and plotted as single point on the contour plot in Fig. 21a. We refer to this point as the optimum energy transfer (%) in the adiabatic-κ case for the particular (κ/Γ_B, Γ_B/Γ_A) under consideration. We also plot in Fig. 21d the corresponding value of the total energy lost (%) at the optimum of E_2. We repeat these calculations for all pairs (κ/Γ_B, Γ_B/Γ_A) shown in the contour plots. In the constant-κ transfer case, for each (κ/Γ_B, Γ_B/Γ_A), the time evolution of E_2(%) and E_{lost} are calculated for $0<t<2/\kappa$, and optimum transfer, shown in Fig. 21b, refers to the maximum of $E_3(t)$ over $0<t<2/\kappa$. The corresponding total energy lost at optimum constant-transfer is shown in Fig. 21e. Now that we calculated the energies of interest as functions of (κ/Γ_B, Γ_B/Γ_A), we look for ranges of the relevant parameters in which the adiabatic-κ transfer has advantages over the constant-κ one. So, we plot the ratio of $(E_2)_{adiabatic\text{-}\kappa}/(E_2)_{constant\text{-}\kappa}$ in Fig. 21c, and $(E_{lost})_{constant\text{-}\kappa}/(E_{lost})_{adiabatic\text{-}\kappa}$ in Fig. 21f. We find that, for $\Gamma_B/\Gamma_A>50$, the optimum energy transferred in the adiabatic-κ case exceeds that in the constant-κ case, and the improvement factor can be larger than 2. From Fig. 21f, one sees that the adiabatic-κ scheme can reduce the total energy lost by factor of 3 compared to the constant-κ scheme, also in the range $\Gamma_B/\Gamma_A>50$. As in the constant-κ case, also in the adiabatic-κ case the efficiency increases as the ratio of the maximum value, κ, of the coupling rates to the loss rate of the intermediate object (and thus also the first and second objects for $\Gamma_B/\Gamma_A>1$) increases. In some examples, one may design a system so that κ is larger than each of Γ_B and Γ_A. In some examples, one may design a system so that κ is at least 2 times larger than each of Γ_B and Γ_A. In some examples, one may design a system so that κ is at least 4 times larger than each of Γ_B and Γ_A.

Although one may be interested in reducing the total energy lost (radiated + absorbed) as much as possible in order to make the transfer more efficient, the undersirable nature of the radiated energy may make it important to consider reducing the energy radiated. For this purpose, we calculate the energy radiated at optimum transfer in both the adiabatic-κ and constant-κ schemes, and compare them. The relevant parameters in this case are κ/Γ_B, Γ_B/Γ_A, $\Gamma_{rad}^{A}/\Gamma_A$, and $\Gamma_{rad}^{B}/\Gamma_B$. The problem is more complex

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because the parameter space is now 4-dimensional. So we focus on those particular cross sections that can best reveal the most important differences between the two schemes. From Fig. 21c and 21f, one can guess that the best improvement in both E_2 and E_{lost} occurs for $\Gamma_B/\Gamma_A \geq 500$. Moreover, knowing that it is the intermediate object R_B that makes the main difference between the adiabatic-κ and constant-κ schemes, being "energy-empty" in the adiabatic-κ case and "energy-full" in the constant-κ one, we first look at the special situation where $\Gamma^A_{rad}=0$. In Fig. 22a and Fig. 22b, we show contour plots of the energy radiated at optimum transfer, in the constant-κ and adiabatic-κ schemes respectively, for the particular cross section having $\Gamma_B/\Gamma_A=500$ and $\Gamma^A_{rad}=0$. Comparing these two figures, one can see that, by using the adiabatic-κ scheme, one can reduce the energy radiated by factor of 6.3 or more.

To get quantitative estimate of the radiation reduction factor in the general case where $\Gamma_{A,rad} \neq 0$, we calculate the ratio of energies radiated at optimum transfers in both schemes, namely,

$$\frac{(E_{rad})_{\text{constant}-\kappa}}{(E_{rad})_{\text{adiabatic}-\kappa}} = \frac{2\int_0^{t_*^{\text{constant}-\kappa}} \left\{ \frac{\Gamma^B_{rad}}{\Gamma^A_{rad}} \left| a_B^{\text{constant}-\kappa}(t) \right|^2 + \left| a_1^{\text{constant}-\kappa}(t) \right|^2 + \left| a_2^{\text{constant}-\kappa}(t) \right|^2 \right\}}{2\int_0^{t_*^{\text{adiabatic}-\kappa}} \left\{ \frac{\Gamma^B_{rad}}{\Gamma^A_{rad}} \left| a_B^{\text{adiabatic}-\kappa}(t) \right|^2 + \left| a_1^{\text{adiabatic}-\kappa}(t) \right|^2 + \left| a_2^{\text{adiabatic}-\kappa}(t) \right|^2 \right\}} \quad (46)$$

which depends only on $\Gamma^B_{rad}/\Gamma^A_{rad}$, the time-dependent mode amplitudes, and the optimum transfer times in both schemes. The latter two quantities are completely determined by κ/Γ_B and Γ_B/Γ_A. Hence the only parameters relevant to the calculations of the ratio of radiated energies are $\Gamma^B_{rad}/\Gamma^A_{rad}$, κ/Γ_B and Γ_B/Γ_A, thus reducing the dimensionality of the investigated parameter space from down to 3. For convenience, we multiply the first relevant parameter $\Gamma^B_{rad}/\Gamma^A_{rad}$ by Γ_B/Γ_A which becomes $(\Gamma^B_{rad}/\Gamma_B)/(\Gamma^A_{rad}/\Gamma_A)$, i.e. the ratio of quantities that specify what percentage of each object's loss is radiated. Next, we

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calculate the ratio of energies radiated as function of $(\Gamma^{B}_{rad}/\Gamma_B)/(\Gamma^{A}_{rad}/\Gamma_A)$ and κ/Γ_B in the two special cases $\Gamma_B/\Gamma_A=50$, and $\Gamma_B/\Gamma_A=500$, and plot them in Fig. 22c and Fig. 22d, respectively. We also show, in Fig. 22e, the dependence of $(E_{rad})_{constant\text{-}\kappa}/(E_{rad})_{EIT\text{-}like}$ on κ/Γ_B and Γ_B/Γ_A, for the special case $\Gamma^{A}_{rad}=0$. As can be seen from Fig. 22c-22d, the adiabatic-κ scheme is less radiative than the constant-κ scheme whenever $\Gamma^{B}_{rad}/\Gamma_B$ is larger than $\Gamma^{A}_{rad}/\Gamma_A$, and the radiation reduction ratio increases as Γ_B/Γ_A and κ/Γ_B are increased (see fig. 22e). In some examples, the adiabatic-κ scheme is less radiative than the constant-κ scheme whenever $\Gamma^{B}_{rad}/\Gamma^{A}_{rad}$ is larger than about 20. In some examples, the adiabatic-κ scheme is less radiative than the constant-κ scheme whenever $\Gamma^{B}_{rad}/\Gamma^{A}_{rad}$ is larger than about 50.

It is to be understood that while three resonant objects are shown in the previous examples, other examples can feature four or more resonant objects. For example, in some examples, a single source object can transfer energy to multiple device objects through one intermediate object. In some examples, energy can be transferred from a source resonant object to a device resonant object, through two or more intermediate resonant objects, and so forth.

6. System Sensitivity to Extraneous Objects

In general, the overall performance of an example of the resonance-based wireless energy-transfer scheme depends strongly on the robustness of the resonant objects' resonances. Therefore, it is desirable to analyze the resonant objects' sensitivity to the near presence of random non-resonant extraneous objects. One appropriate analytical model is that of "perturbation theory" (PT), which suggests that in the presence of an extraneous perturbing object p the field amplitude $a_1(t)$ inside the resonant object 1 satisfies, to first order:

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$$\frac{da_1}{dt} = -i(\omega_1 - i\Gamma_1)a_1 + i\left(\delta\kappa_{11(p)} + i\delta\Gamma_{1(p)}\right)a_1 \qquad (47)$$

where again ω_1 is the frequency and Γ_1 the intrinsic (absorption, radiation etc.) loss rate, while $\delta\kappa_{11(p)}$ is the frequency shift induced onto 1 due to the presence of p and $\delta\Gamma_{1(p)}$ is the extrinsic due to p (absorption inside p, scattering from p etc.) loss rate. $\delta\Gamma_{1(p)}$ is defined as $\delta\Gamma_{1(p)} \equiv \Gamma_{1(p)} - \Gamma_1$, where $\Gamma_{1(p)}$ is the total perturbed loss rate in the presence of p. The first-order PT model is valid only for small perturbations. Nevertheless, the parameters $\delta\kappa_{11(p)}$, $\delta\Gamma_{1(p)}$ are well defined, even outside that regime, if a_1 is taken to be the amplitude of the exact perturbed mode. Note also that interference effects between the radiation field of the initial resonant-object mode and the field scattered off the extraneous object can for strong scattering (e.g. off metallic objects) result in total $\Gamma_{1,rad(p)}$ that are smaller than the initial $\Gamma_{1,rad}$ (namely $\delta\Gamma_{1,rad(p)}$ is negative).

