the page. When the two devices are close to each other, the magnets attract and align the coils. U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein, each of which applications are hereby incorporated by reference herein, previously described improvements on the design of alignment magnets. For example, in Figure 15 or Figure 16, disc, square, rectangular, or ring magnets are used in the charger and the receiver with the magnets magnetized in the direction perpendicular to the flat surface. A gap in the ring magnet is incorporated to reduce potential eddy currents due to changing magnetic field of the wireless charger / power supply. Ring magnets have better performance for these applications due to the larger diameter of the magnet that can be used in this case (thereby providing a larger alignment target for the user), the ability to rotate one coil with respect to the other one at any angle and maintain alignment, and the ability to reduce or eliminate any potential eddy currents through a cut in the ring as described above. In accordance with other embodiments, other shapes or combinations of shapes, such as square, rectangle, circle, oval, or triangle, etc. rins or other narrow wall, or others or combination of the above can be used depending on the particular needs of the intended application.

[0088] In some situations, the charger / and or power supply is incorporated into a mobile device or part that includes a magnetically sensitive portion. For example, the charger can be

incorporated into a notebook or laptop or computer with a disk drive, compass, or other magnetically sensitive parts. In these instances, incorporation of the magnet or magnets in the charger as well as the receiver can pose problems for the device incorporating the charger as well as for the device or part incorporating the receiver.

[0089] In accordance with various embodiments, the coils described here can be manufactured with wires, Litz wire, Printed circuit board (PCB), stamped, formed, shaped, etc. metal or magnetic material. The spiral patterns shown here are for example only and the coils can be any shape or size or pattern that could generate a magnetic field.

[0090] Similarly, the alignment can be achieved between a magnet or magnets incorporated into or around one of the coils and a part constructed of ferromagnetic or other magnetic material that can be attracted to the magnet for alignment. The magnet or the magnetically attracted part can be made from Nickel, Iron, Cobalt, gadolinium and dysprosium, steel, etc. or an alloy of these materials or ceramic, Alnico, Ticonal, Rare Earth magnets, flexible or injection molded or nano-crystalline magnets so that the magnets on the receiver attract and attach to the magnetic or ferromagnetic material on the other part. Examples of metal or magnetic material or ferromagnetic material that could form the opposite side are Nickel, Steel, cobalt, gadolinium and dysprosium, steel, etc. or an alloy of these material or ceramic, Alnico, Ticonal, Rare Earth magnetic material, flexible or injection molded or nano-crystalline materials or any other material that can be attracted to a magnet or an alloy containing such. Of course, either the receiver or charger can incorporate a magnet and the other part a material that is attracted to a magnet or vice versa or both can contain magnets with poles arranged such that they attract each other for alignment. The type of materials discussed above or combination thereof can be used in any of these cases. The magnets can be permanent magnets or electromagnets activated by application of an electrical current.

[0091] Similarly, in conductive types of wireless or wire free charging or power, the connectors on a receiver in or on a device or skin, etc. are often magnetized to attract strips of metal or additional magnets on a pad to make a strong connection. For example, some companies produce a conductive type of so called “wireless” or “wire-free” charger. In some instances, connectors on the back of a mobile device incorporated into the device, its skin, or battery door, or an additional part attached to the back of the device contain a number of metallic contacts which make contact with metal strips on a pad. The metal strips are connected to a power supply rail with an applied voltage and upon contact with the receiver connectors and verification of the receiver, provide necessary voltage and/or current to the receiver. To enable a strong connection between the receiver and the pad metal strips or to enable the receiver and the device it is attached or incorporated in, to be placed at an angle or vertically, etc., the metal strips are made of a magnetic or ferromagnetic material such as Nickel, Iron, Cobalt, gadolinium and dysprosium, steel, etc. or an alloy so that the magnets on the receiver contact attract and

attach to the strips. Enabling such an attractive contact is especially important when it is desired that the device not move during the charging process such as when the charger pad is used or incorporated into a car, airplane, ship, boat, etc. where motion is present. However, in instances where the mobile device contains a compass such as an electronic compass in certain phones, use of magnets in the receiver connectors interferes with such an operation. Therefore the manufacturer has generally not incorporated magnetic connectors for such instances, which eliminates the benefits of the magnetic attachment.

[0092] In these and many other applications, it may be desirable to benefit from the seemingly contradictory use of magnets for their advantages in providing an attractive force for fastening, mounting, holding, or alignment, while at the same time it is desired to minimize or eliminate any effect on magnetically sensitive components in the charger or receiver or devices or parts nearby. This contradiction can be resolved by realizing that it is possible to create magnets with a net magnetic field that is zero or small in areas near or far from the magnet and at the same time that the part retains its magnetic or attractive properties at close distances and can provide attractive forces.

[0093] To achieve small overall net magnetic field, it is important to realize that the magnetic field is a vector and fields from several magnets or parts or poles of the same magnet add to provide the total sum of the field at any location in space.

[0094] Many magnets such as Rare Earth magnets are made using a sintering process whereby the basic material components such as Iron, Nickel, Cobalt, and/or Rare Earth material are refined and then combined in the desired composition and melted in a furnace to produce starting ingots for a magnet. The ingots are then ground and the resulting particles are placed in a jig or mold with the desired shape and dimensions and pressed into shape while an external magnetic field is applied to orient the particles. By applying the appropriate magnetic field in the desired direction, in plane, out of plane, radial, or multi-pole poling of the magnet can be achieved. For example, multi-pole magnets are created by pulse magnetization. To create a linear period multi-pole magnet, a magnetizing fixture with a back and forth copper wire arrangement is used. Application of a short current pulse from a capacitor through the fixture produces a magnetic field strong enough to magnetize material in the vicinity of the wire pattern. By controlling the shape and size of the induced magnetic field various magnet types can be created. The resulting part is then treated in a sintering furnace to compact the material before further testing of the parameters and coating of the final magnet to avoid corrosion. As an example, multi-pole magnets with periodicity of 1-2 mm in substrates of 2 mm thick or less have been studied for micro-actuator applications (J.Topfer, and V. Christoph, "Multi-pole Magnetization of NdFeB Sintered Magnets and Thick Films for Magnetic Micro-Actuators", Sensors and Actuators, A 113 (2004) 257-263 AND J. Töpfer, B. Pawlowski, H. Beer, K. Plötner, P. Hofmann, M. Herfurth, "Multi-pole magnetization of NdFeB magnets for magnetic

micro-actuators and its characterization with a magnetic field mapping device, J. Magn. Magn. Mater. 270 (2004) 124–129).

[0095] Töpfer, et al. manufactured NdFeB square magnets of 50 x 50 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part and characterized it. **Figure 16** shows Measured z-component (along the axial direction of magnetization) of the magnetic flux density of this magnet measured by moving a Hall Sensor along the middle of one edge of the square to the opposite edge of the square 250 micrometers above the surface of the magnet as shown in the inset. The results show that in such a magnet, the field peaks at the edges and in the center, a strong demagnetization field exists that almost reduces the magnetic flux to zero at this center, thereby not providing much attractive or retention force for such thin magnets.

[0096] In **Figure 17**, the same researchers compare the performance of a 50 x 50 x 1 mm^3 magnet with one of 10 x 10 x 1 mm^3 dimension magnetized axially perpendicular to the square surface of the part. The smaller magnet retains its magnetic flux to a greater degree at its center and has higher peaks at the edges. Also note that the peak of the magnetic flux is higher for this magnet.

[0097] To further retain high flux density in a magnet, the same shape part can be periodically poled in a multi-pole pattern as shown in **Figure 18**. Here, the 10 x 10 x 1 mm^3 magnet is magnetized periodically with a periodicity of 2 mm as shown on the top Figure 18. The bottom figure shows the measured magnetic flux density. It can be seen that flux density follows the poling pattern but in addition, comparing the magnitude of the flux density, it can be seen that the peak values are about twice the peak value of the flux density in a uniformly magnetized magnet. In addition, the magnetic flux does not show any sign of demagnetization and reduction of the peak values at the center of the magnet that is seen in Figures 16 and 17. Overall, multi-pole magnetization can provide a method for achieving higher and more uniform magnetic flux in a magnet. These characteristics are desirable for applications described here where retention and alignment of parts are required.

[0098] An important aspect of the performance of the multi-pole magnets described here is the performance of these magnets away from the surface of the magnets. **Figure 19** shows the drop off of maximum flux density value for a 10 x 10 x 1 mm^3 magnet magnetized periodically with a periodicity of 1 and 2 mm as shown on the top as a function of distance between the probe and the top of the magnet. It can be seen that the flux density drops off very quickly and reaches small values for over 1 mm. This is a result of the geometry shown on the top of the figure. With multiple poles present, as the distance between the probe and the magnet increases, the probe measures the sum of the flux density from the multiple poles present and this value approaches zero quickly away from the surface. At the same time, near the surface, the flux density is larger for the multi-pole magnet as compared to a single pole magnet, and increases as the pole periodicity increases (up to a limit given the physical dimensions of the

magnet, its thickness, etc.). It is important to recall that the peak for a uniformly magnetized magnet of same dimension was only around 0.13 T (< 1/3 of the 1 mm periodically poled similarly sized magnet value) as shown in Figures 18 and 19. At the same time, as discussed above, the uniformly magnetized magnet also showed a very significant reduction of the flux density at its center which is not present for the multi-pole magnet.

[0099] In summary, the results above demonstrate that properly designed multi-pole magnets can provide significantly higher and more uniform flux density near their surface while at the same time providing much lower flux densities away from the surface.

[00100] These characteristics can be used to provide the combination of characteristics that are useful for mounting, holding, attachment, and alignment purposes for the applications discussed earlier. By using multi-pole magnets higher retention and alignment force can be provided, while reducing the effect of any stray fields on nearby magnetically sensitive components, parts, or materials.

[00101] **Figure 20** shows several magnet types that are magnetized perpendicular to the magnet surface (axially), in accordance with various embodiments. For example, **Figure 20** shows (a) rectangular magnet magnetized in a checkerboard pattern, (b) square magnet magnetized in a checkerboard pattern, (c) rectangular magnet magnetized in a single direction multi-pole pattern, (d) square magnet magnetized in a single direction multi-pole pattern, (e) disc magnet magnetized into 4 sections, (f) disc magnet magnetized into 8 sections, (g) ring magnet magnetized into 8 sections, and (h) disc magnet magnetized into concentric circular sections. These patterns are shown by way of illustration and it is obvious that many types of magnets and shapes can be devised for various applications with regular or irregular shapes that have multi-pole magnetic patterns.

[00102] For applications in securing or mounting of parts to another part, a multi-pole magnet similar to magnets in **Figure 20** or another appropriate shape and size and number of poles can be devised for the device to be mounted or the mount and combined with a matching magnet or ferromagnet or other magnetically attractable material on the opposite part (device or mount) to provide attraction between the two parts. Since each magnet includes a number of poles, this approach allows both for central alignment between the two parts (i.e. their respective magnets or magnetically attractable material are centered with respect to one another); and stepped or rotational alignment between the two parts (i.e. their respective magnets or magnetically attractable material can be center-aligned with respect to one another, and then rotated around those centers in steps corresponding to the number of poles, wherein at each step the full magnetic attraction is provided). This allows for novel uses of such magnets, for example to allow parts to be attached to one another in a variety or particular number of relative orientations.

[00103] In accordance with an embodiment, in applications such as shown in Figure 11-15, the appropriately designed magnet can be used instead of the uniformly magnetized magnets of

earlier design, to provide stronger or similar attractive force while producing minimal or zero magnetic field away from the magnet not to disturb other magnetically sensitive parts or devices.

[00104] As an example, in accordance with various embodiments, ring or arc multi-pole magnets such as those shown in **Figure 21** can be used with the coil to provide alignment. It will be evident that improvements such as cuts or discontinuities, etc. for reduction of eddy currents can be implemented as in singly poled magnets described for example in U.S. Patent Applications "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", Application No. 11/669,113, filed January 30, 2007 (subsequently published as U.S. Publication No. 20070182367, and issued as U.S. Patent No. 7,952,322); "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", Application No. 11/757,067, filed June 1, 2007 (subsequently published as U.S. Publication No. 20070279002, and issued as U.S. Patent No. 7,948,208); "SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES", Application No. 12/116,876, filed May 7, 2008 (subsequently published as U.S. Publication No. 20090096413); and "SYSTEM AND METHODS FOR INDUCTIVE CHARGING, AND IMPROVEMENTS AND USES THEREOF"; Application No. 12/769,586, filed April 28, 2010 (subsequently published as U.S. Publication No. 20110050164), each of which applications are hereby incorporated by reference herein. For example, the ring magnet in **Figure 22** shows an implementation of such a discontinuity at the bottom of the figure.

[00105] While most of the description below is based on the inductive method of power transfer, the embodiments described here can be implemented with either the inductive method or the conductive method or the magnetic resonance method, optical, or other methods for power transfer some of which have been described above. Inductive methods of power transfer are described above as an example of the more general wireless power transfer.

[00106] Furthermore, the type of magnets discussed above may be used with magnetic shielding material commonly in use for reduction of AC or DC magnetic field such as mumetal, etc. available from Magnetic Shield Corporation or material such as thin flexible sheets available from Maruwa or nano materials such as Finemet from Hitachi Corp or ferromagnetic or alloys of ferromagnetic materials such as iron, nickel and cobalt. For example in the case of the inductive charger or receiver described above, the area behind a coil can be covered by a magnetic shield material and a square, rectangle, ring or arc of multi-pole magnet can be attached around and/or on such a shield and be used for attraction and alignment of the charger and receiver coil to each other. Figure 22 shows such an arrangement where multi-pole magnets (multi-pole ring (left) and arc (right) magnet on or around an inductive coil) and magnetic shielding material are used behind a coil. Here, the magnetic shield layer or material shields behind the coil provides shielding from the alternating magnetic field of the coil. An optional cut / discontinuity in the ring (shown at the bottom of the ring magnet on the left) prevents or reduces eddy currents during operation of the inductive coil.

[00107] In addition, heat transfer layers can be incorporated to spread the heat generated. Such layers need to be designed not to interfere with the operation of the coils. Since alternating magnetic fields are generated and detected in an inductive system, use of a metal layer behind the coil would produce eddy currents and loss. One method for providing thermal conductivity with metal layers is where a metal layer with discontinuous portions is placed behind and/or around the coil. In this case, the metal layer can comprise rectangular slices that can conduct heat away from the center of a coil while, due to discontinuity between the slices, the electrons can not flow in a circular motion due to the alternating magnetic field. The pattern described here has a number of triangular slices but any other pattern which can provide heat transport but does not allow carriers to circulate in a rotational pattern due to the alternating magnetic field can be implemented.

[00108] Alternatively, multi-pole magnets can be manufactured by way of taking a single poled magnet, cutting it into appropriate sections, and reassembling the pieces and attaching them together with an adhesive, glue, or other bonding agent or other material; or alternatively a holder, etc. or clamp or screws or external force or other methods, so that the multi-pole geometry is achieved. For example, a single poled axially poled (out of plane of ring) ring can be cut into 4, 8, 16, or another number of even or odd sections, and half of the sections turned over and reassembled to provide a multi-pole magnet. To aid in assembly of such a magnet, it may be necessary to attach or place the parts on to another solid continuous piece. This piece may be magnetic, ferromagnetic, or non-magnetic itself. For example, in the ring magnet example above, the pieces of the ring magnet can be attached and reassembled in a multi-pole geometry on a stainless steel, iron, Nickel, plastic, or copper, etc. ring to aid in assembly and to hold the sections together. The properties of the backing material, its thickness, etc. can also be optimized to provide necessary performance. For example, use of a ferromagnetic material as backing can further provide a path for the magnetic flux in that section and provide further tighter coupling between sections and reduction of magnetic field away from the ring. It may also be desirable to sandwich the magnet on both sides with similar or dissimilar backing material or layers, or use multiple backing layers to further engineer symmetric or asymmetric properties on the two sides of the multi-pole magnet.

[00109] **Figure 23** shows a multi-pole ring magnet with radially magnetized sections. In use of the magnet for inductive charging applications, a cut or break in the circle or arc magnets as described earlier can be used.

[00110] While in the above description, emphasis has been given to affixing electronic parts, batteries, electric parts, etc to other parts or components or cases, holders, etc., the processes, systems, and methods described above can be similarly used to permanently or temporarily fix, attach, align, or establish relation between any two or more parts of the same or different items, products, areas, etc., including those not directly related to electronics. Examples include in

lighting, furniture, automotive, mechanical instruments or machines, electronics, electrical systems and components, batteries, cases, purses, clothing, footwear, or any other number of applications. Other examples can be developed in accordance with other applications.

[00111] Some aspects of the present invention can be conveniently implemented using a conventional general purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as will be apparent to those skilled in the art.

[00112] In some embodiments, the present invention includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of the present invention. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, DVD, CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00113] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

Claims:

What is claimed is:

1. A system for providing universal or improved compatibility and transfer of wireless power to mobile devices and batteries, comprising:

a charger including a charger coil and one or more half-bridge drivers and/or microcontroller units or other current and/or voltage controlling components, wherein the charger includes a circuit or other components that measures the current through and/or voltage across the charger coil, and wherein the microcontroller unit receives a communication signal from a detection/demodulation circuit and makes appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output, for using in powering or charging a mobile device and/or battery.

2. The system of claim 1, wherein the charger is used with a mobile device having a receiver that is coupled to a receiver coil and a receiver circuit and that includes a capacitor in parallel or series with the receiver coil to produce a tuned receiver circuit.

3. The system of claim 1, wherein the receiver further includes a microcontroller that is used to measure various values such as output voltage, current, temperature, state of charge, battery full status, end of charge, etc. and to report those values back to the charger to provide a closed loop system with the charger.

4. The system of claim 1, wherein communication between the charger and receiver is provided through the power transfer coil or an antenna, or through a separate coil, a radio frequency link , an optical communication system or a combination of these, and wherein the communication in any of these methods can be bi-directional and/or uni-directional.

5. The system of claim 1, wherein the charger and receiver communicate to provide optimal charging information, including the charger periodically activates the charger coil with a drive signal of appropriate frequency, during which ping process, if a receiver coil is placed on top or close to the charger coil, power is received through the receiver coil and the receiver circuit is energized, and wherein the receiver microcontroller is activated by the received power and performs an initiation process whereby the receiver ID, its presence, power or voltage requirements, receiver or battery temperature or state of charge or other information is sent back to the charger.

6. A method for providing universal or improved compatibility and transfer of wireless power to mobile devices and batteries, comprising the steps of:

providing a charger including a charger coil and one or more half-bridge drivers and/or microcontroller units or other current and/or voltage controlling components, wherein the charger includes a circuit or other components that measures the current through and/or voltage across the charger coil, and wherein the microcontroller unit receives a communication signal from a detection/demodulation circuit and makes appropriate adjustments to the charger coil drive circuitry to achieve the desired output voltage, current or power from the receiver output, for using in powering or charging a mobile device and/or battery.