It has been shown that a specific relation is desired between the resonant frequencies of the source and device-objects and the driving frequency. In some examples, all resonant objects must have the same eigenfrequency and this must be equal to the driving frequency. In some implementations, this frequency-shift can be "fixed" by applying to one or more resonant objects and the driving generator a feedback mechanism that corrects their frequencies. In some examples, the driving frequency from the generator can be fixed and only the resonant frequencies of the objects can be tuned with respect to this driving frequency.

The resonant frequency of an object can be tuned by, for example, adjusting the geometric properties of the object (e.g. the height of a self-resonant coil, the capacitor plate spacing of a capacitively-loaded loop or coil, the dimensions of the inductor of an inductively-loaded rod, the shape of a dielectric disc, etc.) or changing the position of a non-resonant object in the vicinity of the resonant object.

In some examples, referring to Fig. 23a, each resonant object is provided with an oscillator at fixed frequency and a monitor which determines the eigenfrequency of the object. At least one of the oscillator and the monitor is coupled to a frequency adjuster which can adjust the frequency of the resonant object. The frequency adjuster determines

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the difference between the fixed driving frequency and the object frequency and acts, as described above, to bring the object frequency into the required relation with respect to the fixed frequency. This technique assures that all resonant objects operate at the same fixed frequency, even in the presence of extraneous objects.

In some examples, referring to Fig. 23(b), during energy transfer from a source object to a device object, the device object provides energy or power to a load, and an efficiency monitor measures the efficiency of the energy-transfer or power-transmission. A frequency adjuster coupled to the load and the efficiency monitor acts, as described above, to adjust the frequency of the object to maximize the efficiency.

In other examples, the frequency adjusting scheme can rely on information exchange between the resonant objects. For example, the frequency of a source object can be monitored and transmitted to a device object, which is in turn synched to this frequency using frequency adjusters, as described above. In other embodiments the frequency of a single clock can be transmitted to multiple devices, and each device then synched to that frequency using frequency adjusters, as described above.

Unlike the frequency shift, the extrinsic perturbing loss due to the presence of extraneous perturbing objects can be detrimental to the functionality of the energy-transfer scheme, because it is difficult to remedy. Therefore, the total perturbed quality factors $Q_{(p)}$ (and the corresponding perturbed strong-coupling factor $U_{(p)}$ should be quantified.

In some examples, a system for wireless energy-transfer uses primarily magnetic resonances, wherein the energy stored in the near field in the air region surrounding the resonator is predominantly magnetic, while the electric energy is stored primarily inside the resonator. Such resonances can exist in the quasi-static regime of operation ($r \ll \lambda$) that we are considering: for example, for coils with $h \ll 2r$, most of the electric field is localized within the self-capacitance of the coil or the externally loading capacitor and, for dielectric disks, with $\epsilon \gg 1$ the electric field is preferentially localized inside the disk. In some examples, the influence of extraneous objects on magnetic resonances is nearly absent. The reason is that extraneous non-conducting objects p that could interact with the magnetic field in the air region surrounding the resonator and act as a perturbation to

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the resonance are those having significant magnetic properties (magnetic permeability $Re(\mu)>1$ or magnetic loss $Im(\mu)>0$). Since almost all every-day non-conducting materials are non-magnetic but just dielectric, they respond to magnetic fields in the same way as free space, and thus will not disturb the resonance of the resonator. Extraneous conducting materials can however lead to some extrinsic losses due to the eddy currents induced inside them or on their surface (depending on their conductivity). However, even for such conducting materials, their presence will not be detrimental to the resonances, as long as they are not in very close proximity to the resonant objects.

The interaction between extraneous objects and resonant objects is reciprocal, namely, if an extraneous object does not influence a resonant object, then also the resonant object does not influence the extraneous object. This fact can be viewed in light of safety considerations for human beings. Humans are also non-magnetic and can sustain strong magnetic fields without undergoing any risk. A typical example, where magnetic fields $B\sim 1T$ are safely used on humans, is the Magnetic Resonance Imaging (MRI) technique for medical testing. In contrast, the magnetic near-field required in typical embodiments in order to provide a few Watts of power to devices is only $B\sim 10^{-4}T$, which is actually comparable to the magnitude of the Earth's magnetic field. Since, as explained above, a strong electric near-field is also not present and the radiation produced from this non-radiative scheme is minimal, the energy-transfer apparatus, methods and systems described herein is believed safe for living organisms.

An advantage of the presently proposed technique using adiabatic variations of the coupling rates between the first and intermediate resonators and between the intermediate and second resonators compared to a mode of operation where these coupling rates are not varied but are constant is that the interactions of the intermediate resonator with extraneous objects can be greatly reduced with the presently proposed scheme. The reason is once more the fact that there is always a substantially small amount of energy in the intermediate resonator in the adiabatic-κ scheme, therefore there is little energy that can be induced from the intermediate object to an extraneous object in its vicinity. Furthermore, since the losses of the intermediate resonator are substantially

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avoided in the adiabatic-κ case, the system is less immune to potential reductions of the quality factor of the intermediate resonator due to extraneous objects in its vicinity.

6.1 Capacitively-loaded conducting loops or coils

In some examples, one can estimate the degree to which the resonant system of a capacitively-loaded conducting-wire coil has mostly magnetic energy stored in the space surrounding it. If one ignores the fringing electric field from the capacitor, the electric and magnetic energy densities in the space surrounding the coil come just from the electric and magnetic field produced by the current in the wire; note that in the far field, these two energy densities must be equal, as is always the case for radiative fields. By using the results for the fields produced by a subwavelength ($r \ll \lambda$) current loop (magnetic dipole) with $h = 0$, we can calculate the ratio of electric to magnetic energy densities, as a function of distance D_p from the center of the loop (in the limit $r \ll D_p$) and the angle θ with respect to the loop axis:

$$\frac{w_e(x)}{w_m(x)} = \frac{\varepsilon_o |E(x)|^2}{\mu_o |H(x)|^2} = \frac{\left(1+\frac{1}{x^2}\right)\sin^2\theta}{\left(\frac{1}{x^2}+\frac{1}{x^4}\right)4\cos^2\theta + \left(1-\frac{1}{x^2}+\frac{1}{x^4}\right)\sin^2\theta}; \; x = 2\pi\frac{D_p}{\lambda}$$
$$\Rightarrow \frac{\oiint_{S_p} w_e(x)\,dS}{\oiint_{S_p} w_m(x)\,dS} = \frac{1+\frac{1}{x^2}}{1+\frac{1}{x^2}+\frac{3}{x^4}}; \; x = 2\pi\frac{D_p}{\lambda} \qquad (48)$$

where the second line is the ratio of averages over all angles by integrating the electric and magnetic energy densities over the surface of a sphere of radius D_p. From Eq.(48) it is obvious that indeed for all angles in the near field ($x \ll 1$) the magnetic energy density is dominant, while in the far field ($x \gg 1$) they are equal as they should be. Also, the preferred positioning of the loop is such that objects which can interfere with its resonance lie close to its axis ($\theta = 0$), where there is no electric field. For example, using the systems described in Table 4, we can estimate from Eq.(48) that for the loop of $r = 30cm$ at a distance $D_p = 10r = 3m$ the ratio of average electric to average magnetic

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energy density would be $\sim 12\%$ and at $D_p = 3r = 90cm$ it would be $\sim 1\%$, and for the loop of $r = 10cm$ at a distance $D_p = 10r = 1m$ the ratio would be $\sim 33\%$ and at $D_p = 3r = 30cm$ it would be $\sim 2.5\%$. At closer distances this ratio is even smaller and thus the energy is predominantly magnetic in the near field, while in the radiative far field, where they are necessarily of the same order (ratio $\rightarrow 1$), both are very small, because the fields have significantly decayed, as capacitively-loaded coil systems are designed to radiate very little. Therefore, this is the criterion that qualifies this class of resonant system as a magnetic resonant system.

To provide an estimate of the effect of extraneous objects on the resonance of a capacitively-loaded loop including the capacitor fringing electric field, we use the perturbation theory formula, stated earlier, $\delta\Gamma_{1,abs(p)} = \omega_1 / 4 \cdot \int d^3\mathbf{r}\, \mathrm{Im}\{\varepsilon_p(\mathbf{r})\}|\mathbf{E}_1(\mathbf{r})|^2 / W$ with the computational FEFD results for the field of an example like the one shown in the plot of Fig. 5 and with a rectangular object of dimensions *30cm x 30cm x 1.5m* and permittivity ε=*49+16i* (consistent with human muscles) residing between the loops and almost standing on top of one capacitor (~*3cm* away from it) and find $\delta Q_{abs(human)} \sim 10^5$ and for ~*10cm* away $\delta Q_{abs(human)} \sim 5 \cdot 10^5$. Thus, for ordinary distances (~*1m*) and placements (not immediately on top of the capacitor) or for most ordinary extraneous objects p of much smaller loss-tangent, we conclude that it is indeed fair to say that $\delta Q_{abs(p)} \rightarrow \infty$. The only perturbation that is expected to affect these resonances is a close proximity of large metallic structures.