7. A system for attachment or fastening of one or more device, component, or part thereof to another device, component, or part thereof, using a multi-pole magnet comprising:

a first magnet attached to or included within a first one of the device, component, or part thereof, wherein the first magnet includes more than one magnetic pole; and

a second magnet or a magnetic or ferromagnetic material attached to or included within or on second of the device, component, or part thereof, which is magnetically attracted to the first magnet to provide a measure of alignment, attachment or fastening of the first and second devices, components, or parts.

8. The system of claim 7, wherein the multi-pole magnet has an appropriate shape, size and number of poles, which can be mounted within or upon the electronic device and/or battery, and used with a matching magnet or a ferromagnetic material in a base unit, surface, part, cradle, holder or other device, to provide attraction and/or alignment between the electronic device and/or battery and other device.

9. The system of claim 7, wherein the multi-pole magnet is a square or rectangular magnet magnetized in a linear or checkerboard pattern.

10. The system of claim 7, wherein the multi-pole magnet is a square or rectangular magnet magnetized in a single direction multi-pole pattern.

11. The system of claim 7, wherein the multi-pole magnet is a disc, ring, oval, or similarly shaped magnet magnetized into a plurality of sections.

12. The system of claim 7, wherein the multi-pole magnet is a disc magnet magnetized into a plurality of concentric circular or alternating sections around its center

13. The system of claim 7, wherein the multi-pole allows both for central alignment between the two parts, so that their respective magnets or magnetically attractable material are centered with respect to one another, and also stepped or rotational alignment between the two parts, so that their respective magnets or magnetically attractable material can be center-aligned with respect to one another and then rotated around those centers in steps corresponding to the number of poles, wherein at each step the full magnetic attraction is provided.

14. The system of claim 7, including a backing material which can be optimized to provide necessary performance or to alter the path for the magnetic flux in various sections

15. A method for the use of magnets in electronic devices and/or battery, and in particular to devices or parts having proximity to magnetic sensors, comprising the steps of:

providing a first magnet attached to or included within a first one of the device, component, or part thereof, wherein the first magnet includes more than one magnetic pole, and a second magnet or a magnetic or ferromagnetic material attached to or included within or on second of the device, component, or part thereof, which is magnetically attracted to the first magnet to provide a measure of alignment, attachment or fastening of the first and second devices, components, or parts.

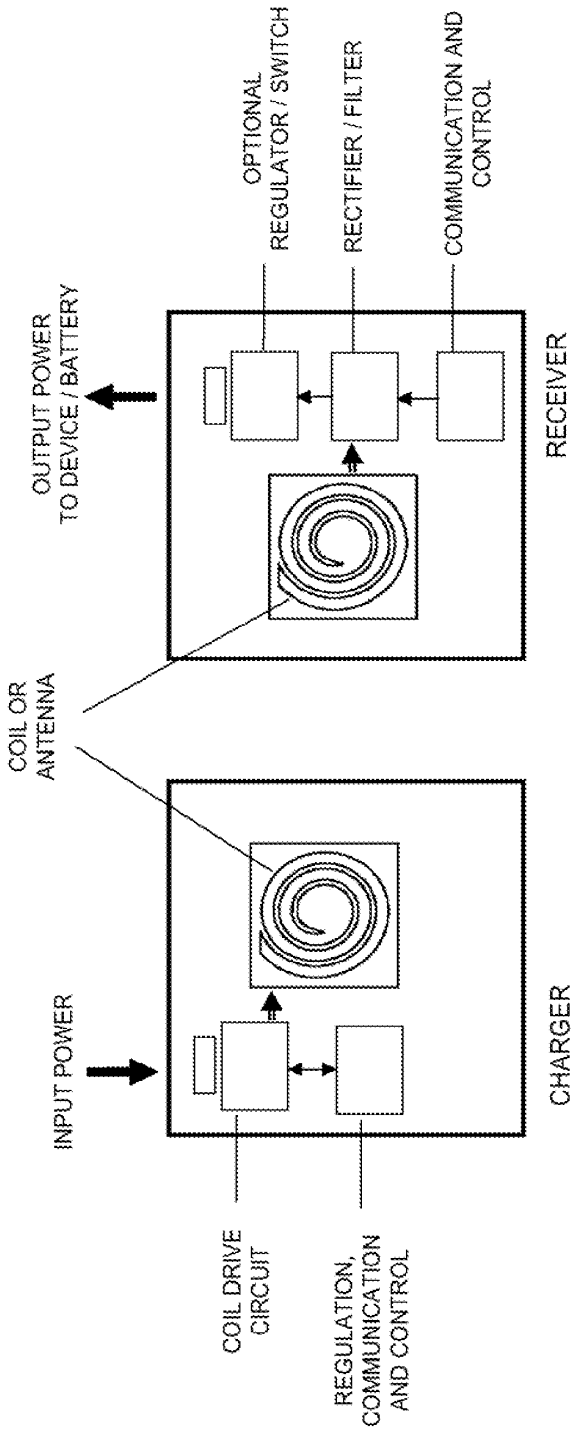

OPTIONAL REGULATOR / SWITCH
RECTIFIER / FILTER
COMMUNICATION AND CONTROL
OUTPUT POWER TO DEVICE / BATTERY
RECEIVER
COIL OR ANTENNA
INPUT POWER
CHARGER
COIL DRIVE CIRCUIT
REGULATION, COMMUNICATION AND CONTROL

FIGURE 1

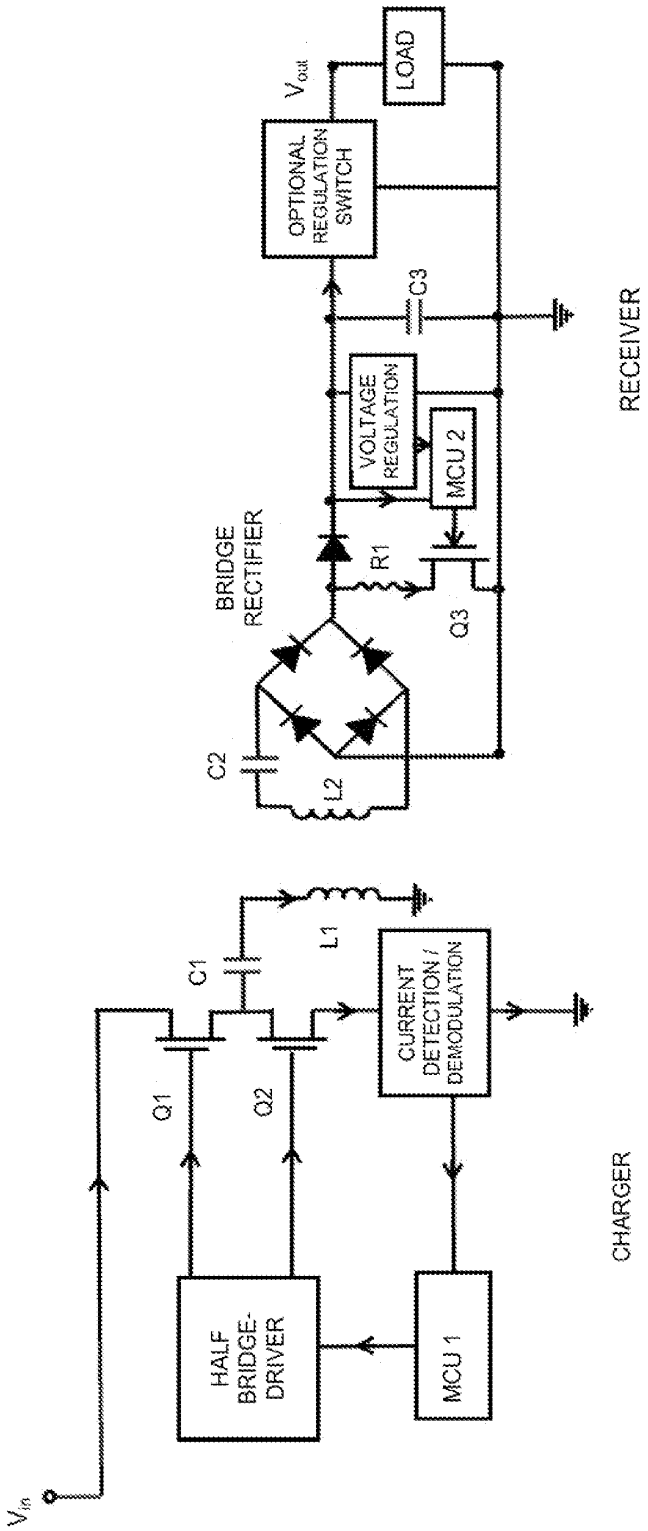

LOAD
V_{out}
OPTIONAL REGULATION SWITCH
C3
RECEIVER
VOLTAGE REGULATION
MCU 2
BRIDGE RECTIFIER
R1
Q3
C2
L2
L1
C1
CURRENT DETECTION / DEMODULATION
Q1
Q2
CHARGER
HALF BRIDGE-DRIVER
MCU 1
V_{in}

FIGURE 2

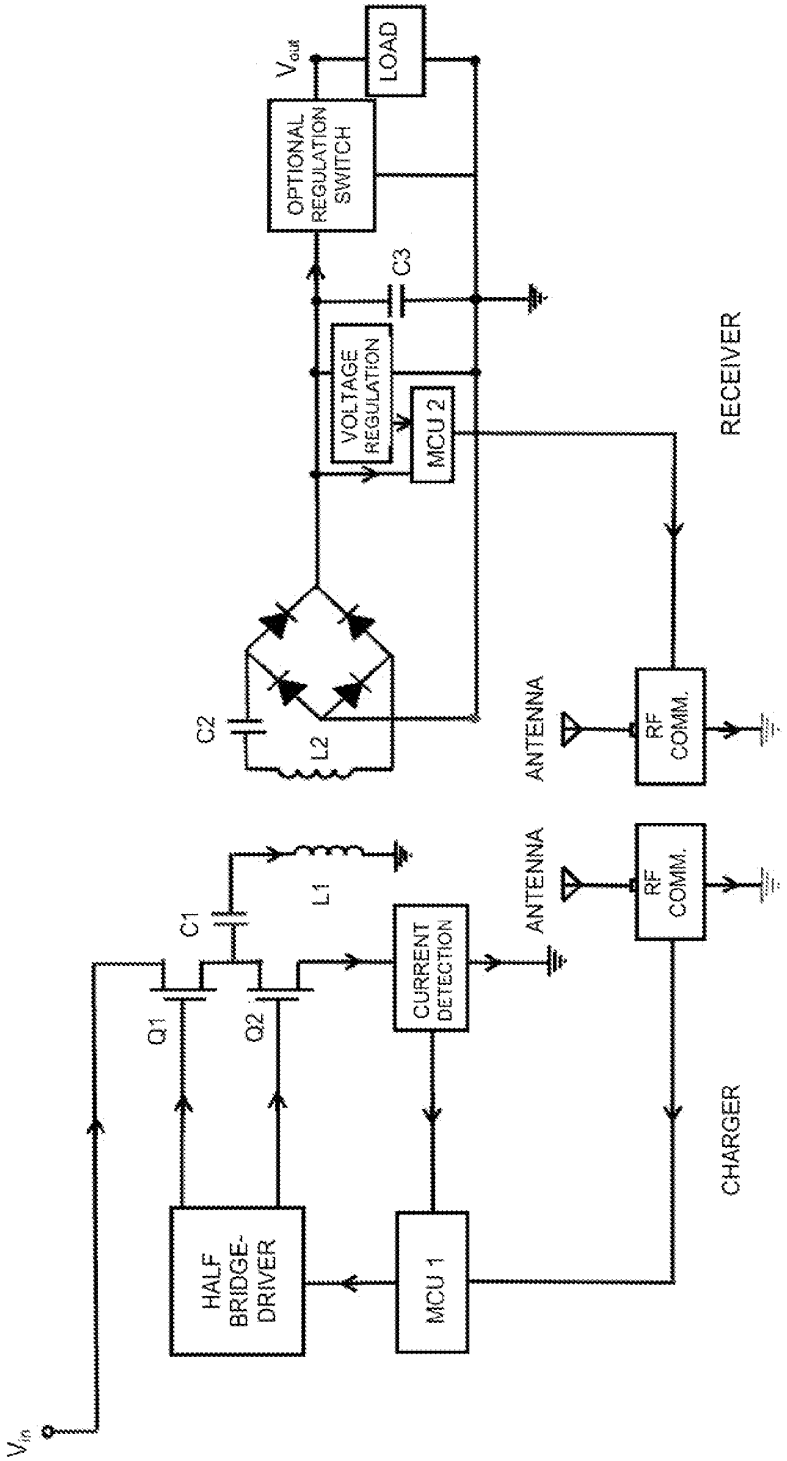

LOAD
V_{out}
OPTIONAL REGULATION SWITCH
C3
VOLTAGE REGULATION
MCU 2
RECEIVER
C2
L2
ANTENNA
RF COMM.
ANTENNA
RF COMM.
L1
C1
CURRENT DETECTION
Q1
Q2
HALF BRIDGE-DRIVER
MCU 1
CHARGER
V_{in}

FIGURE 3

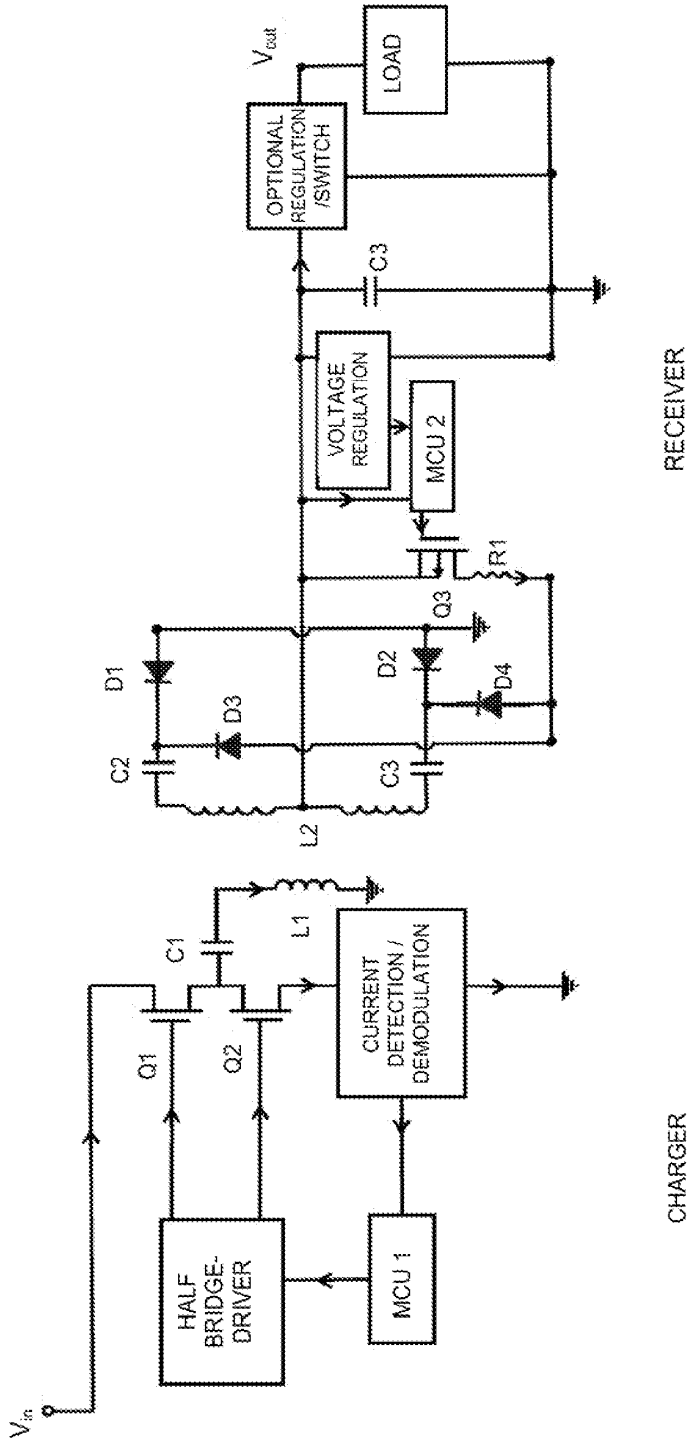

V_{out}
LOAD
OPTIONAL REGULATION /SWITCH
C3
VOLTAGE REGULATION
MCU 2
RECEIVER
R1
Q3
D1
D2
D4
D3
C2
C3
L2
C1
L1
CURRENT DETECTION / DEMODULATION
Q1
Q2
HALF BRIDGE-DRIVER
MCU 1
CHARGER
V_{in}