Self-resonant coils can be more sensitive than capacitively-loaded coils, since for the former the electric field extends over a much larger region in space (the entire coil) rather than for the latter (just inside the capacitor). On the other hand, self-resonant coils can be simple to make and can withstand much larger voltages than most lumped capacitors. Inductively-loaded conducting rods can also be more sensitive than capacitively-loaded coils, since they rely on the electric field to achieve the coupling.

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6.2 Dielectric disks

For dielectric disks, small, low-index, low-material-loss or far-away stray objects will induce small scattering and absorption. In such cases of small perturbations these extrinsic loss mechanisms can be quantified using respectively the analytical first-order perturbation theory formulas

$$\left[\delta Q_{1,rad(p)}\right]^{-1} \equiv 2\delta\Gamma_{1,rad(p)} / \omega_1 \propto \int d^3\mathbf{r}\left[\mathrm{Re}\left\{\varepsilon_p(\mathbf{r})\right\}\left|\mathbf{E}_1(\mathbf{r})\right|\right]^2 \Big/ W$$

$$\left[\delta Q_{1,abs(p)}\right]^{-1} \equiv 2\delta\Gamma_{1,abs(p)} / \omega_1 = \int d^3\mathbf{r}\,\mathrm{Im}\left\{\varepsilon_p(\mathbf{r})\right\}\left|\mathbf{E}_1(\mathbf{r})\right|^2 \Big/ 2W$$

where $W = \int d^3\mathbf{r}\varepsilon(\mathbf{r})\left|\mathbf{E}_1(\mathbf{r})\right|^2 / 2$ is the total resonant electromagnetic energy of the unperturbed mode. As one can see, both of these losses depend on the square of the resonant electric field tails **E**1 at the site of the extraneous object. In contrast, the coupling factor from object 1 to another resonant object 2 is, as stated earlier,

$$k_{12} = 2\kappa_{12} / \sqrt{\omega_1\omega_2} \approx \int d^3\mathrm{r}\varepsilon_2(\mathrm{r})\mathrm{E}_2^*(\mathrm{r})\mathrm{E}_1(\mathrm{r}) / \int d^3\mathrm{r}\varepsilon(\mathrm{r})\left|\mathrm{E}_1(\mathrm{r})\right|^2$$

and depends *linearly* on the field tails $\mathbf{E}_1$ of 1 inside 2. This difference in scaling gives us confidence that, for, for example, exponentially small field tails, coupling to other resonant objects should be much faster than all extrinsic loss rates ($\kappa_{12} \gg \delta\Gamma_{1,2(p)}$), at least for small perturbations, and thus the energy-transfer scheme is expected to be sturdy for this class of resonant dielectric disks.

However, we also want to examine certain possible situations where extraneous objects cause perturbations too strong to analyze using the above first-order perturbation theory approach. For example, we place a dielectric disk close to another off-resonance object of large Re{ε}, Im{ε} and of same size but different shape (such as a human being *h*), as shown in Fig. 24a, and a roughened surface of large extent but of small Re{ε}, Im{ε} (such as a wall *w*), as shown in Fig. 24b. For distances $D_{h,w} / r = 10-3$ between the disk-center and the "human"-center or "wall", the numerical FDFD simulation results presented in Figs. 24a and 24b suggest that, the disk resonance seems to be fairly robust,

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since it is not detrimentally disturbed by the presence of extraneous objects, with the exception of the *very* close proximity of high-loss objects. To examine the influence of large perturbations on an entire energy-transfer system we consider two resonant disks in the close presence of both a "human" and a "wall". Comparing Table 8 to the table in Figure 24c, the numerical FDFD simulations show that the system performance deteriorates from $U \sim 1-50$ to $U_{(hw)} \sim 0.5-10$, i.e. only by acceptably small amounts.

In general, different examples of resonant systems have different degree of sensitivity to external perturbations, and the resonant system of choice depends on the particular application at hand, and how important matters of sensitivity or safety are for that application. For example, for a medical implantable device (such as a wirelessly powered artificial heart) the electric field extent must be minimized to the highest degree possible to protect the tissue surrounding the device. In such cases where sensitivity to external objects or safety is important, one should design the resonant systems so that the ratio of electric to magnetic energy density w_e / w_m is reduced or minimized at most of the desired (according to the application) points in the surrounding space.

7 Applications

The non-radiative wireless energy transfer techniques described above can enable efficient wireless energy-exchange between resonant objects, while suffering only modest transfer and dissipation of energy into other extraneous off-resonant objects. The technique is general, and can be applied to a variety of resonant systems in nature. In this Section, we identify a variety of applications that can benefit from or be designed to utilize wireless power transmission.

Remote devices can be powered directly, using the wirelessly supplied power or energy to operate or run the devices, or the devices can be powered by or through or in addition to a battery or energy storage unit, where the battery is occasionally being charged or re-charged wirelessly. The devices can be powered by hybrid battery/energy storage devices such as batteries with integrated storage capacitors and the like. Furthermore, novel battery and energy storage devices can be designed to take advantage of the operational improvements enabled by wireless power transmission systems.

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Devices can be turned off and the wirelessly supplied power or energy used to charge or recharge a battery or energy storage unit. The battery or energy storage unit charging or recharging rate can be high or low. The battery or energy storage units can be trickle charged or float charged. It would be understood by one of ordinary skill in the art that there are a variety of ways to power and/or charge devices, and the variety of ways could be applied to the list of applications that follows.

Some wireless energy transfer examples that can have a variety of possible applications include for example, placing a source (e.g. one connected to the wired electricity network) on the ceiling of a room, while devices such as robots, vehicles, computers, PDAs or similar are placed or move freely within the room. Other applications can include powering or recharging electric-engine buses and/or hybrid cars and medical implantable devices. Additional example applications include the ability to power or recharge autonomous electronics (e.g. laptops, cell-phones, portable music players, house-hold robots, GPS navigation systems, displays, etc), sensors, industrial and manufacturing equipment, medical devices and monitors, home appliances (e.g. lights, fans, heaters, displays, televisions, counter-top appliances, etc.), military devices, heated or illuminated clothing, communications and navigation equipment, including equipment built into vehicles, clothing and protective-wear such as helmets, body armor and vests, and the like, and the ability to transmit power to physically isolated devices such as to implanted medical devices, to hidden, buried, implanted or embedded sensors or tags, to and/or from roof-top solar panels to indoor distribution panels, and the like.

A number of examples of the invention have been described. Nevertheless, it will be understood that various modifications can be made without departing from the spirit and scope of the invention.

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WHAT IS CLAIMED IS:

1. A method for transferring energy wirelessly, the method comprising:

transferring energy wirelessly from a first resonator structure to an intermediate resonator structure, wherein the coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B};

transferring energy wirelessly from the intermediate resonator structure to a second resonator structure, wherein the coupling rate between the intermediate resonator structure and the second resonator structure is κ_{B2}; and

during the wireless energy transfers, adjusting at least one of the coupling rates κ_{1B} and κ_{B2} to reduce energy accumulation in the intermediate resonator structure and improve wireless energy transfer from the first resonator structure to the second resonator structure through the intermediate resonator structure.

2. The method of claim 1, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} minimizes energy accumulation in the intermediate resonator structure and causes wireless energy transfer from the first resonator structure to the second resonator structure.

3. The method of claims 1 or 2, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} maintains energy distribution in the field of the three-resonator system in an eigenstate having substantially no energy in the intermediate resonator structure.

4. The method of claim 3, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} further causes the eigenstate to evolve substantially adiabatically from an initial state with substantially all energy in the resonator structures in the first resonator structure to a final state with substantially all of the energy in the resonator structures in the second resonator structure.

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5. The method of any of claims 1 to 4, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjustments of both coupling rates κ_{1B} and κ_{B2} during wireless energy transfer.

6. The method of claim 1, wherein the resonator structures each have a quality factor larger than 10.

7. The method of any of the preceding claims, wherein resonant energy in each of the resonator structures comprises electromagnetic fields.

8. The method of claim 7, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} for inductive coupling between the intermediate resonator structure and each of the first and second resonator structures are each larger than twice the loss rate Γ for each of the first and second resonators.

9. The method of claim 8, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} for inductive coupling between the intermediate resonator structure and each of the first and second resonator structures are each larger than four (4) times the loss rate Γ for each of the first and second resonators.

10. The method of claim 7, wherein each resonator structure has a resonant frequency between 50 KHz and 500 MHz.

11. The method of any of the preceding claims, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} are each at least five (5) times greater than the coupling rate between the first resonator structure and the second resonator structure.

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12. The method of any of the preceding claims, wherein the intermediate resonator structure has a rate of radiative energy loss that is at least twenty (20) times greater than that for either the first resonator structure or the second resonator structure.

13. The method of claim 1, wherein the first and second resonator structures are substantially identical.

14. The method of any of the preceding claims, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} causes peak energy accumulation in the intermediate resonator structure to be less than five percent (5%) of the peak total energy in the three resonator structures.

15. The method of any of the preceding claims, wherein adjusting at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjusting a relative position and/or orientation between one or more pairs of the resonator structures.

16. The method of any of the preceding claims, wherein adjusting at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjusting a resonator property of one or more of the resonator structures.