FIGURE 4

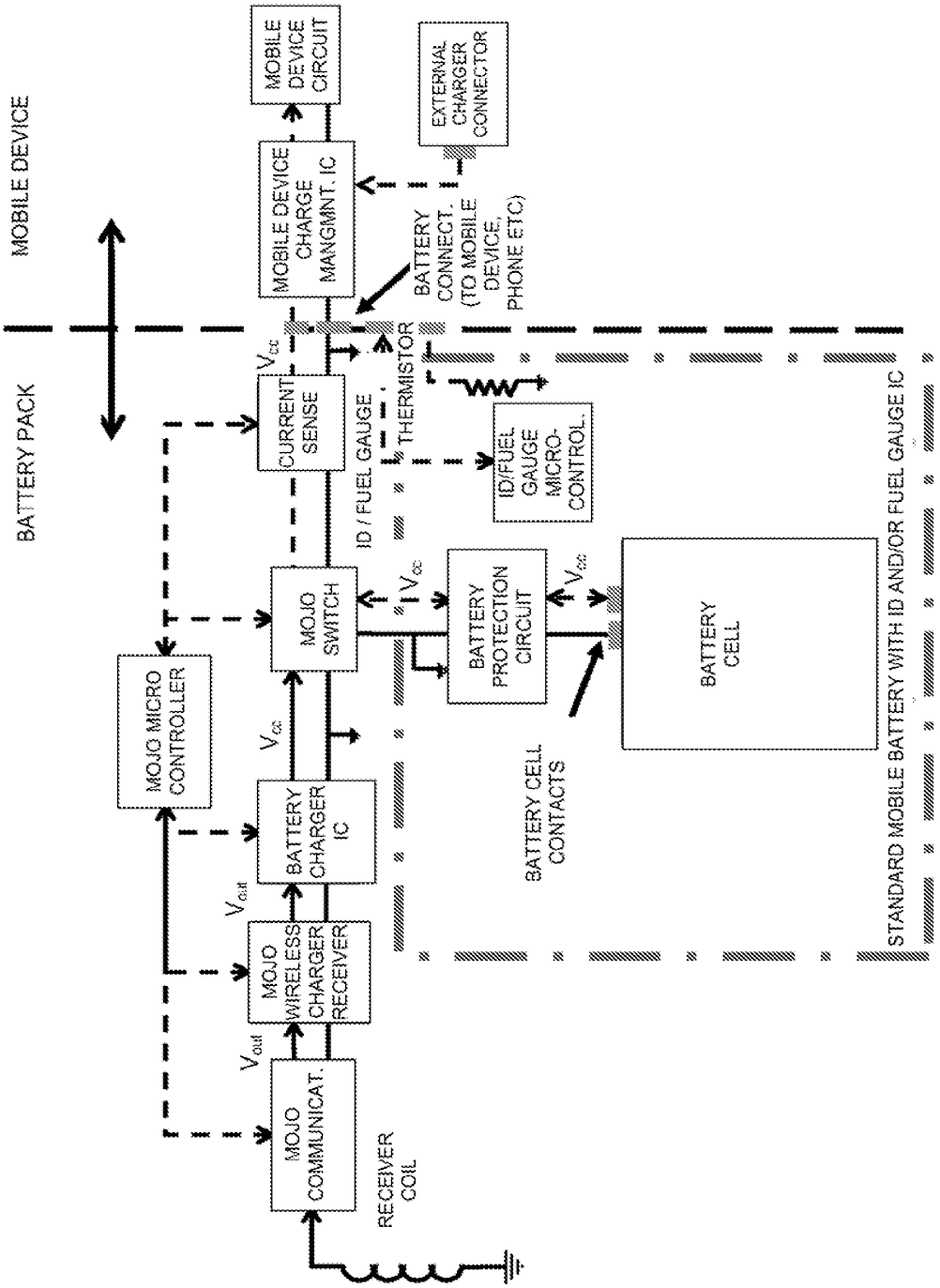

MOBILE DEVICE
BATTERY PACK
MOBILE DEVICE CIRCUIT
EXTERNAL CHARGER CONNECTOR
MOBILE DEVICE CHARGE MANGMNT. IC
BATTERY CONNECT. (TO MOBILE DEVICE, PHONE ETC)
THERMISTOR
ID / FUEL GAUGE
CURRENT SENSE
ID/FUEL GAUGE MICRO-CONTROL.
MOJO SWITCH
BATTERY PROTECTION CIRCUIT
BATTERY CELL
MOJO MICRO CONTROLLER
BATTERY CHARGER IC
MOJO WIRELESS CHARGER RECEIVER
MOJO COMMUNICAT.
RECEIVER COIL
BATTERY CELL CONTACTS
STANDARD MOBILE BATTERY WITH ID AND/OR FUEL GAUGE IC

FIGURE 6

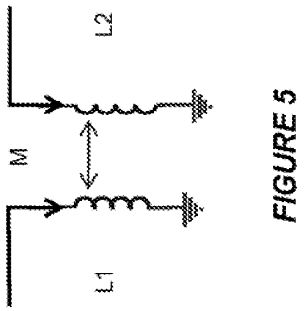


FIGURE 5

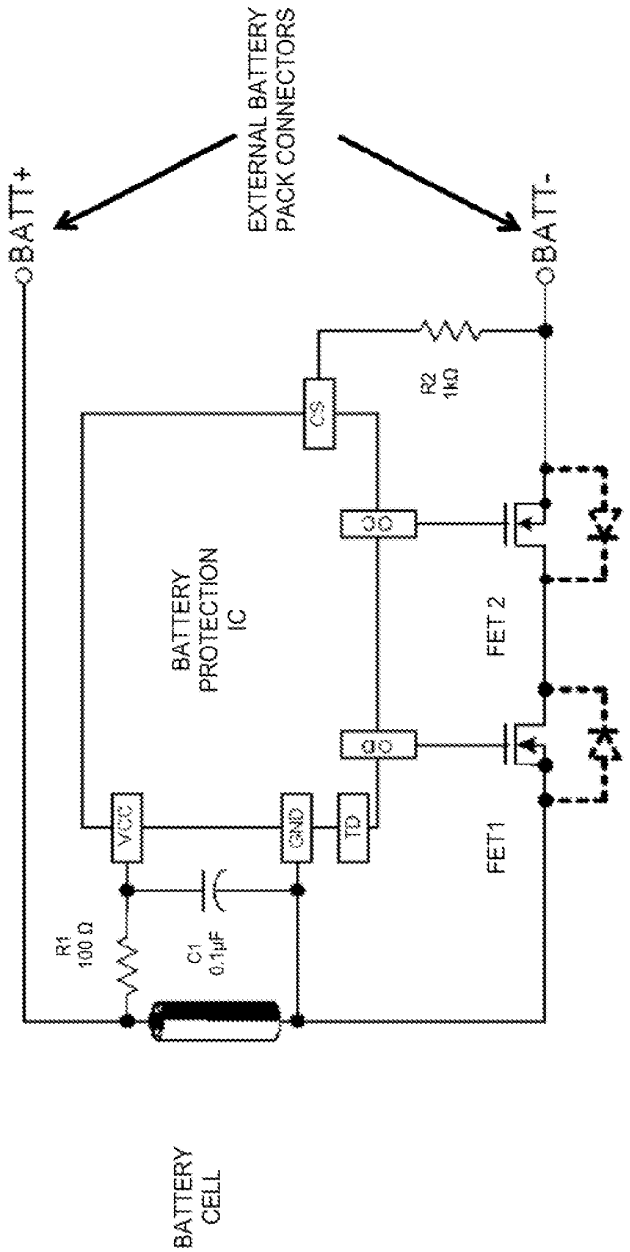


FIGURE 7

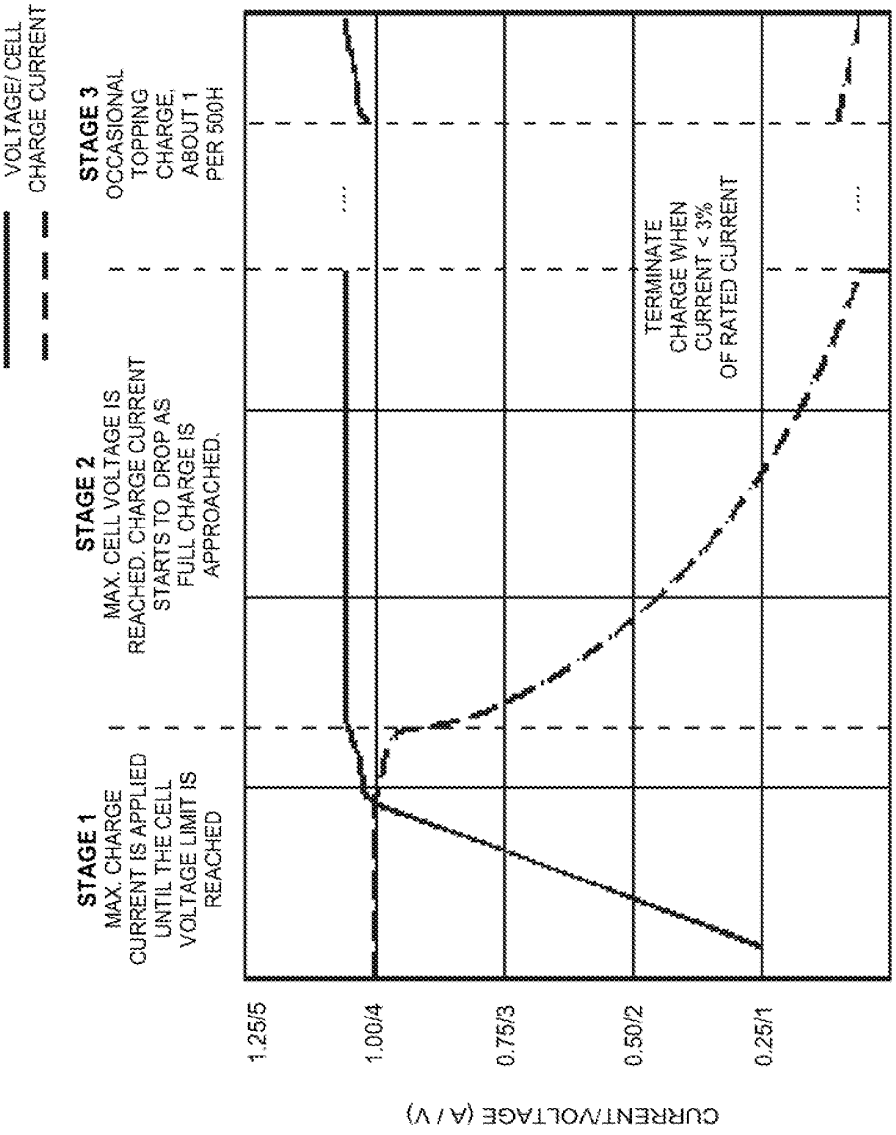

VOLTAGE/ CELL
CHARGE CURRENT
STAGE 1
MAX. CHARGE CURRENT IS APPLIED UNTIL THE CELL VOLTAGE LIMIT IS REACHED
STAGE 2
MAX. CELL VOLTAGE IS REACHED. CHARGE CURRENT STARTS TO DROP AS FULL CHARGE IS APPROACHED.
STAGE 3
OCCASIONAL TOPPING CHARGE, ABOUT 1 PER 500H
TERMINATE CHARGE WHEN CURRENT < 3% OF RATED CURRENT
1.25/5
1.00/4
0.75/3
0.50/2
0.25/1
CURRENT/VOLTAGE (A / V)
1
2
3
TIME (HRS)

FIGURE 8

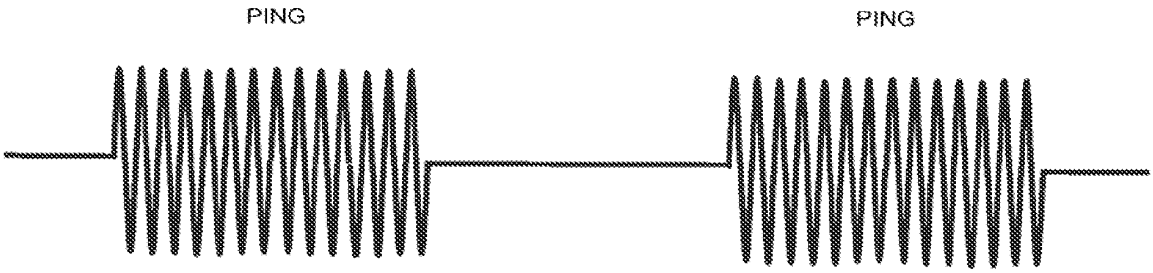


FIGURE 9

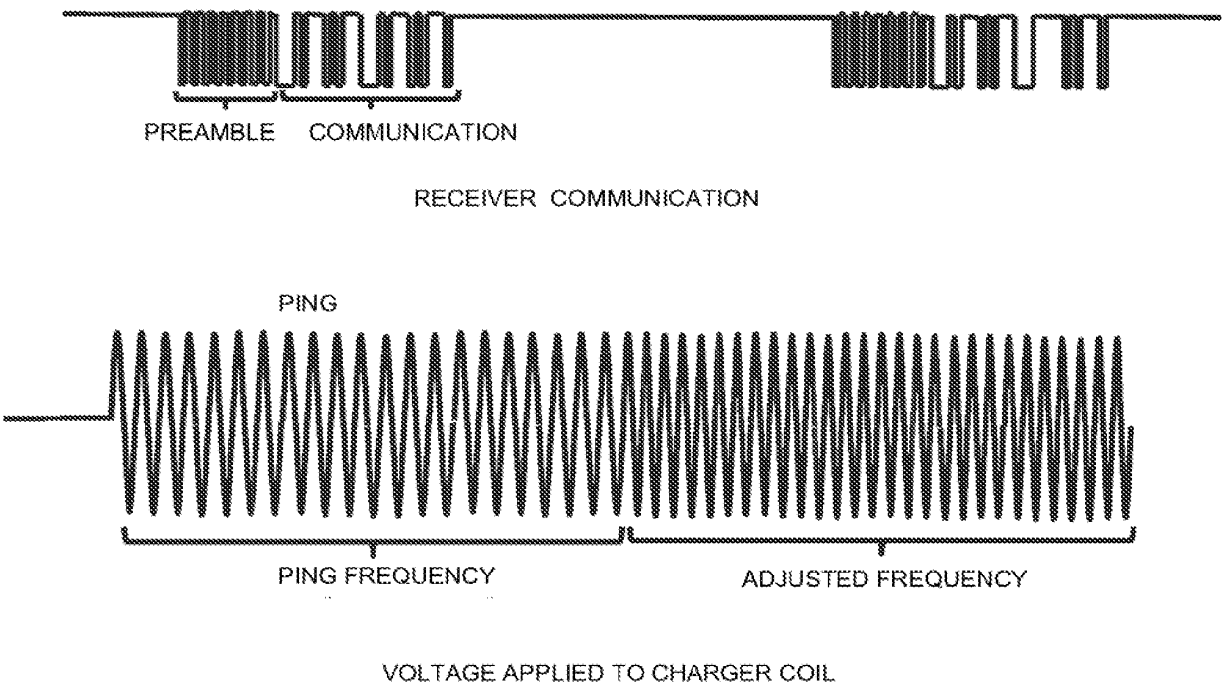


FIGURE 10

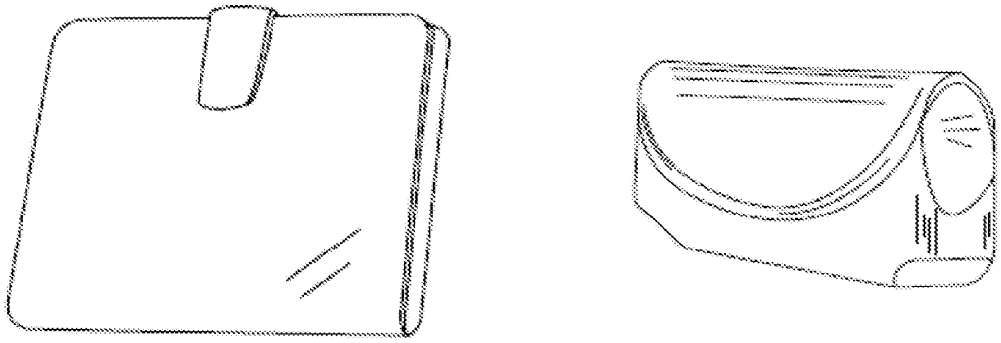


FIGURE 11

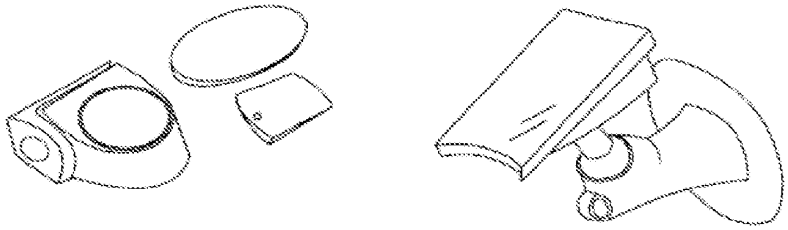
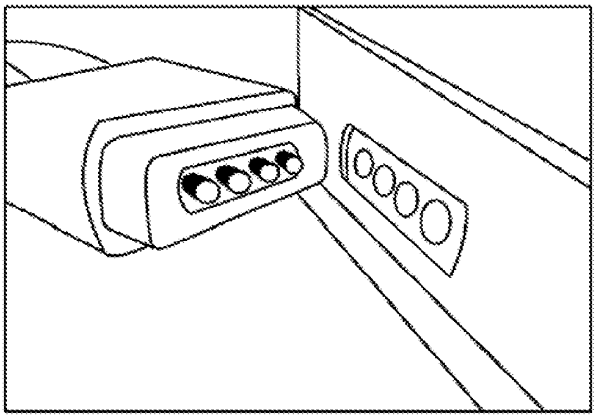


FIGURE 12



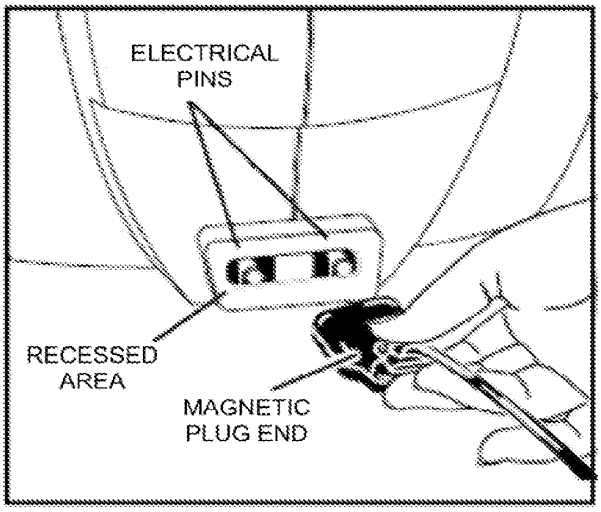
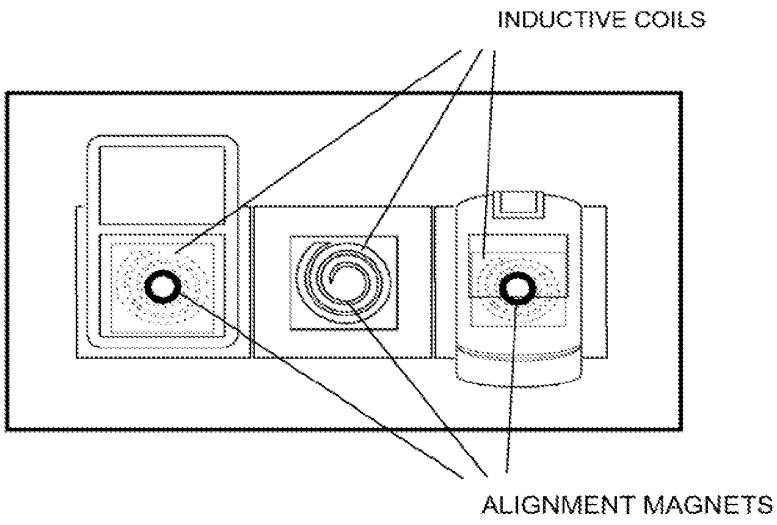