17. The method of claim 16, wherein the resonator property comprises mutual inductance.

18. The method of any of the preceding claims, wherein at least one of the resonator structures comprises a capacitively loaded loop or coil of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

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19. The method of any of the preceding claims, wherein at least one of the resonator structures comprises an inductively loaded rod of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

20. An apparatus comprising:
first, intermediate, and second resonator structures, wherein a coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B} and a coupling rate between the intermediate resonator structure and the second resonator structure is κ_{B2}; and
means for adjusting at least one of the coupling rates κ_{1B} and κ_{B2} during wireless energy transfers among the resonator structures to reduce energy accumulation in the intermediate resonator structure and improve wireless energy transfer from the first resonator structure to the second resonator structure through the intermediate resonator structure.

21. The apparatus of claim 20, wherein the means for adjusting comprises a rotation stage for adjusting the relative orientation of the intermediate resonator structure with respect to the first and second resonator structures.

22. The apparatus of claim 20, wherein the means for adjusting comprises a translation stage for moving the first and/or second resonator structures relative to the intermediate resonator structure.

23. The apparatus of claim 20, wherein the means for adjusting comprises a mechanical, electro-mechanical, or electrical staging system for dynamically adjusting the effective size of one or more of the resonator structures.

24. The method of claim 4, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} causes peak energy accumulation in the intermediate resonator

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structure during the wireless energy transfers to be less than ten percent (10%) of the peak total energy in the three resonator structures.

25. The method of any of claims 1-19 and 24, wherein the wireless energy transfers are non-radiative energy transfers mediated by a coupling of a resonant field evanescent tail of the first resonator structure and a resonant field evanescent tail of the intermediate resonator structure and a coupling of the resonant field evanescent tail of the intermediate resonator structure and a resonant field evanescent tail of the second resonator structure.

26. The method of claim 25, wherein the first and second resonator structures each have a quality factor greater than 50.

27. The method of claim 25, wherein the first and second resonator structures each have a quality factor greater than 100.

28. A method for transferring energy wirelessly, the method comprising:
transferring energy wirelessly from a first resonator structure to a intermediate resonator structure, wherein the coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B};
transferring energy wirelessly from the intermediate resonator structure to a second resonator, wherein the coupling rate between the intermediate resonator structure and the second resonator structure is κ_{B2}; and
during the wireless energy transfers, adjusting at least one of the coupling rates κ_{1B} and κ_{B2} to cause an energy distribution in the field of the three-resonator system to have substantially no energy in the intermediate resonator structure while wirelessly transferring energy from the first resonator structure to the second resonator structure through the intermediate resonator structure.

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29. The method of claim 28, wherein having substantially no energy in the intermediate resonator structure means that peak energy accumulation in the intermediate resonator structure is less than ten percent (10%) of the peak total energy in the three resonator structures throughout the wireless energy transfer.

30. The method of claim 28, wherein having substantially no energy in the intermediate resonator structure means that peak energy accumulation in the intermediate resonator structure is less than five percent (5%) of the peak total energy in the three resonator structures throughout the wireless energy transfer.

31. The method of any of claims 28 to 30, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} maintains the energy distribution in the field of the three-resonator system in an eigenstate having the substantially no energy in the intermediate resonator structure.

32. The method of claim 31, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} further causes the eigenstate to evolve substantially adiabatically from an initial state with substantially all energy in the resonator structures in the first resonator structure to a final state with substantially all of the energy in the resonator structures in the second resonator structure.

33. The method of any of claims 28 to 32, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjustments of both coupling rates κ_{1B} and κ_{B2} during wireless energy transfers.

34. The method of any of claims 28 to 33, wherein resonant energy in each of the resonator structures comprises electromagnetic fields.

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35. The method of claim 34, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} for inductive coupling between the intermediate resonator structure and each of the first and second resonator structures are each larger than twice the loss rate Γ for each of the first and second resonators.

36. The method of claim 34, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} for inductive coupling between the intermediate resonator structure and each of the first and second resonator structures are each larger than four (4) times the loss rate Γ for each of the first and second resonators.

37. The method of any of claims 34 to 36, wherein each resonator structure has a resonant frequency between 50 KHz and 500 MHz.

38. The method of any of claims 28 to 37, wherein the maximum value of the coupling rate κ_{1B} and the maximum value of the coupling rate κ_{B2} are each at least five (5) times greater than the coupling rate between the first resonator structure and the second resonator structure.

39. The method of any of claims 28 to 38, wherein the intermediate resonator structure has a rate of radiative energy loss that is at least twenty (20) times greater than that for either the first resonator structure or the second resonator structure.

40. The method of any of claims 28 to 39, wherein the first and second resonator structures are substantially identical.

41. The method of any of claims 28 to 40, wherein adjusting at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjusting a relative position and/or orientation between one or more pairs of the resonator structures.

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42. The method of any of claims 28-41, wherein adjusting at least one of the coupling rates κ_{1B} and κ_{B2} comprises adjusting a resonator property of one or more of the resonator structures.

43. The method of claim 42, wherein the resonator property comprises mutual inductance.

44. The method of any of claims 28 to 43, wherein at least one of the resonator structures comprises a capacitively loaded loop or coil of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

45. The method of any of claims 28 to 44, wherein at least one of the resonator structures comprises an inductively loaded rod of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

46. The method of any of claims 28 to 45, wherein the wireless energy transfers are non-radiative energy transfers mediated by a coupling of a resonant field evanescent tail of the first resonator structure and a resonant field evanescent tail of the intermediate resonator structure and a coupling of the resonant field evanescent tail of the intermediate resonator structure and a resonant field evanescent tail of the second resonator structure.

47. The method of claim 46, wherein the first and second resonator structures each have a quality factor greater than 50.

48. The method of claim 47, wherein the first and second resonator structures each have a quality factor greater than 100.

49. The method of any of claims 28 to 48, wherein the adjustment of at least one of the coupling rates κ_{1B} and κ_{B2} to cause the energy distribution in the field of the three-

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resonator system to have substantially no energy in the intermediate resonator structure improves wireless energy transfer between the first and second resonator structures.

50. An apparatus comprising:
first, intermediate, and second resonator structures, wherein a coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B} and a coupling rate between the intermediate resonator structure and the second resonator structure is κ_{B2}; and
means for adjusting at least one of the coupling rates κ_{1B} and κ_{B2} during wireless energy transfers among the resonator structures to cause an energy distribution in the field of the three-resonator system to have substantially no energy in the intermediate resonator structure while wirelessly transferring energy from the first resonator structure to the second resonator structure through the intermediate resonator structure.

51. The apparatus of claim 50, wherein having substantially no energy in the intermediate resonator structure means that peak energy accumulation in the intermediate resonator structure is less than ten percent (10%) of the peak total energy in the three resonator structures throughout the wireless energy transfers.

52. The apparatus of claim 50, wherein having substantially no energy in the intermediate resonator structure means that peak energy accumulation in the intermediate resonator structure is less than five percent (5%) of the peak total energy in the three resonator structures throughout the wireless energy transfers.

53. The apparatus of any of claims 50 to 52, wherein the means for adjusting is configured to maintain the energy distribution in the field of the three-resonator system in an eigenstate having the substantially no energy in the intermediate resonator structure.

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54. The apparatus of any of claims claim 50 to 53, wherein the means for adjusting comprises a rotation stage for adjusting the relative orientation of the intermediate resonator structure with respect to the first and second resonator structures.

55. The apparatus of any of claims 50 to 54, wherein the means for adjusting comprises a translation stage for moving the first and/or second resonator structures relative to the intermediate resonator structure.

56. The apparatus of any of claims 50 to 55, wherein the means for adjusting comprises a mechanical, electro-mechanical, or electrical staging system for dynamically adjusting the effective size of one or more of the resonator structures.

57. The apparatus of any of claims 50 to 56, wherein at least one of the resonator structures comprises a capacitively loaded loop or coil of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

58. The apparatus of any of claims 50 to 57, wherein at least one of the resonator structures comprises an inductively loaded rod of at least one of a conducting wire, a conducting Litz wire, and a conducting ribbon.

59. The apparatus of any of claims 50 to 58, further comprising a source coupled to the first resonator structure and a load coupled to the second resonator structure.

60. The method of any of claims 1-19 and 24-27, wherein the adjustment of the at least one of the coupling rates defines a first mode of operation,
wherein the reduction in the energy accumulation in the intermediate resonator structure is relative to energy accumulation in the intermediate resonator structure for a second mode of operation of wireless energy transfer among the three resonator structures having a coupling rate κ'_{1B} for wireless energy transfer from the first resonator structure to the intermediate resonator structure and a coupling rate κ'_{B2} for wireless energy transfer

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from the intermediate resonator structure to the second resonator structure with κ'_{1B} and κ'_{B2} each being substantially constant during the second mode of wireless energy transfer, and

wherein the adjustment of the coupling rates κ_{1B} and κ_{2B} in the first mode of operation satisfies $\kappa_{1B}, \kappa_{B2} < \sqrt{\left(\kappa'^{2}_{1B} + \kappa'^{2}_{B2}\right)/2}$.

61. The method of claim 60, wherein the first mode of operation has a greater efficiency of energy transferred from the first resonator to the second resonator compared to that for the second mode of operation.

62. The method of claim 61, wherein the first and second resonator structures are substantially identical and each one has a loss rate Γ_A, the intermediate resonator structure has a loss rate Γ_B, and wherein Γ_B/Γ_A is greater than 50.

63. The method of claim 60, wherein a ratio of energy lost to radiation and total energy wirelessly transferred between the first and second resonator structures in the first mode of operation is less than that for the second mode of operation.

64. The method of claim 63, wherein the first and second resonator structures are substantially identical and each one has a loss rate Γ_A and a loss rate only due to radiation $\Gamma_{A,rad}$, the intermediate resonator structure has a loss rate Γ_B and a loss rate only due to radiation $\Gamma_{B,rad}$ and wherein $\Gamma_{B,rad}/\Gamma_B > \Gamma_{A,rad}/\Gamma_A$.

65. The method of claim 60, wherein in the first mode of operation the intermediate resonator structure interacts less with extraneous objects than it does in the second mode of operation.

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66. The method of any of claims 1-19, 24-27, and 60-65, wherein during the wireless energy transfer from the first resonator structure to the second resonator structure at least one of the coupling rates is adjusted so that $\kappa_{1B} << \kappa_{B2}$ at a start of the energy transfer and $\kappa_{1B} >> \kappa_{B2}$ by a time a substantial portion of the energy has been transferred from the first resonator structure to the second resonator structure.

67. The method of claim 66, wherein the coupling rate κ_{B2} is maintained at a fixed value and the coupling rate κ_{1B} is increased during the wireless energy transfer from the first resonator structure to second resonator structure.

68. The method of claim 66, wherein the coupling rate κ_{1B} is maintained at a fixed value and the coupling rate κ_{B2} is decreased during the wireless energy transfer from the first resonator structure to second resonator structure.

69. The method of claim 66, wherein, during the wireless energy transfer from the first resonator structure to second resonator structure, the coupling rate κ_{1B} is increased and the coupling rate κ_{B2} is decreased.

70. The method of any of claims 28-49, wherein the adjustment of the at least one of the coupling rates defines a first mode of operation,
wherein energy accumulation in the intermediate resonator structure during the wireless energy transfer from the first resonator structure to second resonator structure is smaller than that for a second mode of operation of wireless energy transfer among the three resonator structures having a coupling rate κ'_{1B} for wireless energy transfer from the first resonator structure to the intermediate resonator structure and a coupling rate κ'_{B2} for wireless energy transfer from the intermediate resonator structure to the second resonator structure with κ'_{1B} and κ'_{B2} each being substantially constant during the second mode of wireless energy transfer, and

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wherein the adjustment of the coupling rates κ_{1B} and κ_{B2} in the first mode of operation satisfies $\kappa_{1B}, \kappa_{B2} < \sqrt{\left(\kappa'^{2}_{1B} + \kappa'^{2}_{B2}\right)/2}$.

71. The method of claim 70, wherein the first mode of operation has a greater efficiency of energy transferred from the first resonator to the second resonator compared to that for the second mode of operation.

72. The method of claim 71, wherein the first and second resonator structures are substantially identical and each one has a loss rate Γ_A, the intermediate resonator structure has a loss rate Γ_B, and wherein Γ_B/Γ_A is greater than 50.

73. The method of claim 70, wherein a ratio of energy lost to radiation and total energy wirelessly transferred between the first and second resonator structures in the first mode of operation is less than that for the second mode of operation.

74. The method of claim 73, wherein the first and second resonator structures are substantially identical and each one has a loss rate Γ_A and a loss rate only due to radiation $\Gamma_{A,rad}$, the intermediate resonator structure has a loss rate Γ_B and a loss rate only due to radiation $\Gamma_{B,rad}$ and wherein $\Gamma_{B,rad}/\Gamma_B > \Gamma_{A,rad}/\Gamma_A$.

75. The method of claim 70, wherein in the first mode of operation the intermediate resonator structure interacts less with extraneous objects than it does in the second mode of operation.

76. The method of any of claims 28-49 and 70-75, wherein during the wireless energy transfer from the first resonator structure to the second resonator structure at least one of the coupling rates is adjusted so that $\kappa_{1B} << \kappa_{B2}$ at a start of the energy transfer and

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$\kappa_{1B} >> \kappa_{B2}$ by a time a substantial portion of the energy has been transferred from the first resonator structure to the second resonator structure.

77. The method of claim 76, wherein the coupling rate κ_{B2} is maintained at a fixed value and the coupling rate κ_{1B} is increased during the wireless energy transfer from the first resonator structure to second resonator structure.

78. The method of claim 76, wherein the coupling rate κ_{1B} is maintained at a fixed value and the coupling rate κ_{B2} is decreased during the wireless energy transfer from the first resonator structure to second resonator structure.

79. The method of claim 76, wherein, during the wireless energy transfer from the first resonator structure to second resonator structure, the coupling rate κ_{1B} is increased and the coupling rate κ_{B2} is decreased.

80. A method for transferring energy wirelessly, the method comprising:
transferring energy wirelessly from a first resonator structure to a intermediate resonator structure, wherein the coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B};
transferring energy wirelessly from the intermediate resonator structure to a second resonator, wherein the coupling rate between the intermediate resonator structure and the second resonator structure with a coupling rate is κ_{B2}; and
during the wireless energy transfers, adjusting at least one of the coupling rates κ_{1B} and κ_{B2} to define a first mode of operation in which energy accumulation in the intermediate resonator structure is reduced relative to that for a second mode of operation of wireless energy transfer among the three resonator structures having a coupling rate κ'_{1B} for wireless energy transfer from the first resonator structure to the intermediate resonator

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structure and a coupling rate κ'_{B2} for wireless energy transfer from the intermediate resonator structure to the second resonator structure with κ'_{1B} and κ'_{B2} each being substantially constant during the second mode of wireless energy transfer, and

wherein the adjustment of the coupling rates κ_{1B} and κ_{B2} in the first mode of operation satisfies $\kappa_{1B}, \kappa_{B2} < \sqrt{\left(\kappa'^{2}_{1B} + \kappa'^{2}_{B2}\right)/2}$.

81. An apparatus comprising:

first, intermediate, and second resonator structures, wherein a coupling rate between the first resonator structure and the intermediate resonator structure is κ_{1B} and a coupling rate between the intermediate resonator structure and the second resonator structure is κ_{B2}; and

means for adjusting at least one of the coupling rates κ_{1B} and κ_{B2} during wireless energy transfers among the resonator structures to define a first mode of operation in which energy accumulation in the intermediate resonator structure is reduced relative to that for a second mode of operation for wireless energy transfer among the three resonator structures having a coupling rate κ'_{1B} for wireless energy transfer from the first resonator structure to the intermediate resonator structure and a coupling rate κ'_{B2} for wireless energy transfer from the intermediate resonator structure to the second resonator structure with κ'_{1B} and κ'_{B2} each being substantially constant during the second mode of wireless energy transfer, and

wherein the adjustment of the coupling rates κ_{12} and κ_{B2} in the first mode of operation satisfies $\kappa_{1B}, \kappa_{B2} < \sqrt{\left(\kappa'^{2}_{1B} + \kappa'^{2}_{B2}\right)/2}$.

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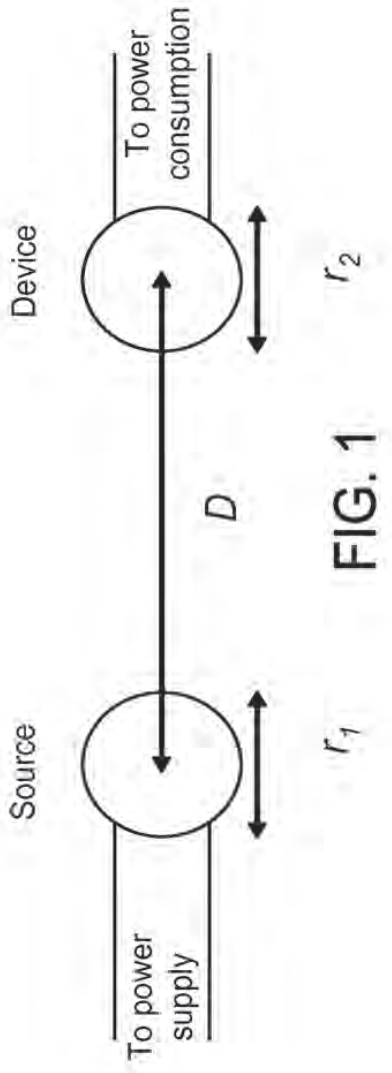