FIGURE 13


INDUCTIVE COILS
ALIGNMENT MAGNETS

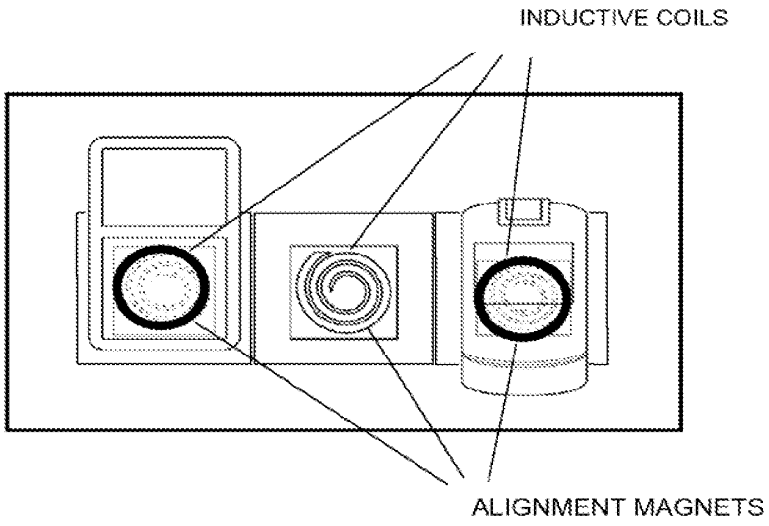

INDUCTIVE COILS
ALIGNMENT MAGNETS

FIGURE 14

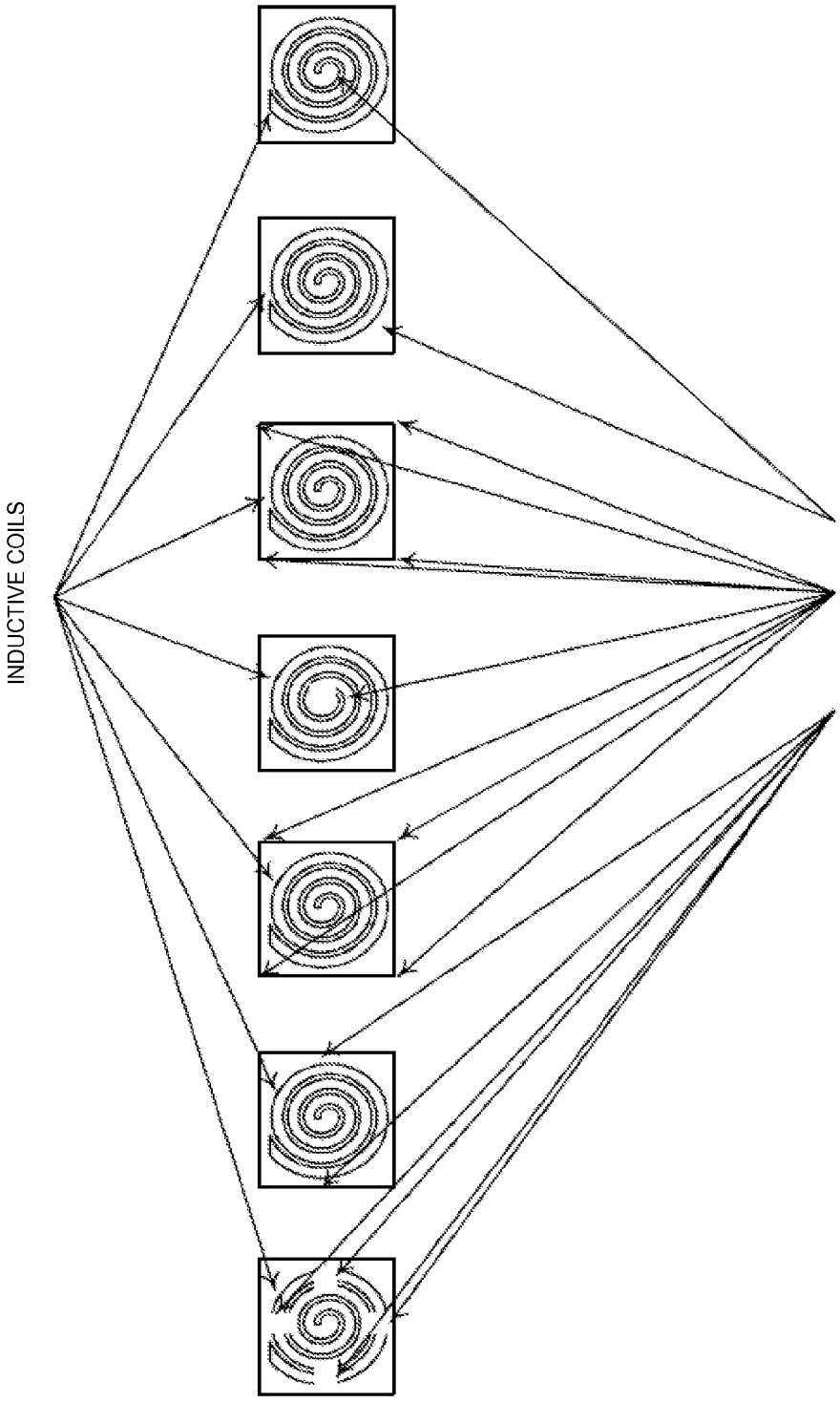


FIGURE 15

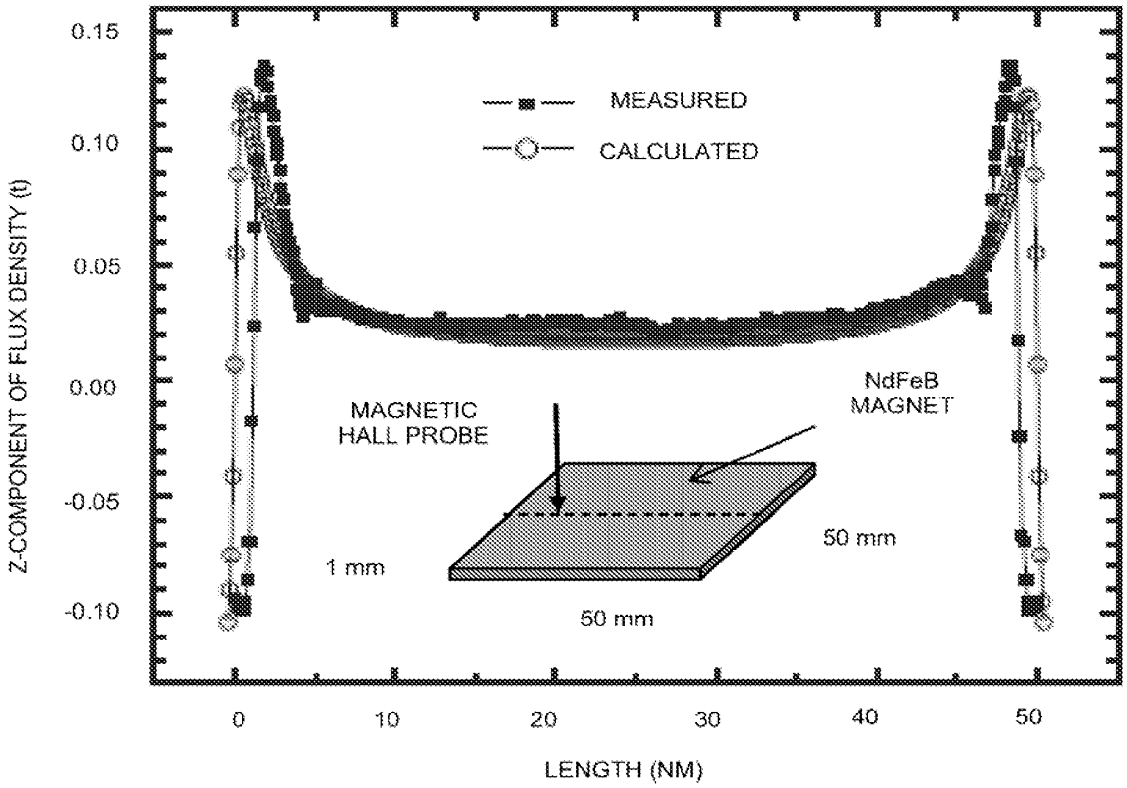

0.15
0.10
0.05
0.00
-0.05
-0.10
Z-COMPONENT OF FLUX DENSITY (t)
MEASURED
CALCULATED
MAGNETIC
HALL PROBE
NdFeB
MAGNET
1 mm
50 mm
50 mm
0
10
20
30
40
50
LENGTH (NM)

FIGURE 16

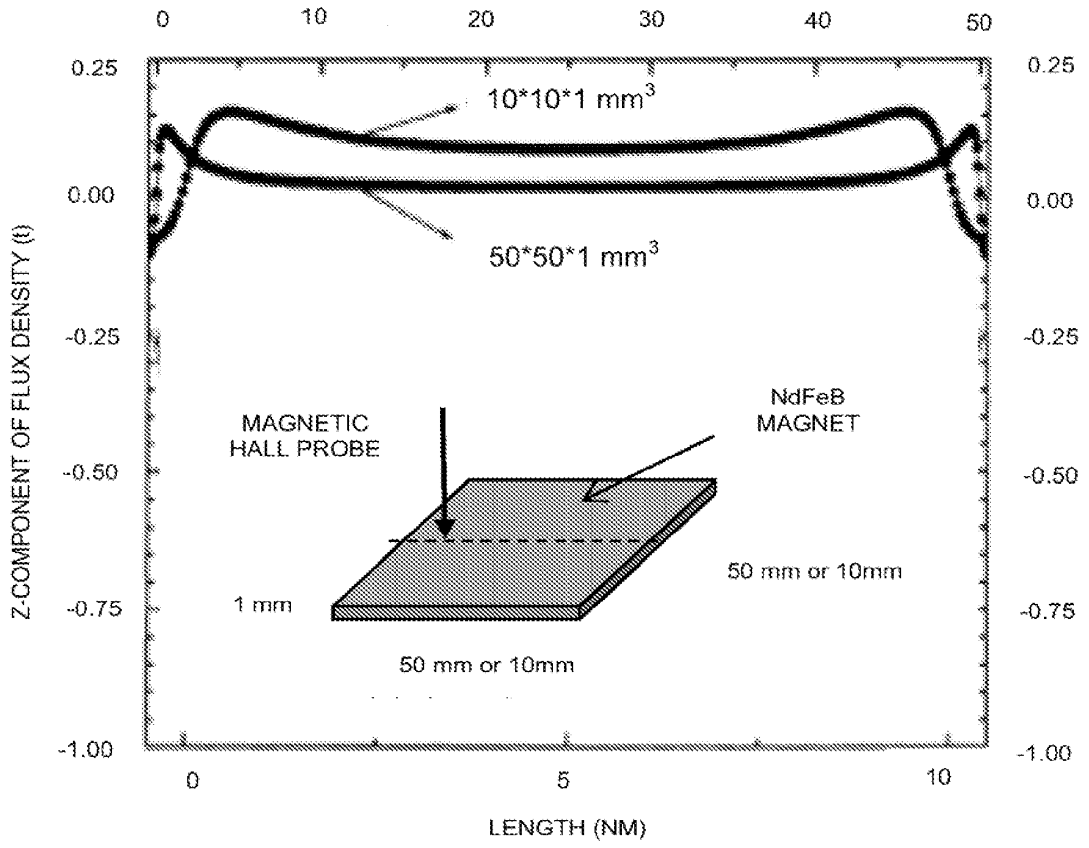

0
10
20
30
40
50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
10*10*1 mm3
50*50*1 mm3
MAGNETIC HALL PROBE
NdFeB MAGNET
1 mm
50 mm or 10mm
50 mm or 10mm
Z-COMPONENT OF FLUX DENSITY (t)
0
5
10
LENGTH (NM)

FIGURE 17

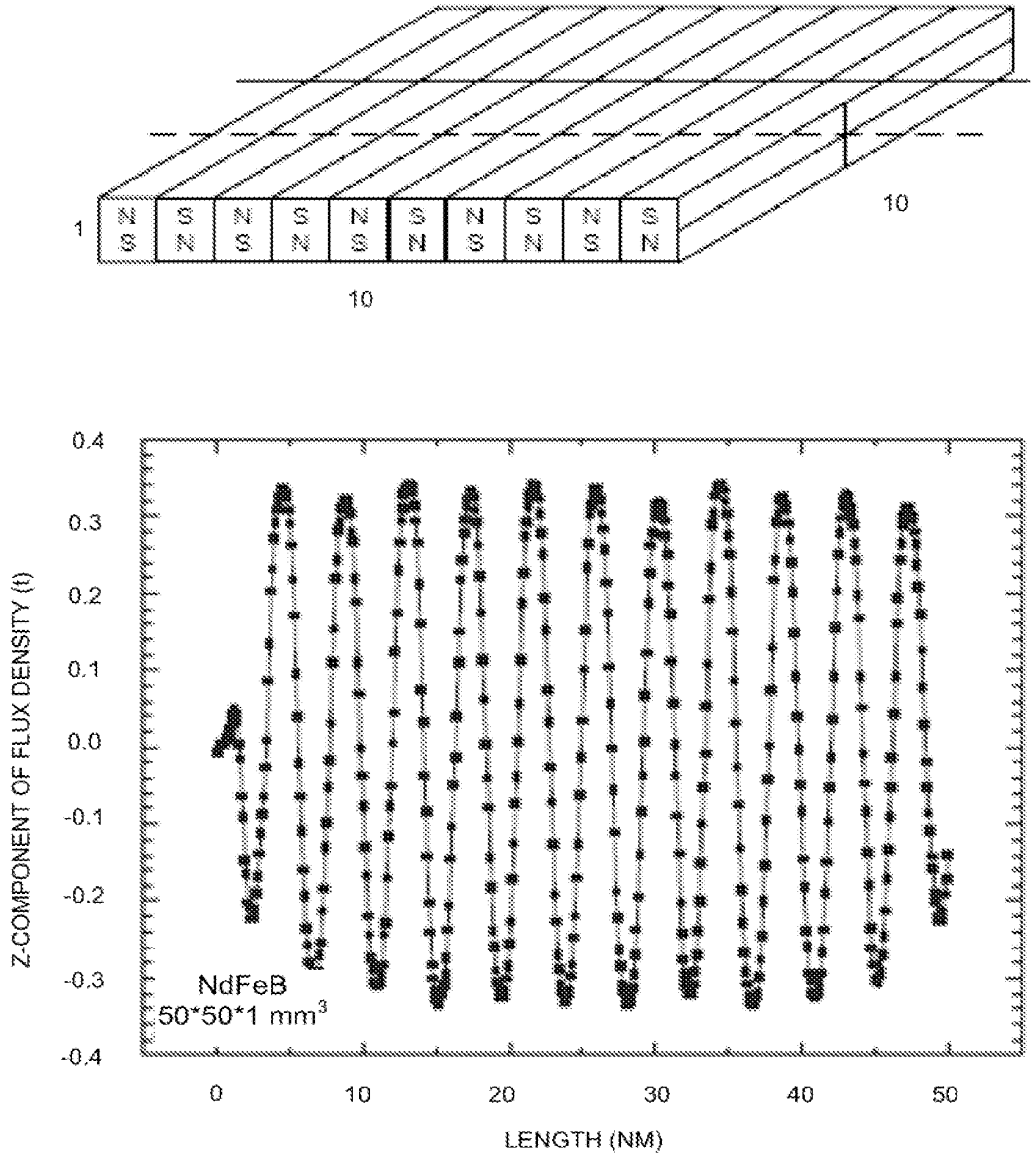
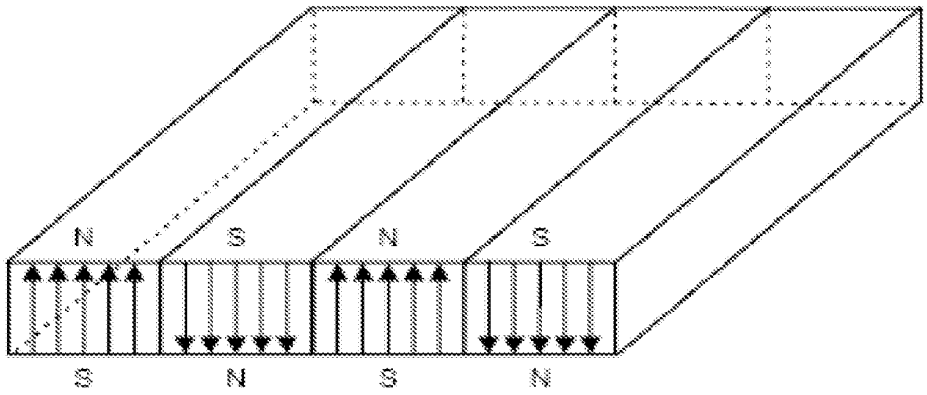

1
N S N S N S N S N S
S N S N S N S N S N
10
10
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
Z-COMPONENT OF FLUX DENSITY (t)
NdFeB
50*50*1 mm3
0
10
20
30
40
50
LENGTH (NM)

FIGURE 18


N
S
N
S
S
N
S
N

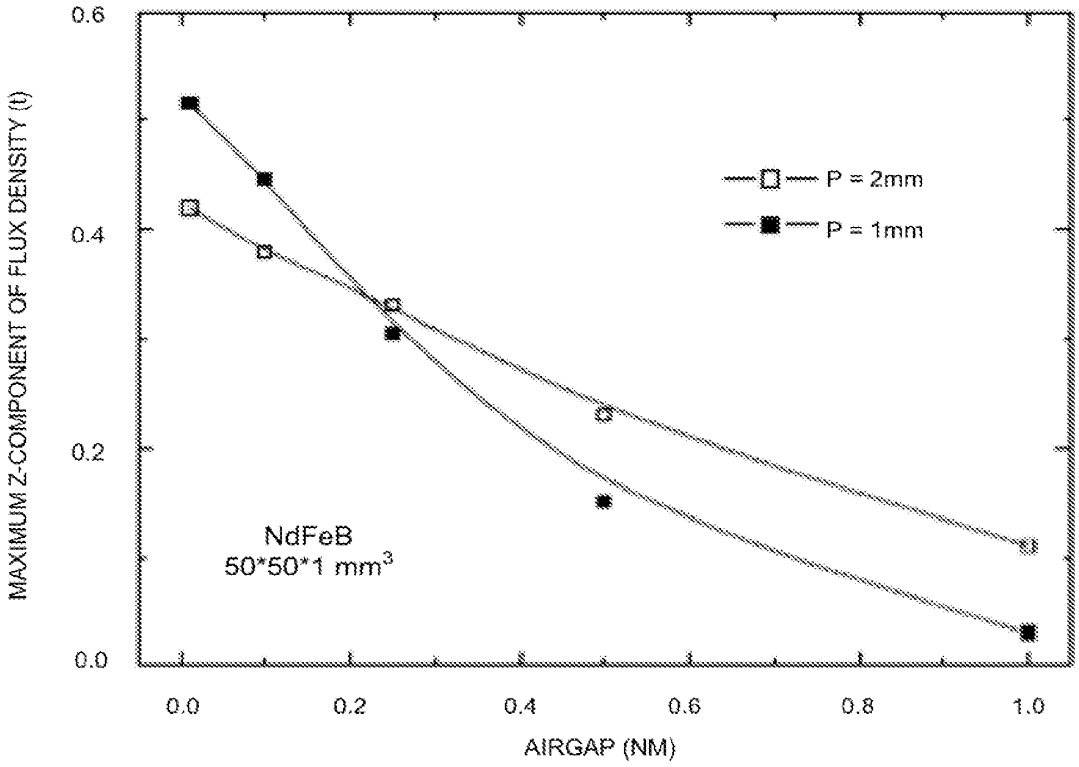

MAXIMUM Z-COMPONENT OF FLUX DENSITY (t)
0.6
0.4
0.2
0.0
P = 2mm
P = 1mm
NdFeB
50*50*1 mm3
0.0
0.2
0.4
0.6
0.8
1.0
AIRGAP (NM)