FIG. 1

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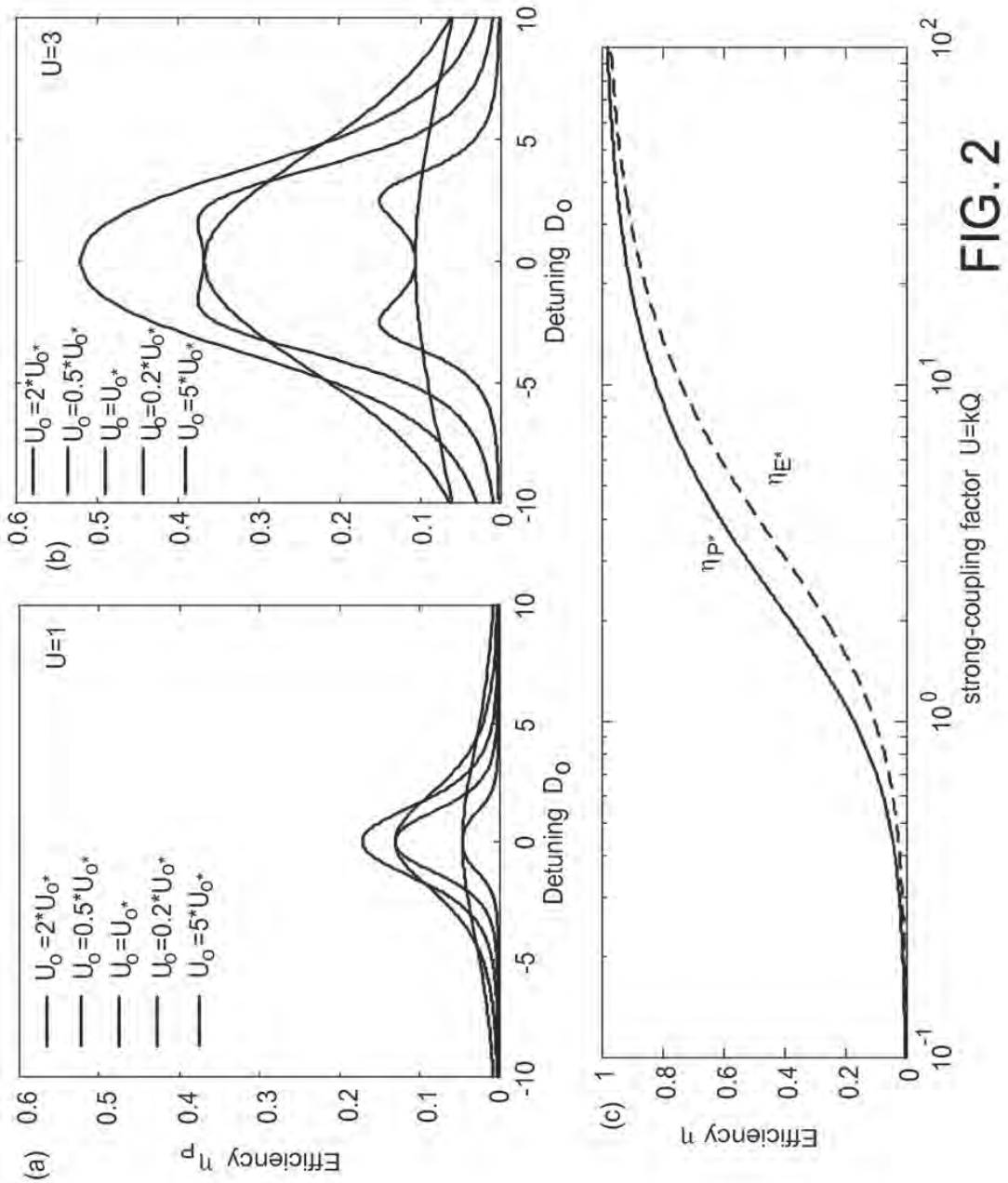


FIG. 2

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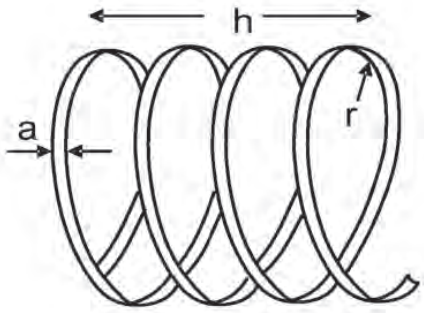


FIG. 3

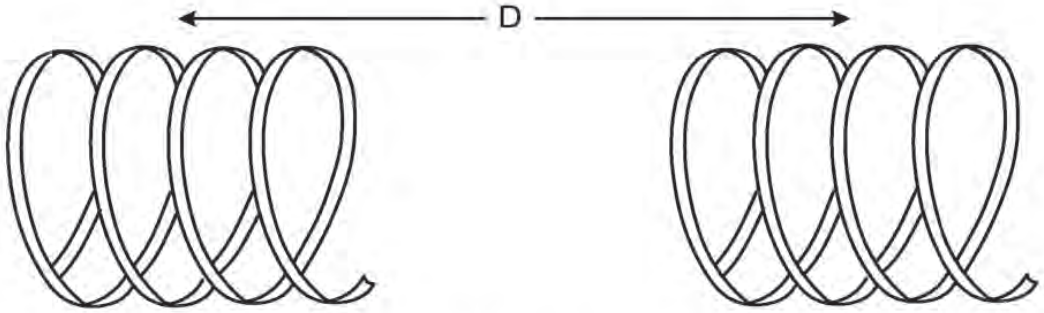


FIG. 4

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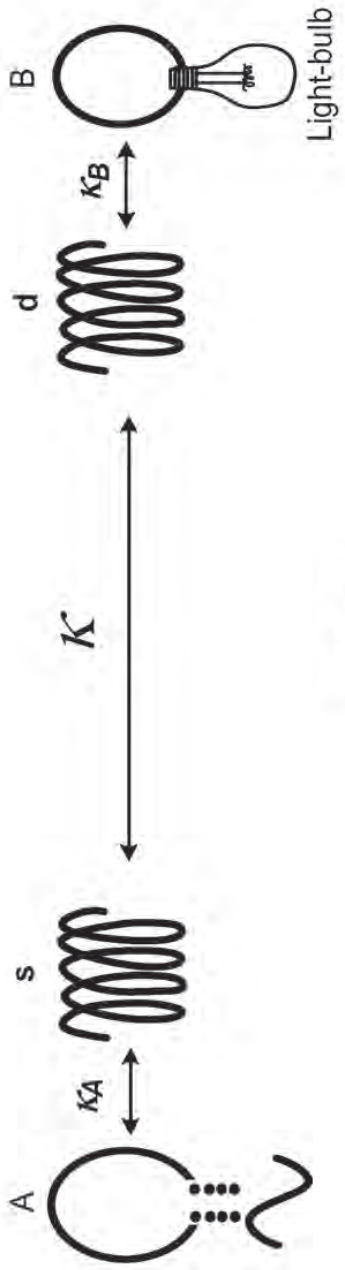
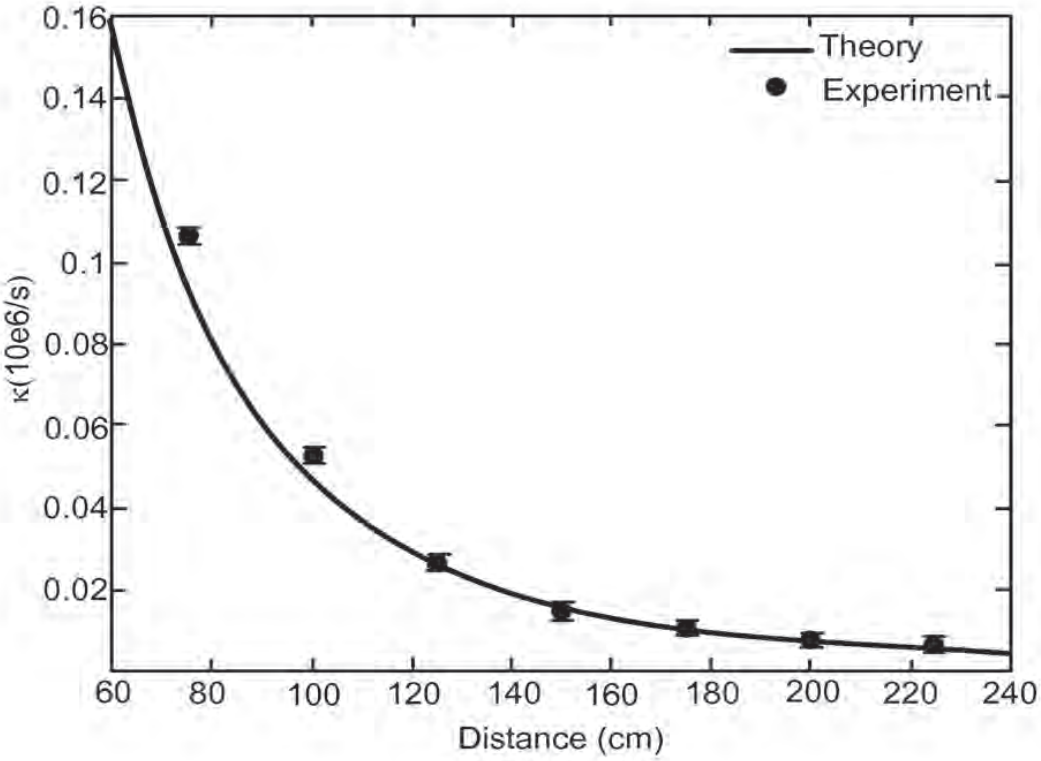


FIG. 5

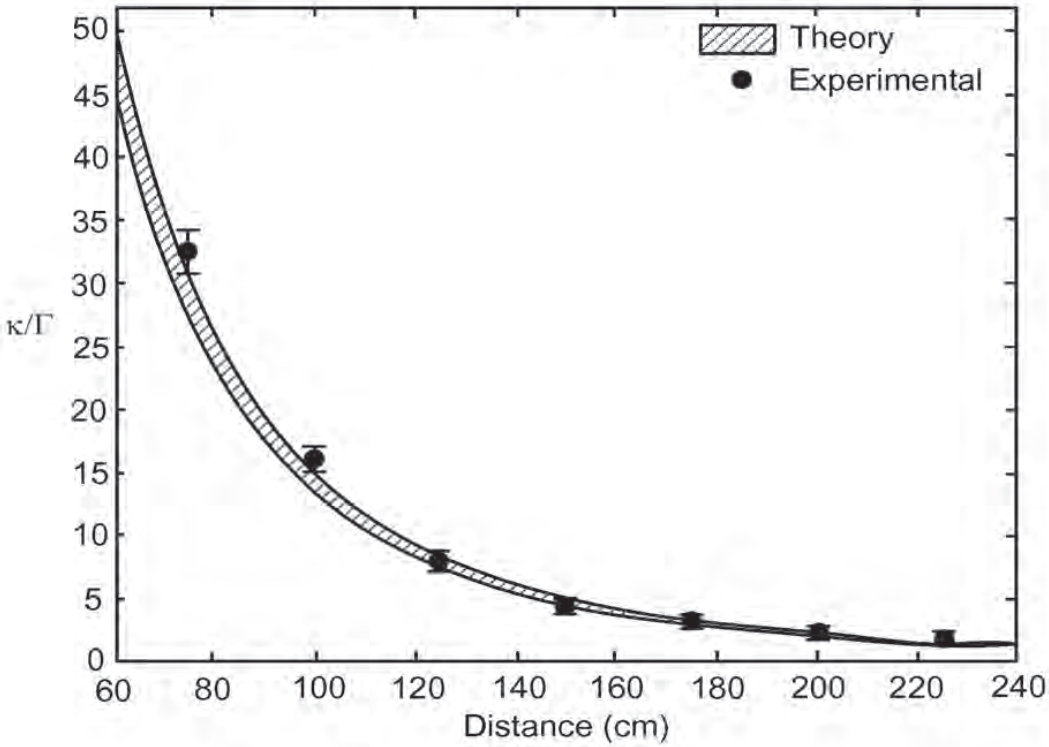
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Comparison of experimental and theoretical values for κ as a function of the separation between the source and device coils.

FIG. 6

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Comparison of experimental and theoretical values for the parameter κ/Γ as a function of the separation between the two coils. The theory values are obtained by using the theoretically obtained κ and the experimentally measured Γ. The shaded area represents the spread in the theoretical κ/Γ due to the ~5% uncertainty in Q.

FIG.7

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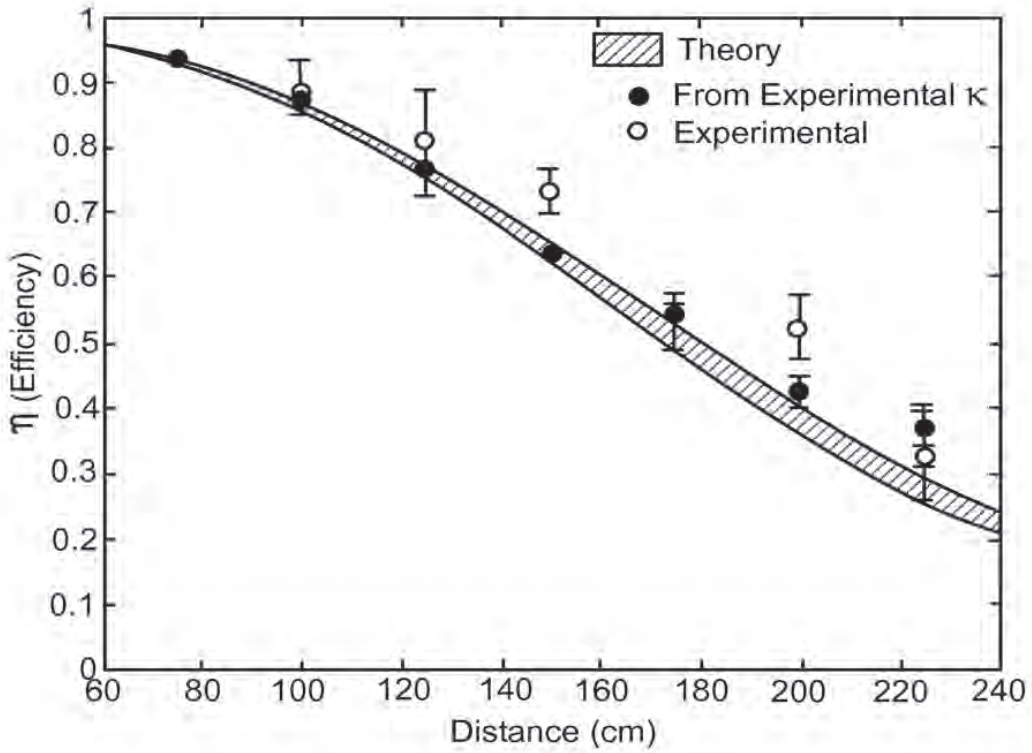


FIG. 8

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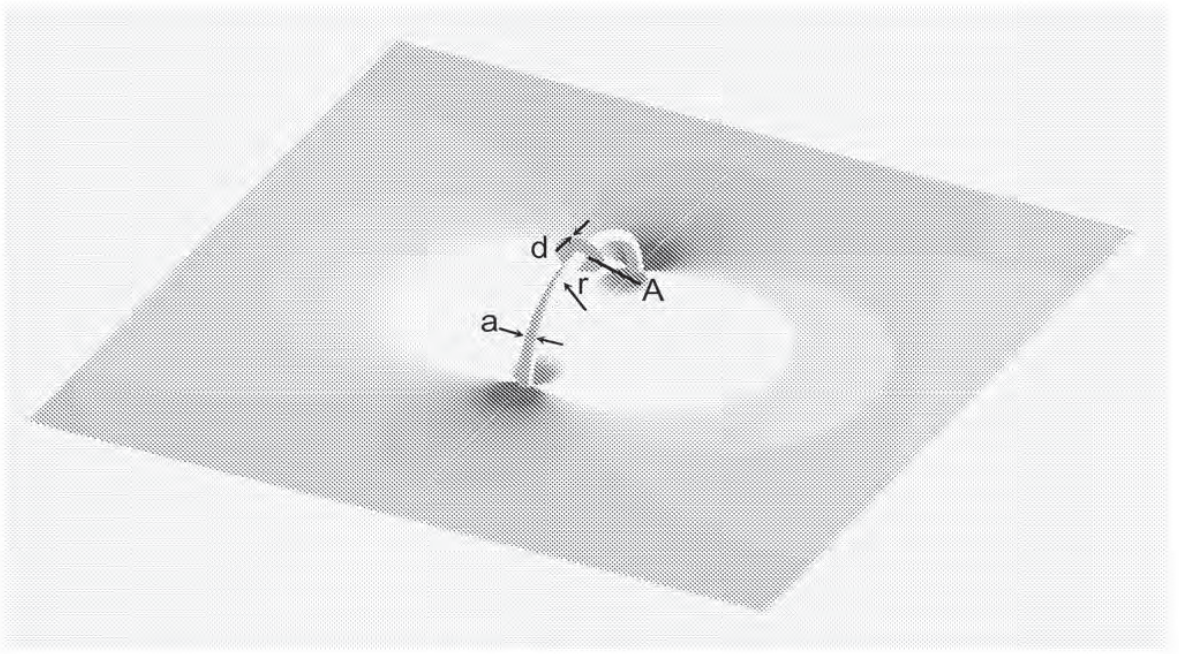


FIG. 9

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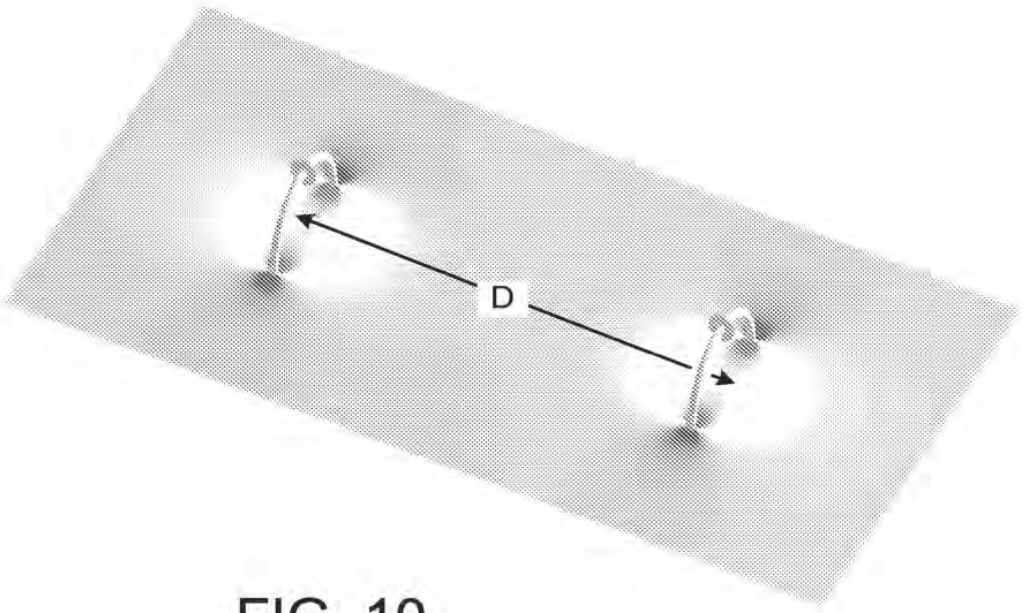