FIGURE 19

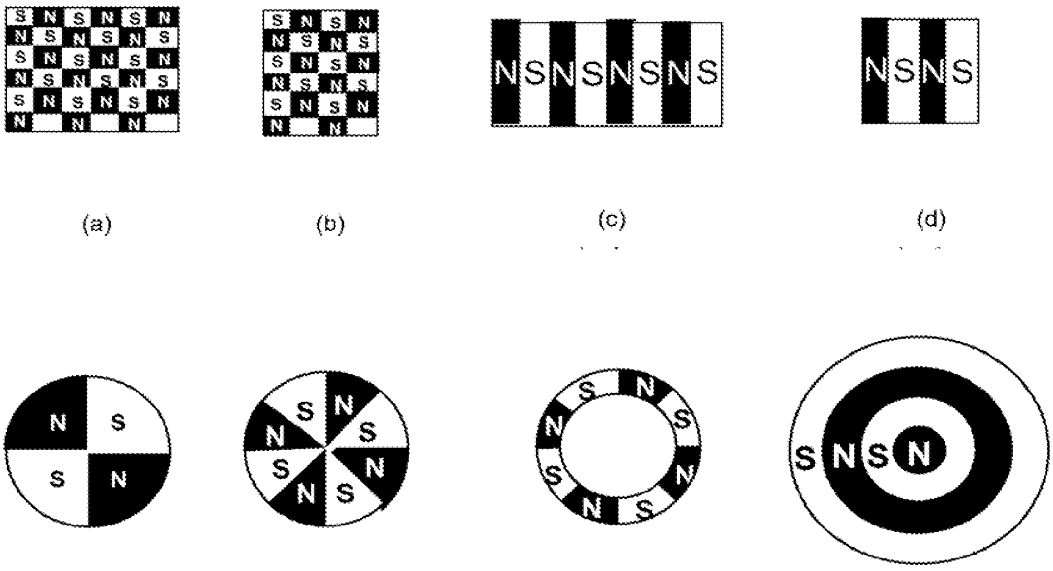


FIGURE 20



FIGURE 21

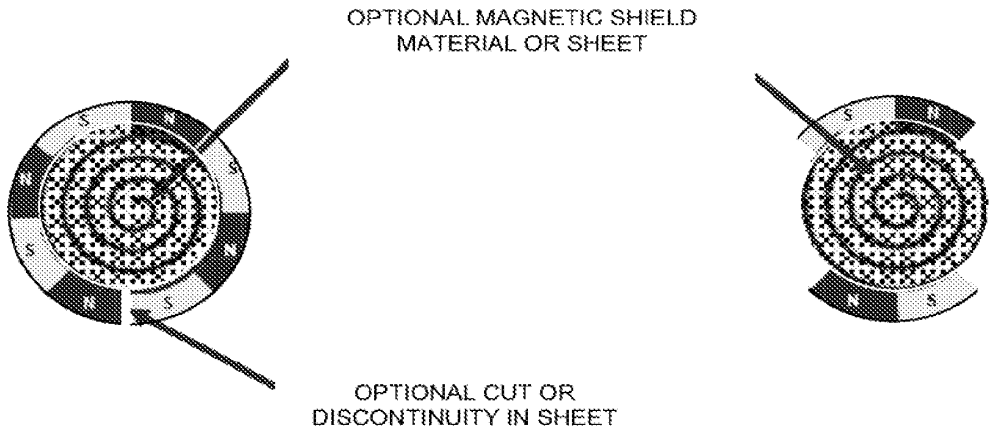


FIGURE 22

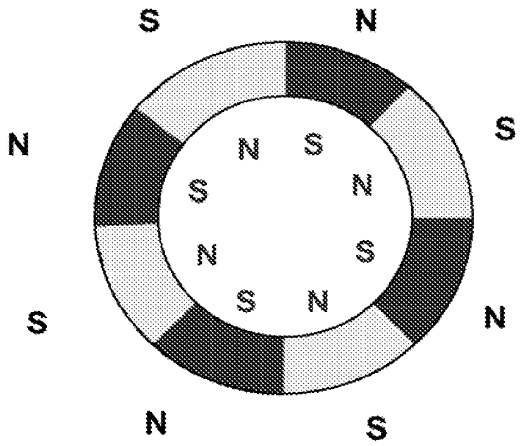


FIGURE 23

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FLIESLER MEYER LLP

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference AFPA01035WO0	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2013/033352	International filing date *(day/month/year)* 21 March 2013	(Earliest) Priority Date *(day/month/year)* 21 March 2012
Applicant MOJO MOBILITY, INC.		

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

This international search report consists of a total of 3 sheets.

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

1. **Basis of the report**

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

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

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

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

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

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

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

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

☒ the text is approved as submitted by the applicant.

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

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

☒ the text is approved as submitted by the applicant.

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

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

a. the figure of the **drawings** to be published with the abstract is Figure No. 30

☒ as suggested by the applicant.

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

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

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

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/033352

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 17-18
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/033352

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 7/00 (2013.01)
USPC - 320/108
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B60L1/00, 11/18; H01F 5/00, 38/14; H02J 7/00, 7/02, 17/00 (2013.01)
USPC - 307/10.1, 104; 310/49.03; 320/107, 108, 110, 137

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - H01F38/14; H02J7/025, 17/00 (2013.01)

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	WO 2011/156768 A2 (PARTOVI) 15 December 2011 (15.12.2011) entire document	1-12,15,16,19-23,25-32,34-62 --- 13,14,24,33,81
X -- Y	US 2011/0050164 A1 (PARTOVI et al) 03 March 2011 (03.03.2011) entire document	63-75,77-80,82-84 --- 13,14,76,81
Y	US 2009/0167449 A1 (COOK et al) 02 July 2009 (02.07.2009) entire document	24,33,76
A	US 2008/0067874 A1 (TSENG) 20 March 2008 (20.03.2008) entire document	1-16, 19-84

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2013	14 JUN 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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

Electronic Acknowledgement Receipt

EFS ID:	17260230
Application Number:	13115811
International Application Number:	
Confirmation Number:	4181
Title of Invention:	INDUCTIVE POWER SOURCE AND CHARGING SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Nancy McElrath
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01007US1
Receipt Date:	29-OCT-2013
Filing Date:	25-MAY-2011
Time Stamp:	19:17:09
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	9_Tang_CorelessPrintedCircuit_431_437.pdf	187092 301c18c923cdfd300c965db3b5ef176712c91893	no	7
Warnings:					
Information:					

2	Non Patent Literature	10_Tang_CorelessPrintedCircuitPCBHighPower_943_944.pdf	750755 c5e024179a17cebb7822816d05f92e2f4585297a	no	2
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Information:					
3	Non Patent Literature	11_Borenstein_ManTriesWirelessly.pdf	1029959 9e4225b08d57ac86d512c04e827aba975006fee7	no	5
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Information:					
4	Non Patent Literature	12_Murph_WildChargerCharges.pdf	561375 952e506f6026fa2dd5e3efc3eb32ff2f6edcdac8	no	2
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5	Non Patent Literature	13_GizmoWatch_PitstopATableTop.pdf	969383 761d39ca8bbe61e3e56950f79dd2d6c5591060d5	no	5
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6	Non Patent Literature	14_UNKNOWN_CuttingtheCord.pdf	644513 15d981c7a9ea26ae9b3d0d64830ad161f20cfcca	no	1
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Information:					
7	Non Patent Literature	15_Bishop_MicrosoftSurfaceBrings.pdf	2120129 9d9d5682c1867aa36629160098bd4effe166c00b	no	7
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Information:					
8	Non Patent Literature	16_Wildcharge_TheWireFeePower.pdf	631639 7d8a2c2f704879d7d3e2a19fa80dbaf940812a4d	no	3
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9	Non Patent Literature	17_Economist_ScienceTechnologyQuarterly.pdf	170581 b507140b3cc33473ed16fec384d5134486b72ff8	no	4
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Information:					
10	Foreign Reference	1_WO_03_096512.pdf	3229279 cf9b92db37b18bb7fdeac04719a829a5868e6482	no	76
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12	Foreign Reference	3_WO_2005_109598.pdf	2225633 d7e03b5f8bc909b1b6e00c7b73dbab56c69cc289	no	48
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13	Non Patent Literature	1_Hui_ANewGenerationUniversalContactless_Vol_20.pdf	1886008 9d93835c70ae702d796f696cccd5d618d5a5e0af	no	8
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14	Non Patent Literature	2_Tang_EvaluationoftheShieldingEffects_Vol_17.pdf	1945501 1a81a711164d3ab6c30a6f26fc6469e93ae90761	no	9
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15	Non Patent Literature	3_Liu_AnAnalysisOFaDoubleLayer_1767_1772.pdf	472541 21e561819c5feca1e4084f8a8d76048065e25d5f	no	6
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16	Non Patent Literature	4_Liu_EquivalentCircuitModeling_21_29.pdf	1161060 152e01f18326fba244c8acbfa392e519c82fef7d	no	9
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17	Non Patent Literature	5_Liu_SimulationStudyExperimentalVerification_2202_2210.pdf	5774958 c97610f5804ce23270dc91d27cf742b3f45a432a	no	9
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18	Non Patent Literature	6_Liu_OptimalDesignHybridWinding_455_463.pdf	1371272 c7c29b4ecd22e0426cae15d66777430170b24af2	no	9
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19	Non Patent Literature	7_Karalis_EfficientWirelessNonRadiative_34_48.pdf	1163088 5d1d6fb25a4775e06cb2b0ef043e2b0c4fddadc6	no	15
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20	Non Patent Literature	8_Su_MutualInductanceCalculation_1115_1124.pdf	1105315 6ab51bce94ae2edf79cbfe48f41a798da4490680	no	10
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21	Non Patent Literature	9_Hui_CorelessPrintedBoardPCBTransformer_Vol_11.pdf	3548540 7e13fc24eec9db97157b0b40a7118891cac9000e	no	48
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22	Non Patent Literature	10_Sekitani_ALargeAreaFlexible_4-pgs.pdf	981879 5a3e3eef544f49cc3295d8dc5a20e1ab5d8342ec	no	4
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23	Non Patent Literature	11_Choi_ANewcontactlessBatteryCharger_2001_p58_p59.pdf	550852 a09e315c8520b7ad0ab354b233e046627649faa9	no	2
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24	Non Patent Literature	12_Hui_CorelesPCBTranformersForPowerMOSFET_Vol_14.pdf	251752 3b70bc785c7190850daa6a96d8d5237e14bfd3a0	no	9
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27	Non Patent Literature	15_Fernandez_DesignIssuesofaCorelessTtransformer_2002.pdf	1813896 82d6336b12bbb0f93c4591d0b1ab8f03b1d64312	no	7
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30	Non Patent Literature	18_Topfer_MultiPoleMagnetization_2004_p257_p263.pdf	1677408 df11d9be7f21589c4b2d107e5c220d4fed46e20d	no	7
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31	Non Patent Literature	19_Topfer_MultiPoleMagnetization_2004_p124_p129.pdf	470348 3adc88e488e6fcf7a25d97bbbabc75f9b6db86f4	no	6
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34	Non Patent Literature	22_Waffenschmidt_LimitationofInductivePowerTransfer.pdf	797007 3e1a4773c6463c65c417df99b2a75f9e0f36b77a	no	10
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35	Non Patent Literature	23_STOKES_PalmStrikesBack__Jan_2009_6_pgs.pdf	649691 2ee0570d8c9caed205fc11a61a4b79d8c796908e	no	6
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39	Non Patent Literature	27_Fulton_Innovation_ThePublicDebutECoupled.pdf	87375 e4f558d9444fcdf0b683f30115bebd685f0146c7	no	2
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41	Non Patent Literature	29_MURAKAMI_ConsiderationCordlessPowerStation_Sep_1996_3_pgs.pdf	809537 590ec7bce90ef9d90eba98e2ee338c98366ef02d	no	3
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42	Non Patent Literature	30_Epson_airtrans_12_8_2008_2_pgs.pdf	165936 c3264db9b8c910f8da5ab766752cb534f601debe	no	2
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44	Non Patent Literature	32_IPER_PCTUS_2010_032845_111011_AFPA1026WO0.pdf	196960 53d705cc44dbda3ff131b967d7306c44a3b104b0	no	7
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48	Non Patent Literature	36_witricity_11_18_2011.pdf	195011 daf0689a3e1446e0dc11f5b3cb0cee0ad062 f9db	no	1
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53	Foreign Reference	JP_2006_246633.pdf	1141077 bec37e0f9bc57948284bbe0392fe2f38c4c8 221c	no	24
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54	Foreign Reference	WO_2011_156768_A2.pdf	2682290 bd2b215ceb912b7b6021217822569cb684 b5bfc8	no	49
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55	Non Patent Literature	ISR_PCTUS_2013_033352_061 413_AFPA1035WO0.pdf	176468 fe23b844c4a0fc80fdd6c63f92378d1ea9f59 cfe	no	3
Warnings:					
Information:					

Total Files Size (in bytes):	54121346

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

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

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

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

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/115,811	05/25/2011	Afshin Partovi	AFPA-01007US1

CONFIRMATION NO. 4181

23910
FLIESLER MEYER LLP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

POA ACCEPTANCE LETTER

OC000000064328467

Date Mailed: 10/17/2013

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/09/2013.

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

/qtran/

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

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82B(07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY BY APPLICANT

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

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

23910

OR

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

Name	Registration Number	Name	Registration Number

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

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

OR

☐ The address associated with Customer Number:

OR

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

I am the Applicant:

☐ Inventor or Joint Inventor

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor

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

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

SIGNATURE of Applicant for Patent

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

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

☐ *Total of _____ forms are submitted.

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

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

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

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

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

Electronic Acknowledgement Receipt

EFS ID:	17087555
Application Number:	13115811
International Application Number:	
Confirmation Number:	4181
Title of Invention:	INDUCTIVE POWER SOURCE AND CHARGING SYSTEM
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	23910
Filer:	Karl Kenna/Nancy McElrath
Filer Authorized By:	Karl Kenna
Attorney Docket Number:	AFPA-01007US1
Receipt Date:	09-OCT-2013
Filing Date:	25-MAY-2011
Time Stamp:	19:03:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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Warnings:					
Information:					

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Information:					
			Total Files Size (in bytes):	1505865	

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

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

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

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Partovi, Afshin et al.

Application No./Patent No.: 13/115,811 Filed/Issue Date: 05-25-2011

Titled: INDUCTIVE POWER SOURCE AND CHARGING SYSTEM

MOJO MOBILITY, INC., a corporation

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

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

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

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

1. From: Inventors To: Mojo Mobility, Inc.

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

   Reel 028769, Frame 0532, or for which a copy thereof is attached.

2. From: _____ To: _____

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

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

This collection of information is required by37 CFR3.73(b). The information is required toobtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentialityis governed by35 U.S.C. 122and 37 CFR1.11 and1.14. Thiscollection is estimated to take 12 minutes to complete, including gathering, preparing, and submittingthe 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 tothe Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.**SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**

AFPA-01007US1

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

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

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

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5. From: _____ To: _____

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

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

6. From: _____ To: _____

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

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

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

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

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

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

/Karl F. Kenna/	Oct. 9, 2013
Signature	Date
Karl F. Kenna	Reg. No. 45445
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

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

The informationprovided 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 informationin 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 InternationalApplication 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, arecord 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 thissystem 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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/115,811	05/25/2011	Afshin Partovi	AFPA-01007US1	4181

23910 7590 09/23/2013

FLIESLER MEYER LLP
410 PACIFIC AVENUE
SAN FRANCISCO, CA 94133

EXAMINER	
BERHANU, SAMUEL	
ART UNIT	**PAPER NUMBER**
2859	

NOTIFICATION DATE	DELIVERY MODE
09/23/2013	ELECTRONIC

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

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

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

officeactions@fdml.com
pctoa@fdml.com

Office Action Summary	Application No.	Applicant(s)	
	13/115,811	PARTOVI ET AL.	
	Examiner	Art Unit	
	SAMUEL BERHANU	2859	

-- 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 *25 May 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) *1-36* 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) *1-36* 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 *25 May 2011* 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. *09/12/2013* .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Double Patenting

2. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to

be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

3. Claims 1-36 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-54 of U.S. Patent No. 7,952,322 Although the conflicting claims are not identical, they are not patentably distinct from each other because, all the elements are mentioned explicitly or implicitly.

Claim Rejections - 35 USC § 102

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

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

5. Claims 1-2, 3-8 and 10-12, 22, 30-31, 36, 38-41 and 43-44 are rejected under 35 U.S.C. 102(b) as being anticipated by Lyon (US 2004/0145342).

As to Claims 1, 11 and 43-44, Lyon discloses in Figures 1-6, a mobile device and/or battery capable of being inductively powered or charged comprising:

a battery; (the load is electronic device operated by battery)

a receiver (204) for one of inductively powering the mobile device directly, and/or charging the battery in the mobile device, wherein the receiver includes

a receiver coil(232) having generally planar shape, so that when a magnetic field is applied in a direction generally perpendicularly to the receiver coil using induction from a primary coil in a base unit, an electrical current is generated within the receiver coil and is used to power or charge the mobile device and/or battery, a regulator circuit (that senses the current drawn from the receiver coil and regulates it to match one of either a predefined value of voltage or current, or an appropriate power parameter of the mobile device and/or battery as sensed by the regulator circuit; and wherein the receiver is one of attached to or incorporated into or on the battery or the mobile device.

As to Claim 2, Lyon discloses in Figures 1-6, wherein the receiver is attached to the shell of the mobile device or battery.

As to claim 3, Lyon discloses in figures 1-6, a plurality of coils or wires, wherein the coils or wires are placed in one or more layers and are used to inductively charge a mobile device in proximity to the mobile device charger.

As to Claims 4 and 12, Lyon discloses in Figures 1-6, wherein one or more of the coils are manufactured by one of printed circuit boards or by etching or stamping or forming copper or other material and are manufactured to have a low resistance.

As to claim 5, Lyon discloses in figures 1-6, wherein two or more coils or wires are activated to charge or power a mobile device [Lyon discloses charging plural electrical devices and each device has coils].

As to claim 8, Lyon discloses in figures 1-6, wherein the charger or power supply includes coils or wires for inductively charging or supplying power to the mobile device,

and wherein the coils or wires also function as an antenna for data transfer [see figures 1-2].

As to Claim 22, Lyon discloses in Figures 1-6, a data storage component for storage of data, for subsequent transmission of data to or from the mobile device.

As to Claim 30, Lyon discloses in Figures 1-6, wherein the charger or power supply is made in the shape of a cup, bowl, or other container and mobile devices and/or batteries placed inside would be are charged or powered inductively.

As to Claim 31, Lyon discloses in Figures 1-6, wherein a plurality of modular chargers or power supplies can be interconnected to form a single unit.

As to Claim 36, Lyon discloses in Figures 1-6, wherein, the mobile device includes an after-market or field-replaceable battery pack compatible with an original battery pack for the device, and wherein the matching secondary coil or coils within the mobile device are incorporated into the after-market or field-replaceable battery pack.

As to Claim 38, Lyon discloses in Figures 1-6, wherein two or more primary coils or wires are activated at the same time to charge or power a mobile device and/or battery.

As to Claims 6 and 39, Lyon discloses in Figures 1-6, wherein the base unit and the mobile device and/or battery communicate with each other to transfer data (220).

As to Claims 7 and 40, Lyon discloses in Figures 1-6, wherein the base unit includes a first set of coils (210) or wires for inductively charging or supplying power to the mobile device and/or battery, and a separate antenna or second set of coils or wires

for data transfer or verification or communication for regulation of power or voltage (243-, 242).

As to Claim 41, Lyon discloses in Figures 1-6, wherein the coils or wires also function as an antenna for data transfer (242,243).

As to Claims 10 and 43, Lyon discloses in Figures 1-6, wherein the base unit stores charging or power requirements for mobile devices and/or batteries which can be charged or powered by the charger or power supply.

Claim Rejections - 35 USC § 103

6. 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 negatived by the manner in which the invention was made.

7. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

8. Claims 9, 13,15- 16 and 34-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Van Lerberghe (US 5,925,814) (hereinafter Van)

As to Claims 9 and 13, Lyon discloses all of the Claim limitations except, wherein the base unit includes a primary circuit having a switch means for switching the primary coil on and off whenever the mobile device and/or battery is placed close to the primary coil of the base unit or the presence of the mobile device and/or battery is to be detected.

Van discloses in Figures 1-5, wherein the base unit includes a primary circuit having a switch (28) means for switching the primary coil on and off whenever the mobile device and/or battery is placed close to the primary coil of the base unit or the presence of the mobile device and/or battery is to be detected

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add a switching means in Lyon charger as taught by Van in order to avoid unnecessary power lose due to charging

As to Claim 15, Lyon in combination with Van discloses wherein the alternating switching is periodically started and stopped to automatically detect a presence of a mobile device and/or battery placed close to or aligned with the primary coil of the base unit.

As to Claim 16, Lyon in combination with Van, wherein the presence of the mobile device and/or battery placed close to or aligned with the primary coil of the base reunit is detected by monitoring the current passing through the primary coil or the switching means.

As to Claim 34, Lyon in Combination with Van discloses, charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device to a predetermined maximum voltage.

As to Claim 35, Lyon in Combination with Van discloses, wherein the switch means is a MOSFET and the circuit includes a capacitor connected in parallel to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the MOSFET
when the base unit detects a mobile device and/or battery placed close to or aligned with the primary coil.

9. Claims 14, 17-18, 23-29, 37 and 42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Hui (US 2005/0189910)

As to Claim 14, Lyon discloses all of the claim limitations except, wherein the base unit includes multiple primary coils that can be used to simultaneously charge multiple mobile devices and/or batteries.

Hui discloses in Figure 4(a), wherein the base unit includes multiple primary coils that can be used to simultaneously charge multiple mobile devices and/or batteries.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to modify Lyon's apparatus in order to charge different devices simultaneously to minimize the time it takes to charge a plurality of electronic devices.

As to Claim 17, Hui discloses in Figure 4a, wherein the base unit is in the shape generally of a pad and wherein the multiple primary coils are distributed within layers of the pad.

As to Claim 18, Hui discloses in Figure 4a, wherein the multiple primary coils can move within their plane to more closely align with the secondary coil of a mobile device and/or battery

As to Claim 23, Hui discloses wherein the cover surface of the base unit or pad includes a decorative or non-slip surface.

As to Claim 24, Hui discloses wherein the base unit can be integrated into any of briefcases, bags, carriers, or clothing.

As to Claim 25, Hui discloses wherein the base unit is integrated into a charging kiosk for occasional charging of mobile devices.

As to Claim 26, Lyon in combination with Hui discloses, wherein one or more of the primary coils are stacked to improve transfer efficiency.

As to Claim 27, Lyon in combination with Hui discloses, further comprising a plurality of coils or wires, wherein the charger or power supply senses the location of the mobile device and/or battery and activates a coil or wire near the mobile device and/or battery to charge or provide power the mobile device and/or battery.

As to Claim 28, Lyon in combination with Hui discloses, wherein the charger or power supply senses the location of the mobile device and/or battery by sensing a change in a resonant circuit in the charger or power supply when the mobile device and/or battery is nearby.

As to Claim 29, Lyon in combination with Hui discloses, wherein the mobile device includes an inductively charged battery where a receiver for the inductive power

is made of flexible PCB material and can be shaped into a curve to fit the battery, an application or a device.

As to Claim 37, Lyon in combination with Hui discloses, board PCB layer of at least two different sizes or shapes.

As to Claim 42, Lyon in combination with Hui discloses, wherein the data transfer includes information about the presence of the mobile device and/or battery adjacent to the charger or power supply.

10. Claim 19 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Chen et. al. (US 6,331,744) (hereinafter Chen)

As to Claim 19,Lyon discloses all of the Claim limitations except, wherein a magnet is placed at the center of each primary, wherein the magnet at the center of each primary has a magnetic axis that is perpendicular to the plane of the coil, and wherein one or more of the devices to be charged include a magnet at the center of their receiver coil, so that the magnets in the devices and the magnets in the base are oriented to attract each other when a coil in a mobile device and/or battery_ is placed directly on top of a coil in the base.

Chen discloses in Figure 2, wherein a magnet is placed at the center of each primary, wherein the magnet at the center of each primary has a magnetic axis that is perpendicular to the plane of the coil, and wherein one or more of the devices to be charged include a magnet at the center of their receiver coil, so that the magnets in the devices and the magnets in the base are oriented to attract each other when a coil in a mobile device and/or battery is placed directly on top of a coil in the base.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add Magnetic material in Lyon's charger as taught by Chen in order to strength the inductive charging energy.

11. Claims 20-21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Fukuda et. al. (US 4,311,953)

As to Claims 20 and 21, Fukuda discloses in Column 1, lines 59-67, a charger unit including solar and secondary battery.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add Magnetic material in Lyon's charger as taught by Chen in order to strength the inductive charging energy.

12. Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of SUDO (US JP408000838)

As to Claim 32, Sudo discloses in the Abstract, wherein the mobile device is one of a kitchen appliance or dish, or a toy that can receive power inductively from the charger or power supply.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to use inductive charging of Lyon for vehicle toy as taught by Sudo to extend battery life.

13. Claim 33 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Charych (US 6,798,716)

As to Claim 33, Charych discloses charging RFID tag battery, wherein the mobile device is a charger for inductively charging active RFID batteries, including an

active RFID tag which includes a battery such that the battery can be charged inductively with the system.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to use inductive charging of Lyon for RFID batteries as taught by Charych to extend battery life.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SAMUEL BERHANU whose telephone number is (571)272-8430. The examiner can normally be reached on M-F.

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

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

/Samuel Berhanu/

Primary Examiner, Art Unit 2859

Applicant-Initiated Interview Summary	Application No.	Applicant(s)	
	13/115,811	PARTOVI ET AL.	
	Examiner	Art Unit	
	SAMUEL BERHANU	2859	

All participants (applicant, applicant's representative, PTO personnel):

(1) *SAMUEL BERHANU*. (3)_____.

(2) *Karl Kenna*. (4)_____.

Date of Interview: *12 September 2013*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *3-10*.

Identification of prior art discussed: *None*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

It was agreed that a new action would be required with a new statutory deadline since the claims numbered 1-10 were not acted upon or addressed.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Samuel Berhanu/ Primary Examiner, Art Unit 2859	

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Notice of References Cited	Application/Control No. 13/115,811	Applicant(s)/Patent Under Reexamination PARTOVI ET AL.	
	Examiner SAMUEL BERHANU	Art Unit 2859	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2004/0145342	07-2004	Lyon, Geoff M.	320/108
*	B	US-5,925,814	07-1999	Tsuzuki et al.	73/23.32
*	C	US-2005/0189910	09-2005	Hui, Shu-yuen Ron	320/108
*	D	US-6,331,744	12-2001	Chen et al.	310/171
*	E	US-4,311,953	01-1982	Fukuda et al.	320/101
*	F	US-6,798,716	09-2004	Charych, Arthur	367/119
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13115811	PARTOVI ET AL.
	Examiner	Art Unit
	SAMUEL BERHANU	2859

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320320	108150	3/22/20133/22/2013	SBSB

SEARCH NOTES		
Search Notes	Date	Examiner
EAST inventor and PLUS search conducted----------see printout	3/22/2013	SB

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

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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/115,811	05/25/2011	Afshin Partovi	AFPA-01007US1	4181

23910 7590 03/28/2013

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SAN FRANCISCO, CA 94108

EXAMINER	
BERHANU, SAMUEL	
ART UNIT	PAPER NUMBER
2859	

NOTIFICATION DATE	DELIVERY MODE
03/28/2013	ELECTRONIC

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

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

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

officeactions@fdml.com
pctoa@fdml.com

Office Action Summary	Application No.	Applicant(s)	
	13/115,811	PARTOVI ET AL.	
	Examiner	Art Unit	
	SAMUEL BERHANU	2859	

-- 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 *25 May 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) *1-36* 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) *1-36* 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 *25 May 2011* 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

Double Patenting

1. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

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

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

2. Claims 1-36 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-54 of U.S. Patent No. 7,952,322 Although the conflicting claims are not identical, they are not patentably distinct from each other because, all the elements are mentioned explicitly or implicitly.

Claim Rejections - 35 USC § 102

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

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

4. Claims 1-2, 11-12, 22, 30-31, 36, 38-41 and 43-44 are rejected under 35 U.S.C. 102(b) as being anticipated by Lyon (US 2004/0145342).

As to Claims 1, 11 and 43-44, Lyon discloses in Figures 1-6, a mobile device and/or battery capable of being inductively powered or charged comprising:

a battery; (the load is electronic device operated by battery)

a receiver (204) for one of inductively powering the mobile device directly, and/or charging the battery in the mobile device, wherein the receiver includes

a receiver coil(232) having generally planar shape, so that when a magnetic field is applied in a direction generally perpendicularly to the receiver coil using induction from a primary coil in a base unit, an electrical current is generated within the receiver coil

and is used to power or charge the mobile device and/or battery, a regulator circuit (that senses the current drawn from the receiver coil and regulates it to match one of either a predefined value of voltage or current, or an appropriate power parameter of the mobile device and/or battery as sensed by the regulator circuit; and wherein the receiver is one of attached to or incorporated into or on the battery or the mobile device.

As to Claim 2, Lyon discloses in Figures 1-6, wherein the receiver is attached to the shell of the mobile device or battery.

As to Claim 12, Lyon discloses in Figures 1-6, wherein one or more of the coils are manufactured by one of printed circuit boards or by etching or stamping or forming copper or other material and are manufactured to have a low resistance.

As to Claim 22, Lyon discloses in Figures 1-6, a data storage component for storage of data, for subsequent transmission of data to or from the mobile device.

As to Claim 30, Lyon discloses in Figures 1-6, wherein the charger or power supply is made in the shape of a cup, bowl, or other container and mobile devices and/or batteries placed inside would be are charged or powered inductively.

As to Claim 31, Lyon discloses in Figures 1-6, wherein a plurality of modular chargers or power supplies can be interconnected to form a single unit.

As to Claim 36, Lyon discloses in Figures 1-6, wherein, the mobile device includes an after-market or field-replaceable battery pack compatible with an original battery pack for the device, and wherein the matching secondary coil or coils within the mobile device are incorporated into the after-market or field-replaceable battery pack.

As to Claim 38, Lyon discloses in Figures 1-6, wherein two or more primary coils or wires are activated at the same time to charge or power a mobile device and/or battery.

As to Claim 39, Lyon discloses in Figures 1-6, wherein the base unit and the mobile device and/or battery communicate with each other to transfer data (220).

As to Claim 40, Lyon discloses in Figures 1-6, wherein the base unit includes a first set of coils (210) or wires for inductively charging or supplying power to the mobile device and/or battery, and a separate antenna or second set of coils or wires for data transfer or verification or communication for regulation of power or voltage (243-, 242).

As to Claim 41, Lyon discloses in Figures 1-6, wherein the coils or wires also function as an antenna for data transfer (242,243).

As to Claim 43, Lyon discloses in Figures 1-6, wherein the base unit stores charging or power requirements for mobile devices and/or batteries which can be charged or powered by the charger or power supply.

Claim Rejections - 35 USC § 103

5. 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 negatived by the manner in which the invention was made.

6. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein

were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claims 13,15- 16 and 34-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Van Lerberghe (US 5,925,814) (hereinafter Van)

As to Claim 13, Lyon discloses all of the Claim limitations except, wherein the base unit includes a primary circuit having a switch means for switching the primary coil on and off whenever the mobile device and/or battery is placed close to the primary coil of the base unit or the presence of the mobile device and/or battery is to be detected.

Van discloses in Figures 1-5, wherein the base unit includes a primary circuit having a switch (28) means for switching the primary coil on and off whenever the mobile device and/or battery is placed close to the primary coil of the base unit or the presence of the mobile device and/or battery is to be detected

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add a switching means in Lyon charger as taught by Van in order to avoid unnecessary power lose due to charging

As to Claim 15, Lyon in combination with Van discloses wherein the alternating switching is periodically started and stopped to automatically detect a presence of a mobile device and/or battery placed close to or aligned with the primary coil of the base unit.

As to Claim 16, Lyon in combination with Van, wherein the presence of the mobile device and/or battery placed close to or aligned with the primary coil of the base unit is detected by monitoring the current passing through the primary coil or the switching means.

As to Claim 34, Lyon in Combination with Van discloses, charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to
the mobile device to a predetermined maximum voltage.

As to Claim 35, Lyon in Combination with Van discloses, wherein the switch means is a MOSFET and the circuit includes a capacitor connected in parallel to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the MOSFET
when the base unit detects a mobile device and/or battery placed close to or aligned with the primary coil.

8. Claims 14, 17-18, 23-29, 37 and 42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Hui (US 2005/0189910)

As to Claim 14, Lyon discloses all of the claim limitations except, wherein the base unit includes multiple primary coils that can be used to simultaneously charge multiple mobile devices and/or batteries.

Hui discloses in Figure 4(a), wherein the base unit includes multiple primary coils that can be used to simultaneously charge multiple mobile devices and/or batteries.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to modify Lyon's apparatus in order to charge different devices simultaneously to minimize the time it takes to charge a plurality of electronic devices.

As to Claim 17, Hui discloses in Figure 4a, wherein the base unit is in the shape generally of a pad and wherein the multiple primary coils are distributed within layers of the pad.

As to Claim 18, Hui discloses in Figure 4a, wherein the multiple primary coils can move within their plane to more closely align with the secondary coil of a mobile device and/or battery

As to Claim 23, Hui discloses wherein the cover surface of the base unit or pad includes a decorative or non-slip surface.

As to Claim 24, Hui discloses wherein the base unit can be integrated into any of briefcases, bags, carriers, or clothing.

As to Claim 25, Hui discloses wherein the base unit is integrated into a charging kiosk for occasional charging of mobile devices.

As to Claim 26, Lyon in combination with Hui discloses, wherein one or more of the primary coils are stacked to improve transfer efficiency.

As to Claim 27, Lyon in combination with Hui discloses, further comprising a plurality of coils or wires, wherein the charger or power supply senses the location of the mobile device and/or battery and activates a coil or wire near the mobile device and/or battery to charge or provide power the mobile device and/or battery.

As to Claim 28, Lyon in combination with Hui discloses, wherein the charger or power supply senses the location of the mobile device and/or battery by sensing a change in a resonant circuit in the charger or power supply when the mobile device and/or battery is nearby.

As to Claim 29, Lyon in combination with Hui discloses, wherein the mobile device includes an inductively charged battery where a receiver for the inductive power is made of flexible PCB material and can be shaped into a curve to fit the battery, an application or a device.

As to Claim 37, Lyon in combination with Hui discloses, board PCB layer of at least two different sizes or shapes.

As to Claim 42, Lyon in combination with Hui discloses, wherein the data transfer includes information about the presence of the mobile device and/or battery adjacent to the charger or power supply.

9. Claim 19 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Chen et. al. (US 6,331,744) (hereinafter Chen)

As to Claim 19,Lyon discloses all of the Claim limitations except, wherein a magnet is placed at the center of each primary, wherein the magnet at the center of each primary has a magnetic axis that is perpendicular to the plane of the coil, and wherein one or more of the devices to be charged include a magnet at the center of their receiver coil, so that the magnets in the devices and the magnets in the base are oriented to attract each other when a coil in a mobile device and/or battery_ is placed directly on top of a coil in the base.

Chen discloses in Figure 2, wherein a magnet is placed at the center of each primary, wherein the magnet at the center of each primary has a magnetic axis that is perpendicular to the plane of the coil, and wherein one or more of the devices to be charged include a magnet at the center of their receiver coil, so that the magnets in the devices and the magnets in the base are oriented to attract each other when a coil in a mobile device and/or battery is placed directly on top of a coil in the base.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add Magnetic material in Lyon's charger as taught by Chen in order to strength the inductive charging energy.

10. Claims 20-21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Fukuda et. al. (US 4,311,953)

As to Claims 20 and 21, Fukuda discloses in Column 1, lines 59-67, a charger unit including solar and secondary battery.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to add Magnetic material in Lyon's charger as taught by Chen in order to strength the inductive charging energy.

11. Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of SUDO (US JP408000838)

As to Claim 32, Sudo discloses in the Abstract, wherein the mobile device is one of a kitchen appliance or dish, or a toy that can receive power inductively from the charger or power supply.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to use inductive charging of Lyon for vehicle toy as taught by Sudo to extend battery life.

12. Claim 33 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lyon in view of Charych (US 6,798,716)

As to Claim 33, Charych discloses charging RFID tag battery, wherein the mobile device is a charger for inductively charging active RFID batteries, including an active RFID tag which includes a battery such that the battery can be charged inductively with the system.

It would have been obvious to a person having ordinary skill in the art at the time of the invention to use inductive charging of Lyon for RFID batteries as taught by Charych to extend battery life.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SAMUEL BERHANU whose telephone number is (571)272-8430. The examiner can normally be reached on M-F.

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

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

/Samuel Berhanu/

Primary Examiner, Art Unit 2859

Notice of References Cited	Application/Control No. 13/115,811	Applicant(s)/Patent Under Reexamination PARTOVI ET AL.	
	Examiner SAMUEL BERHANU	Art Unit 2859	Page 1 of 1

U.S. PATENT DOCUMENTS

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*	A	US-2004/0145342	07-2004	Lyon, Geoff M.	320/108
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*	C	US-2005/0189910	09-2005	Hui, Shu-yuen Ron	320/108
*	D	US-6,331,744	12-2001	Chen et al.	310/171
*	E	US-4,311,953	01-1982	Fukuda et al.	320/101
*	F	US-6,798,716	09-2004	Charych, Arthur	367/119
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N	JP408000838A	01-1996	Japan	SUDO	
	O					
	P					
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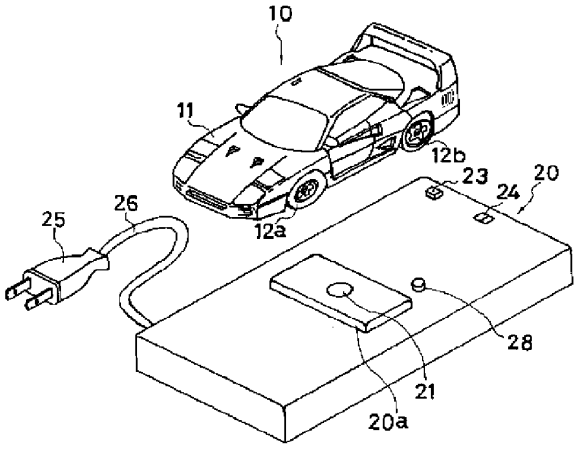
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(54)【発明の名称】　電磁誘導充電方式の乗物玩具

(57)【要約】
【目的】　電池を搭載したまま充電することにより電池の充電に際し電池の劣化を防ぎ、また充電器プラグなどの破損や腐食による接触不良をなくし、誰でも簡単に安全かつ確実に電池を充電できる乗物玩具を提供する。
【構成】　外部磁界による電磁誘導により、乗物玩具１０に内蔵された電池１７を充電する電磁誘導充電手段を備える。



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【特許請求の範囲】
【請求項１】　外部磁界による電磁誘導により、乗物玩具に内蔵された電池を充電する電磁誘導充電手段を備えた電磁誘導充電方式の乗物玩具。
【請求項２】　電磁誘電により電流を発生する第１の誘導コイルと、第１の誘導コイルに発生した交流電流を直流に変換して充電する整流器と、該整流器の電流により充電される充電式電池と、該電池により駆動される駆動手段と、該電池と前記整流器または駆動手段との回路を切り換え接続する切り換え手段とを搭載した乗物玩具本体と、前記第１の誘導コイルに接近させると該第１の誘導コイルに電磁誘導電流を発生させるような磁界を発生する第２の誘導コイルと、第２の誘導コイルを充電制御手段を介して電源に接続する接続手段とを設けた充電台とを備えた請求項１に記載の電磁誘導充電方式の乗物玩具。
【請求項３】　前記乗物玩具本体を前記充電台の上に載せたときに、前記乗物玩具本体の整流器と充電式電池との回路がオンに、該電池と駆動手段との回路がオフになり、乗物玩具本体を充電台から下ろしたときは、前記整流器と充電式電池の回路がオフになり充電式電池と駆動手段との回路がオンになる第１の切り換え手段を乗り物玩具本体に備え、乗物玩具本体を充電台の上に載せたときは商用電源と充電台との回路がオンになり、乗物玩具本体を充電台から下ろしたときは、商用電源と充電台との回路がオフとなる第２の切り換え手段を充電台に備えた請求項１または２に記載の電磁誘導充電方式の乗物玩具。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、電池駆動の乗物玩具を誘電磁界を発生させる充電台の上に置くだけで乗物玩具に内蔵された電池に充電することのできる乗物玩具に関するものである。
【０００２】
【従来の技術】従来、電池駆動の乗物玩具などにおいて、使用する電池を充電する場合には、玩具から電池を取り出した後に専用の充電器により電池を充電するか、あるいは電池は玩具に内蔵したまま外部の充電器から接続プラグを介して充電を行っていた。
【０００３】しかしながら、玩具から電池を取り出して充電する場合には、頻繁に電池の脱着を繰り返すため電池の被膜などが劣化したり、外部の充電器からプラグを介して充電する場合には、プラグが破損したり腐食により充電しにくくなる欠点があった。また、電池を交換する場合に、電池の陽極と陰極の方向を間違えて入れてしまうことがあった。
【０００４】
【発明が解決しようとする課題】そこで本発明は、電池を搭載したまま充電することにより電池の充電に際し電池の劣化を防ぎ、また充電器プラグなどの破損や腐食による接触不良をなくし、誰でも簡単に安全かつ確実に電池を充電できる乗物玩具を提供することを目的とする。

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【０００５】
【課題を解決するための手段】上記目的を達成するために、本発明の電磁誘導充電方式の乗物玩具は、外部磁界による電磁誘導により、乗物玩具に内蔵された電池を充電する電磁誘導充電手段を備えるものである。
【０００６】また、電磁誘電により電流を発生する第１の誘導コイルと、第１の誘導コイルに発生した交流電流を直流に変換して充電する整流器と、該整流器の電流により充電される充電式電池と、該電池により駆動される駆動手段と、該電池と前記整流器または駆動手段との回路を切り換え接続する切り換え手段とを搭載した乗物玩具本体と、前記第１の誘導コイルに接近させると該第１の誘導コイルに電磁誘導電流を発生させるような磁界を発生する第２の誘導コイルと、第２の誘導コイルを充電制御手段を介して電源に接続する接続手段とを設けた充電台とを備えることが好ましい。
【０００７】さらに、前記乗物玩具本体を前記充電台の上に載せたときに、前記乗物玩具本体の整流器と充電式電池との回路がオンに、該電池と駆動手段との回路がオフになり、乗物玩具本体を充電台から下ろしたときは、前記整流器と充電式電池の回路がオフになり充電式電池と駆動手段との回路がオンになる第１の切り換え手段を乗り物玩具本体に備え、乗物玩具本体を充電台の上に載せたときは商用電源と充電台との回路がオンになり、乗物玩具本体を充電台から下ろしたときは、商用電源と充電台との回路がオフとなる第２の切り換え手段を充電台に備えることが好ましい。
【０００８】
【作用】本発明の構成の電磁誘導充電方式の乗物玩具は、外部磁界による電磁誘導の原理で乗物玩具に内蔵された電池に充電される。
【０００９】また、乗物玩具本体を充電台の上に載せて、充電台に内蔵した電磁誘電効果を生ずる磁界を発生した第２の誘導コイルに乗物玩具本体に搭載した第１の誘導コイルを接近させて、該第１の誘導コイルに電磁誘導により交流電流を発生させる。この第１の誘導コイルに発生した交流電流を整流器により直流に変換して充電式電池に充電する。充電された電池は、切り換え手段により乗物玩具本体のの駆動手段に接続され駆動手段を駆動する。前記充電台の第２の誘導コイルは、充電制御手段を介して商用電源に接続され、接近した置かれた前記第１の誘導コイルに電磁誘電電流を発生させるような磁界を発生させる。
【００１０】さらに、乗物玩具本体を充電台の上に載せると内蔵した整流器と電池との回路がオンになり、電池と駆動部との回路がオフになる第１の切り換え手段を備えるので充電台に乗物玩具車体を載せるだけで内蔵した

電池に自動的に充電される。また、前記第１の切り換え手段は、乗物玩具車体を充電台から下ろすと整流器と電池の回路がオフになり、電池と駆動部との回路がオンになるので、直ちに駆動手段により駆動できる。

【００１１】

【実施例】以下、本発明を図示の一実施例により具体的に説明する。図１乃至図８は本発明の実施例であり、図１は乗物玩具本体及び充電台の斜視図、図２は乗物玩具本体内部の機器配置を示す断面図、図３は乗物玩具本体内部の機器配置を示す平面図、図４は充電台の機器配置を示す断面図、図５は充電台の機器配置を示す平面図、図６は送信機の斜視図、図７は送信機の内部構成を示す図、図８は全体構成を示すブロック図である。

【００１２】これらの図において、本発明の電磁誘導充電方式の乗物玩具は、乗物玩具本体１０と、この乗物玩具本体１０に内蔵した電池を充電するための充電台２０と、乗物玩具本体１０をラジオ・コントロールにより操縦するための送信機３０などとからなる。

【００１３】乗物玩具本体１０は、プラスチックなどの材料を成型して形成された車体１１に左右の操縦車輪１２ａ，１２ａと左右の駆動車輪１２ｂ，１２ｂとを備えており、操縦車輪１２ａ，１２ａは操縦部１３で左右に操縦され、駆動車輪１２ｂ，１２ｂは駆動部１４の駆動モータ１４ａで駆動されるようになっている。

【００１４】車体１１のほぼ中央部の下部側には、第１電磁誘導コイル１５が配設され、また車体１１内部には、整流器１６及び充電式電池１７が配設され、さらに切換えスイッチ１８（第１切換え手段）が車体１１を充電台２０に載せたときその充電台２０に形成された突起２８に対応する位置に設けられている。この切換えスイッチ１８（第１切換え手段）は、車体１１を充電台２０に載せたとき突起２８によって押し上げられて作動し、整流器１６と電池１７との間がオンに、電池１７と受信部１９との間がオフになり、車体１１を充電台２０から下ろすと、整流器１６と電池１７との間がオフになり、電池１７と受信部１９との間がオンになるようになっている。

【００１５】充電台２０は、例えば、プラスチックなどの材料からなり、上部に車体１１を載せることができる大きさの扁平な矩形状に形成されるとともに、中央部の上部は矩形状の低い突起部２０ａが形成されている。この充電台２０の突起部２０ａの内側部分には、車体１１を突起部２０ａに合わせて充電台２０に載せたとき、第１電磁誘導コイル１５ができるだけ接近するように、これに対応する位置に第２電磁誘導コイル２１が配設され、かつこの第２電磁誘導コイル２１を制御する充電制御部（充電制御手段）２２が配設されている。また、充電台２０には、車体１１に設けられた突起２９に対応する位置にスイッチ２３（第２の切換え手段）が設けられている。このスイッチ２３（第２の切換え手段）は、車体１１を充電台２０に載せないときは主スイッチ２４と充電制御部２２との間の回路を切断し、車体１１を充電台２０に載せたときは突起２９により押し下げられて主スイッチ２４と充電制御部２２の回路を接続するようになっている。充電台２０は、スイッチ２３（第２の切換え手段）、主スイッチ２４、電線２６及び接続プラグ２５を介して商用電源に接続されるようになっている。

【００１６】送信機３０は、そのケース３１の正面側にコントロール・スティック３５ａ，３５ｂ、上部の中央部にアンテナ３２が設けられ、内部には送信部３３、この送信部３３へ電源を供給する電池３４及びスイッチ３６が設けられている。

【００１７】上記構成によれば、まず接続プラグ２５を商用電源に接続し主スイッチ２４をオンにすると、充電台２０には電源が供給されるが、乗物玩具本体１０が充電台２０の上に載っていない状態では、スイッチ２３がオフになっており充電制御部２２には電流は流れない。

【００１８】次に、乗物玩具本体１０を充電台２０の上に載せると、充電台２０のスイッチ２３は車体１１下部の突起２９により押し下げられオンになる。これにより、充電台２０には充電制御部２２を介して第２誘導コイル２１に電流が流れて誘電磁界を発生する。

【００１９】充電台２０の上に載せた車体１１の切換えスイッチ１８は、電池１７と受信部１９の回路をオフし、整流器１６を電池１７に接続する。一方、充電台２０の上に載せられた車体１１に設けられた第１の誘導コイル１５は、充電台２０の第２の誘導コイル２１に対応する位置に接近するため、この第２の誘導コイル２１の磁場により第１の誘導コイル１５に電磁誘導の原理により誘導電流が発生する。この誘導電流は整流器１６により直流に変換され、電池１７を充電する。

【００２０】このようにして乗物玩具本体１０を充電台２０の上で所定時間載せたままにしておくことにより、充電が完了する。充電が完了して乗物玩具１０を充電台２０の上から下ろすと、充電台２０のスイッチ２３は車体１１の突起２９から離れるのでオフになり、充電制御部２２、第１誘導コイル２１の電流は断たれる。また、車体１１の切換えスイッチ１８は、充電台２０の突起２８から離れて切換わり第１の誘導コイル１５及び整流器１６と電池１７の回路がオフになり、電池１７と受信部１９の回路が接続される。

【００２１】そこで、乗物玩具１０を床の上に置き、送信器３０のスイッチ３６をオンにしてコントロール・スティック３５ａ，３５ｂを操作することにより操縦、駆動の信号がアンテナ３２から送信され、この信号が車体１１側の受信部１９で受信され、操縦部１３及び駆動部１４が制御されることにより、乗物玩具１０を前進、停止、前後左右に自在に操作できる。

【００２２】なお、上記実施例では、充電台２０に車体１１を載せたときに充電が行われるようにスイッチを設

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けた例を説明したが、これらのスイッチを設けず充電台に載せる車体の方向に無関係に充電できるようにすることもできる。

【００２３】本発明の好適な実施例について説明したが、本発明の精神を逸脱しない範囲において種々の改良及び変更をなし得ることはもちろんである。

【００２４】

【発明の効果】以上説明したように、本発明の電磁誘導充電方式の乗物玩具によれば、誘導コイルと電池を内蔵した乗物玩具を充電台の上に置くだけで、電磁誘導の原理で乗物玩具に内蔵された電池に容易に充電でき、乗物玩具から電池を取り出したり乗物玩具に接続プラグを直接つないだりする必要がない。したがって、充電が極めて容易で幼児でも充電操作を行うことができ、また電池の破損の機会が少なく、プラグの腐食などによる充電不良を防止できる。さらに、充電の際の取り扱いが簡単になり幼児にも安全である。

【図面の簡単な説明】

【図１】本発明実施例の乗物玩具本体及び充電台の斜視図である。

【図２】本発明実施例の乗物玩具本体内部の機器配置を示す断面図である。

【図３】本発明実施例の乗物玩具本体内部の機器配置を示す平面図である。

【図４】本発明実施例の充電台の機器配置を示す断面図である。

【図５】本発明実施例の充電台の機器配置を示す平面図である。

【図６】本発明実施例の送信機の斜視図である。

【図７】本発明実施例の送信機の内部構成を示す図である。

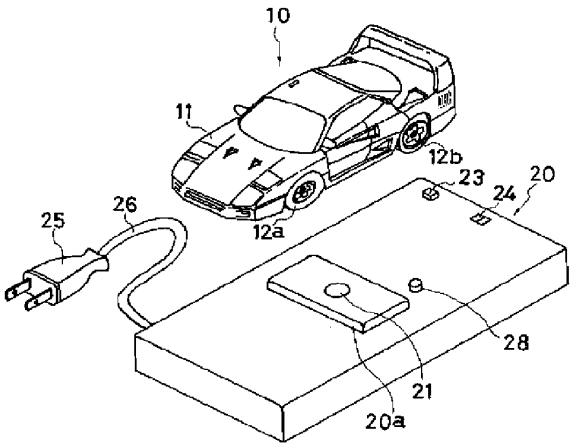
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【図８】本発明実施例の全体構成を示すブロック図である。

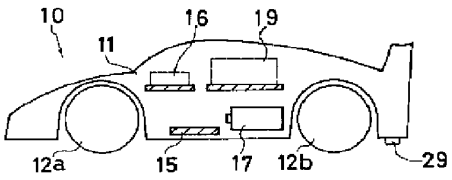
【符号の説明】

１０　乗物玩具
１１　車体
１２　車輪
１３　操縦部
１４　駆動部
１４ａ　駆動モータ
１５　第１の誘導コイル
１６　整流器
１７　電池
１８　切換えスイッチ
１９　受信部
２０　充電台
２１　第１の誘導コイル
２２　充電制御部
２３　スイッチ
２４　主スイッチ
２５　接続プラグ
２６　電線
２８　突起
２９　突起
３０　送信機
３１　ケース
３２　アンテナ
３３　送信部
３４　電池
３５　コントロール・スティック
３６　スイッチ

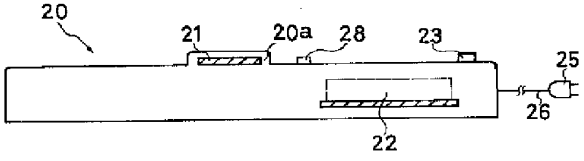
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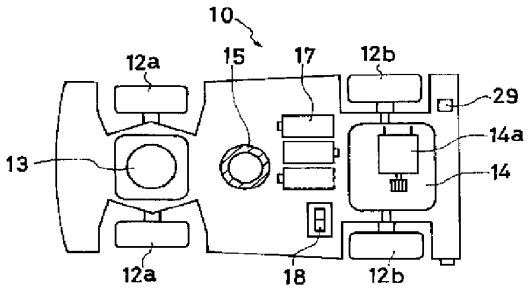
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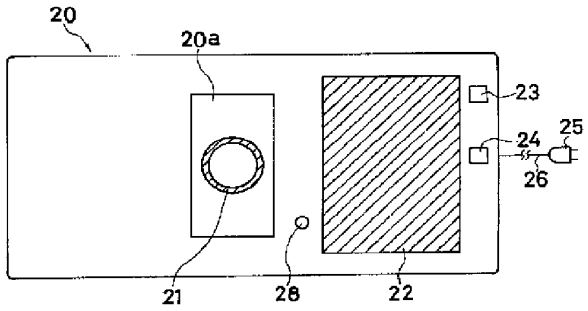
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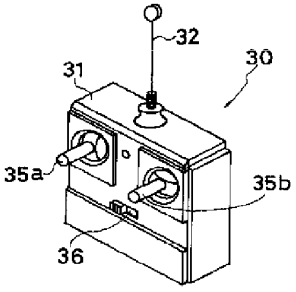
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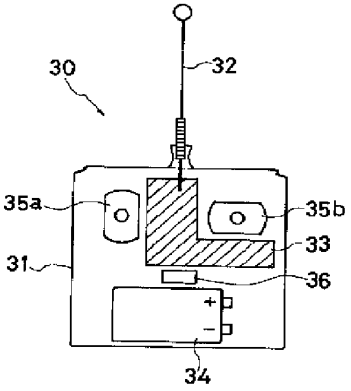
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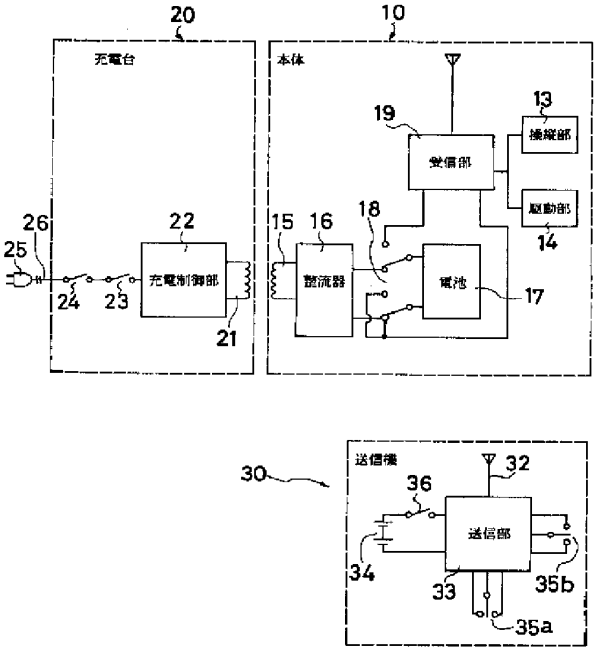
【図６】


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【図７】


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【図８】


20
充電台
10
本体
19
受信部
13
操縦部
駆動部
14
26
25
22
充電制御部
24
23
21
15
16
整流器
18
電池
17
30
送信機
32
36
送信部
34
33
35b
35a

PAT-NO: JP408000838A

DOCUMENT-IDENTIFIER: JP 08000838 A

TITLE: VEHICLE TOY OF ELECTROMAGNETIC INDUCTION CHARGING SYSTEM

PUBN-DATE: January 9, 1996

INVENTOR-INFORMATION:

NAME	COUNTRY
SUDO, SHOHEI	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
TAIYO KOGYO KK	N/A

APPL-NO: JP06159687

APPL-DATE: June 20, 1994

INT-CL (IPC): A63H030/02

ABSTRACT:

PURPOSE: To easily, safely and surely perform charging by eliminating any contact defect caused by the damage or corrosion of a charger plug by preventing a battery from being degraded in the case of charging by providing an electromagnetic induction charging means for charging the battery built in the vehicle toy with electromagnetic induction due to an external magnetic field.

CONSTITUTION: First of all, when a connection plug 25 is connected to a commercial power source and a main switch 24 is turned on, power is supplied to a charging stand 20. Next, when a main body 10 of the vehicle toy is put on the charging stand 20, a switch 23 is pushed down with a projection at the lower part of a car body 11 and turned on, a current flows through a charging control part to a second induction coil 21 of the charging stand 20, and an induction magnetic field is generated. On the other hand, since a first induction coil provided at the car body 11 put on the charging stand 20 is made closer to the position corresponding to the second induction coil 21 of the charging stand 20, with the magnetic field of this second induction coil 21, an induction current is generated at the first induction coil by the principle of electromagnetic induction. This induction current is converted to DC by a rectifier and charges the battery built in the car body 11.

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BIB DATA SHEET

CONFIRMATION NO. 4181

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/115,811	05/25/2011	320	2859	AFPA-01007US1

APPLICANTS

Afshin Partovi, Sunnyvale, CA;
Michael Sears, Ben Lomond, CA;

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

This application is a CON of 11/669,113 01/30/2007 PAT 7952322
which claims benefit of 60/763,816 01/31/2006
and claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/868,674 12/05/2006

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

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
06/07/2011

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /SAMUEL BERHANU/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	11	36	3

ADDRESS

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

TITLE

INDUCTIVE POWER SOURCE AND CHARGING SYSTEM

FILING FEE RECEIVED		
878	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S10	1191	((363/70) or (363/65) or (363/67) or (363/69)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/14 19:45
S11	646	(363/65).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/14 19:45
S13	273	S10 and battery	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:06
S14	18	S10 and (Puls$2 with battery)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:06
S15	1	S10 and (Puls$2 with apply$4 with converter)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:13
S17	2105	(Puls$2 with apply$4 with converter)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:14
S18	29	(Puls$2 with apply$4 with converter with battery)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:14
S19	11	(Appl$4 near Puls$2 with converter with battery)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 20:24
S20	153	(DElay control$4 charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 20:29
S22	10	(input delay time charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 21:01

S25	1	(input Manual$4 delay charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 21:04
S26	2	(input near delay charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 21:04
S27	2	(input near delay with charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 21:06
S28	2	(input near delay with charger)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	NEAR	ON	2009/08/14 21:06
S29	2	"US 20080180058"	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2009/08/14 21:08
S30	1	S29 and delay	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2009/08/14 21:09
S31	259	(schedule$4 period charg$4)	US-PGPUB; USPAT; USOCR; DERWENT	WITH	ON	2009/08/14 21:11
S32	18429	("320").CLAS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/14 21:11
S33	28	S31 and S32	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 21:11
S36	43	(determin$4 magnitud$4 load first power source second)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 22:07
S37	9	(determin$4 magnitud$4 differ$4 load first power source second)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 22:09
S38	33	(magnitud$4 difference load first power source second)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/14 22:11
S39	10	(difference with load with first adj power adj source with load with second adj power adj source)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/14 22:16
S46	212	(Capacitor regulat$4 charging voltage battery)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	WITH	ON	2009/08/15 09:55

			DERWENT; IBM_TDB			
S51	4397937	(display or visual or audio or LEd)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/15 10:05
S52	398	(320/108).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/15 10:05
S53	175	S51 and S52	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/15 10:05
S59	912	(320/150).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/15 10:32
S60	2	S59 and (temperature with control$4 with primary with coil)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/08/15 10:32
S61	62	(overload$4 power supply open$3 circuit breaker)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/15 17:54
S62	35	(overload$4 circuit breaker vehicle)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/15 17:56
S63	5	(overload$4 open$3 circuit breaker vehicle)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/15 17:56
S64	178	(overload$4 circuit breaker advantage)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	WITH	ON	2009/08/15 18:10
S65	2	("20040145342").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/15 18:53
S66	2	("5,925,814").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2009/08/15 18:58

3/23/2013 3:47:23 PM
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13115811	PARTOVI ET AL.
	Examiner	Art Unit
	SAMUEL BERHANU	2859

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
320	108	3/22/2013	SB
320	150	3/22/2013	SB

SEARCH NOTES		
Search Notes	Date	Examiner
EAST inventor and PLUS search conducted----------see printout	3/22/2013	SB

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

PLUS Search Results for S/N 13115811, Searched Tue Mar 19 15:32:21 EDT 2013

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/115,811	05/25/2011	Afshin Partovi	AFPA-01007US1

CONFIRMATION NO. 4181

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

PUBLICATION NOTICE

OC00000049847647

Title:INDUCTIVE POWER SOURCE AND CHARGING SYSTEM

Publication No.US-2011-0221385-A1
Publication Date:09/15/2011

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/115,811	05/25/2011	2858	878	AFPA-01007US1	36	3

CONFIRMATION NO. 4181

23910
FLIESLER MEYER LLP
650 CALIFORNIA STREET
14TH FLOOR
SAN FRANCISCO, CA 94108

FILING RECEIPT

OC000000048071938

Date Mailed: 06/10/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Afshin Partovi, Sunnyvale, CA;
Michael Sears, Ben Lomond, CA;

Assignment For Published Patent Application

MOJO MOBILITY, INC., SUNNYVALE, CA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 11/669,113 01/30/2007 PAT 7,952,322
which claims benefit of 60/763,816 01/31/2006
and claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/868,674 12/05/2006

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 06/07/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/115,811**

Projected Publication Date: 09/15/2011

Non-Publication Request: No

Early Publication Request: No
** **SMALL ENTITY** **

Title

INDUCTIVE POWER SOURCE AND CHARGING SYSTEM

Preliminary Class

320

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/115,811

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	82		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	270		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	110		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	36 minus 20 =	* 16	x 26 =	416	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 110 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	878		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

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

AMENDMENT B

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

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

INDUCTIVE POWER SOURCE AND CHARGING SYSTEM

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Claim of Priority:

[0001] This application is a continuation of U.S. Patent Application No. 11/669,113, titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", filed January 30, 2007, which claims the benefit of priority to U.S. Provisional Patent Application titled "PORTABLE INDUCTIVE POWER SOURCE", Application No. 60/763,816, filed January 31, 2006; U.S. Provisional Patent Application titled "MOBILE DEVICE, CHARGER, AND POWER SUPPLY", Application No. 60/810,262, filed June 1, 2006; U.S. Provisional Patent Application titled "MOBILE DEVICE, BATTERY, CHARGING SYSTEM, AND POWER SUPPLY SYSTEM", Application No. 60/810,298, filed June 1, 2006; and U.S. Provisional Patent Application titled "SYSTEM AND METHOD FOR PROVIDING AND USING A PORTABLE INDUCTIVE POWER SOURCE", Application No. 60/868,674, filed December 5, 2006; each of which applications are hereby incorporated by reference herein.

Field of the Invention:

[0002] The invention is related generally to power supplies and other power sources, and particularly to a portable inductive power source.

Background:

[0003] There is currently a need for powering portable or mobile devices for use in commercial, business, personal, consumer, and other applications. Examples of such devices include cellular telephones, personal digital assistants (PDAs), notebook computers, mobile email devices, Blackberry devices, Bluetooth headsets, music players (for example, MP3 players), radios, compact disk players, video game consoles, digital cameras, electric shavers, and electric toothbrushes. Most of these devices include a rechargeable internal battery that must be first charged by an external power supply or charger, before the device itself can be used. The power supply typically provides direct current (DC) voltage through a special connector to the device. The power supply can then be disconnected, and the device will continue to run for a short period of time until the battery is depleted. The voltage and power requirements of the different devices vary,

and to date there is currently no standardized connector for the devices. As a result of this, each mobile device is invariably sold or distributed bundled with its own charger. The costs associated with these multiple different types and numbers of charger are paid by the consumer indirectly by being incorporated into the prices being charged for the mobile device.

[0004] The rapid increase in the total number and variety of mobile products has meant that most people have several of the above-mentioned devices. In a typical day, that user would have to separately connect their multiple devices to each of their appropriate chargers for charging of each device. In addition, many people find it necessary to charge their devices in different locations such as their offices and cars. Thus, many users have purchased additional chargers for their offices and cars, for use in charging their mobile phones, notebook computers, and music players in those locations.

[0005] It will be evident that the above situation has caused typical users to have a multitude of incompatible devices (i.e. power supplies and chargers) that essentially provide the same function of charging a mobile device, but because of the number and variety that must be kept by the user are inconvenient to use. In many situations, users simply forget to charge their devices, or else find they need to recharge their device in situations where no appropriate charger is available. This leads to loss of ability to use the device when desired or needed.

[0006] In addition, when traveling away from home, mobile users have a particular problem in that they need to pack and carry the multiple chargers for their devices. In many situations, these chargers are bulkier and heavier than the devices themselves, and use of these devices in foreign countries requires clumsy adaptors, and sometimes voltage converters. This leads to a high degree of inconvenience for the ever-more-mobile consumer.

[0007] In addition, the power connector for the mobile devices is often cheaply manufactured, and a source of mechanical and electrical failure. In many applications, such as toothbrushes or applications where the device is exposed to water and needs to be hermetically sealed, such a physical connection can not be used. Thus an alternative means of powering those types of devices must be used.

[0008] Several products have tried to address this situation. Some companies propose the use of a universal charger that consists of a power supply base unit, and interchangeable tips that both fit into the base unit and in turn fit different devices. The tip includes a customized regulator that sets the voltage required by the particular device. However, a user must carry the multiple tips he or she needs for each of the various devices they have, and then charge each device serially by connecting the device to the power supply. While this product reduces the overall weight of the charging tools the user must carry, the user still needs to carry and exchange the tips to connect to different devices. In addition, the charging of multiple devices simultaneously is often not possible.

[0009] Realizing that a power supply typically contains a transformer for voltage conversion, another approach is to split the transformer into two parts: a first part can contain the first winding and the electronics to drive this winding at the appropriate operating frequency, while the second part consists of a winding where power is received and then rectified to obtain DC voltage. If the two parts are brought into physical proximity to each other, power is transformed from the first part to the second inductively, i.e. by induction, without any physical electrical connection. This is the approach that is used in many electrical toothbrushes, shavers, and other products that are expected to be used in wet environments. However, a common problem with such inductive units is that the windings are bulky, which restricts their use in lightweight portable devices. Furthermore, to achieve adequate power transfer, the parts must be designed to fit together suitably so that their windings are closely aligned. This is typically done by molding the device casing (for example, an electric toothbrush) and its charger/holder so that they fit together in only one suitable way. However, the molded base and shape of the portable device means they cannot be used in a universal fashion to power other devices.

[0010] Some companies have proposed pad-like charging devices based on inductive concepts, but that also ostensibly allow for different types of devices to be charged. These pads typically includes grids of wires in an x and y direction, that carry an electrical current, and that generate a uniform magnetic field parallel to the surface of the pad. A secondary coil wound around a magnetic core lies on the surface of the pad and picks up the magnetic field parallel to the surface, and in this manner energy can be transferred. However, each of these methods suffer from poor power transfer, in that most of the power in the primary is not picked up in the secondary, and thus the overall power efficiency of the charger is very low. In addition, the magnetic cores used for the primary and secondary are often bulky and add to the total cost and size of the system, and limit incorporation into many devices.

[0011] Another point to note is that, while all of the above devices allow a user to charge a device, they also require the charging device or base unit to be electrically connected to a power source, such as a power outlet or a DC source. In many cases, the user may not have access to such a power source such as when traveling, camping, or working in an area without access to power. However, to date, no device has been provided that is portable, and that allows for inductive charging of multiple devices with differing power requirements, and which itself can be intermittently or occasionally charged either by an external power source, or by other means, or that is self-powered or includes its own power source.

Summary:

[0012] A portable inductive power source, power device, or unit, for use in powering or

charging electrical, electronic, battery-operated, mobile, and other devices is disclosed herein. In accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device. The receiver may comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

[0013] In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device, or to communicate information to the pad. In additional embodiments, the system can provide for additional functionality such as communication of data stored in the electronic device or to be transferred to the device. Some embodiments may also incorporate efficiency measures that improve the efficiency of power transfer between the charger and receiver, and ultimately to the mobile device. In accordance with an embodiment the device includes an internal battery for self-powered operation. In accordance with other embodiments the device can include a solar cell power source, hand crank, or other means of power supply for occasional self powered operation. Other embodiments can be incorporated into charging kiosks, automobiles, and other applications.

Brief Description of the Figures:

[0014] **Figure 1** shows a pad using multiple receiver / energizer coils in accordance with an embodiment of the invention.

[0015] **Figure 2** shows a figure of a circuit diagram in accordance with an embodiment of the invention.

[0016] **Figure 3** shows a charging pad using multiple coils in accordance with an embodiment of the invention..

[0017] **Figure 4** shows a charging pad using multiple overlapping coil layers in accordance with an embodiment of the invention.

[0018] **Figure 5** shows the use of multiple coil types and sizes in overlapping pad layers in accordance with an embodiment of the invention..

[0019] **Figure 6** shows a receiver with an integrated battery in accordance with an embodiment of the invention..

[0020] **Figure 7** shows a coupling of receiver with a device to be charged in accordance with an embodiment of the invention..

[0021] **Figure 8** shows a pad allowing modular or multiple connectivity in accordance with

an embodiment of the invention.

[0022] **Figure 9** shows a figure of a circuit diagram in accordance with an embodiment of the invention.

[0023] **Figure 10** shows a figure of a circuit diagram in accordance with an embodiment of the invention.

[0024] **Figure 11** shows a figure of a circuit diagram in accordance with an embodiment of the invention.

[0025] **Figure 12** shows a figure of power transfer chart in accordance with an embodiment of the invention.

[0026] **Figure 13** shows a figure of a coil layout in accordance with an embodiment of the invention.

[0027] **Figure 14** shows a figure of a coil layout in accordance with an embodiment of the invention.

[0028] **Figure 15** shows a figure of a charging pad with multiple coils in accordance with an embodiment of the invention.

[0029] **Figure 16** shows a figure of a charging pad with movable coils in accordance with an embodiment of the invention.

[0030] **Figure 17** shows a figure of a circuit diagram in accordance with an embodiment of the invention.

[0031] **Figure 18** shows an illustration of a means of stacking coils, in accordance with an embodiment of the invention.

[0032] **Figure 19** shows an illustration of a device for inductive power charging that includes an internal battery for self-powered operation, in accordance with an embodiment of the invention.

[0033] **Figure 20** shows an illustration of an inductive charger unit with a solar cell power source for self powered operation, in accordance with an embodiment of the invention.

[0034] **Figure 21** shows an illustration of an inductive charger unit with an incorporated communications and/or storage unit, in accordance with an embodiment of the invention.

[0035] **Figure 22** shows an illustration of a kiosk that incorporates an inductive charger unit in accordance with an embodiment of the invention.

Detailed Description:

[0036] A portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices is disclosed herein. In accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar

base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. In some embodiments the pad can also contain various signaling, and switching or communication circuitry, or means of identifying the presence of devices to be charged. In some embodiments the pad can also contain multiple coils or sections to charge various devices or to allow charging of devices placed anywhere on the pad. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device. The receiver can comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

[0037] In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device. In some embodiments, the receiver can also contain circuitry to sense and determine the status of the electronic device to be charged, the battery inside, or a variety of other parameters and to communicate this information to the pad. In additional embodiments, the system can provide for additional functionality such as communication of data stored in the electronic device (for example, digital images stored in cameras, telephone numbers in cell phones, songs in MP3 players) or data into the device.

[0038] Embodiments can also incorporate efficiency measures that improve the efficiency of power transfer between the charger and receiver, and ultimately to the mobile device. In accordance with an embodiment, the charger or power supply comprises a switch, (for example, a MOSFET device or another switching mechanism), that is switched at an appropriate frequency to generate an alternative current (AC) voltage across a primary coil, and generates an AC magnetic field. This field in turn generates a voltage in the coil in the receiver that is rectified and then smoothed by a capacitor to provide power to a load, with the result being greater efficiency.

[0039] In accordance with other embodiments the coils are mounted such that they can move laterally within the pad and within an area of their segments, while continuing to be connected to their driver electronics placed on the edges of the area. The floating coils and the drive circuit are sandwiched in between thin upper and lower cover layers that act to allow the coils lateral movement while limiting vertical movement. When a secondary is placed on the pad, the pad senses the position of the secondary coil and moves the coils to the right position to optimize power transfer. Magnets can be used to better orient the coils and improve greater power transfer efficiency.

[0040] Additional embodiments are also described herein. For example, in accordance with an embodiment the device includes an internal battery for self-powered operation. In accordance