FIG. 10

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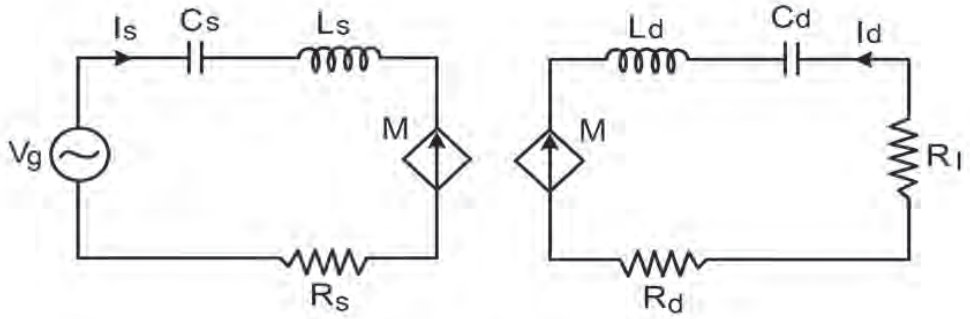


FIG. 11

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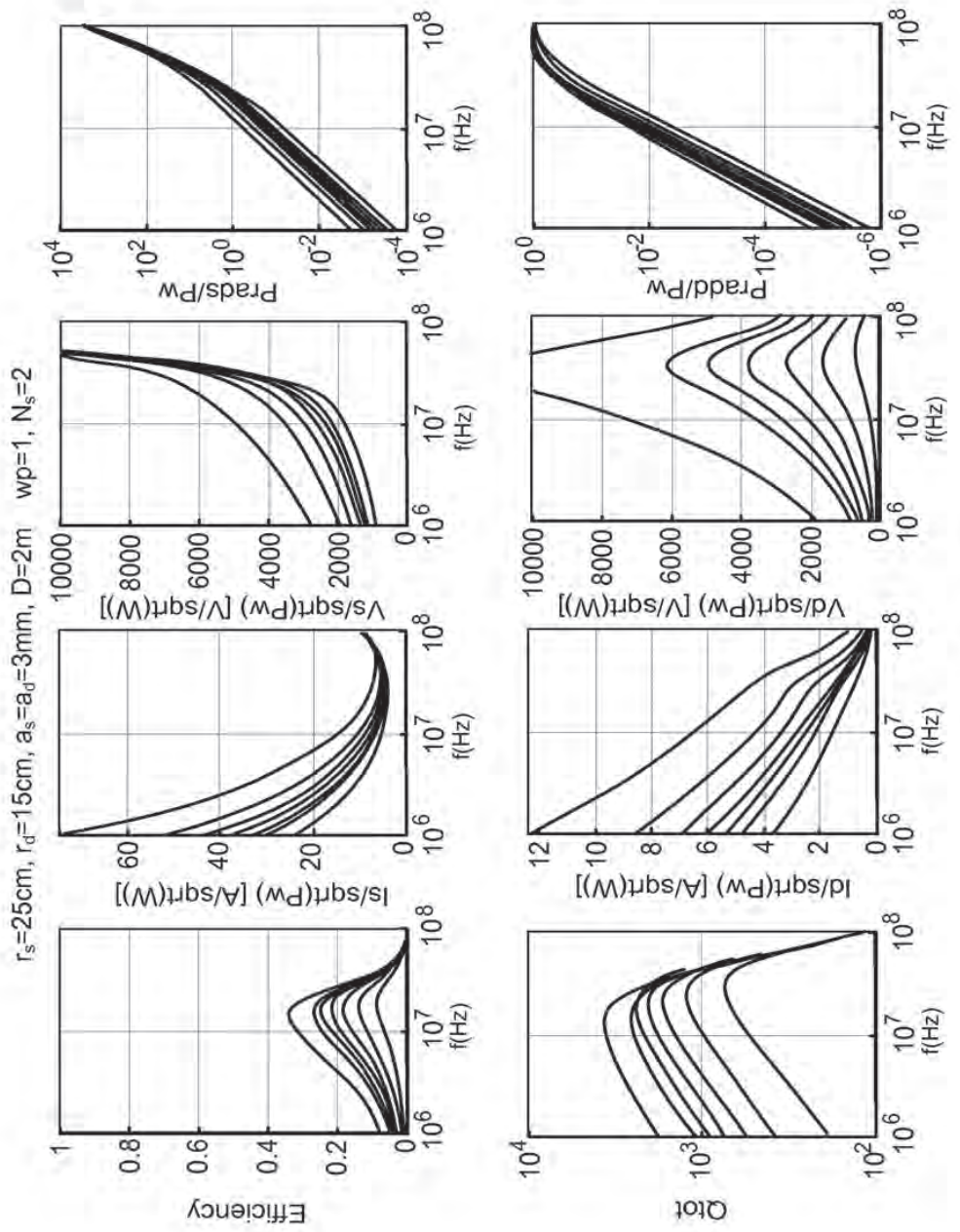


FIG. 12

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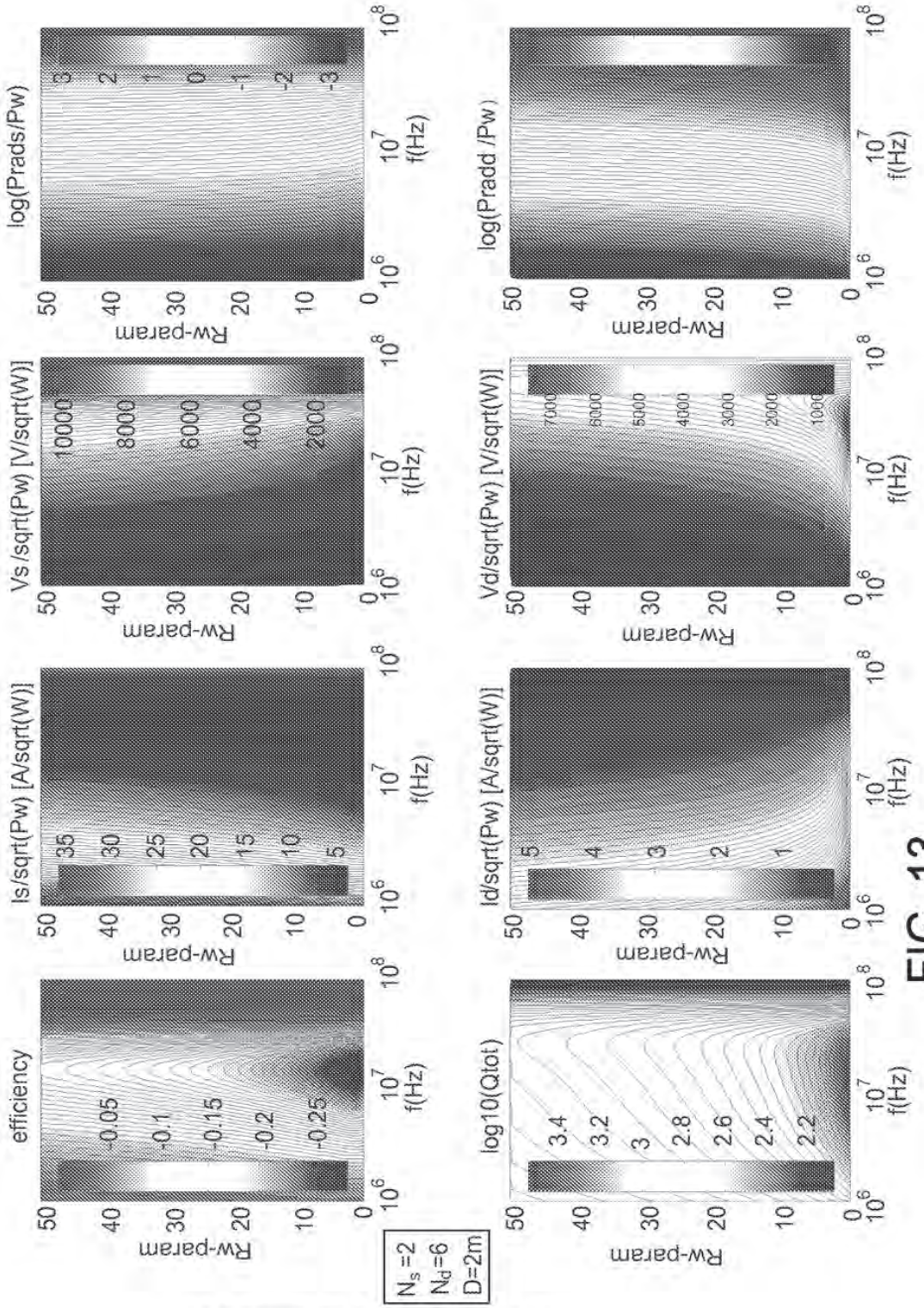


FIG. 13

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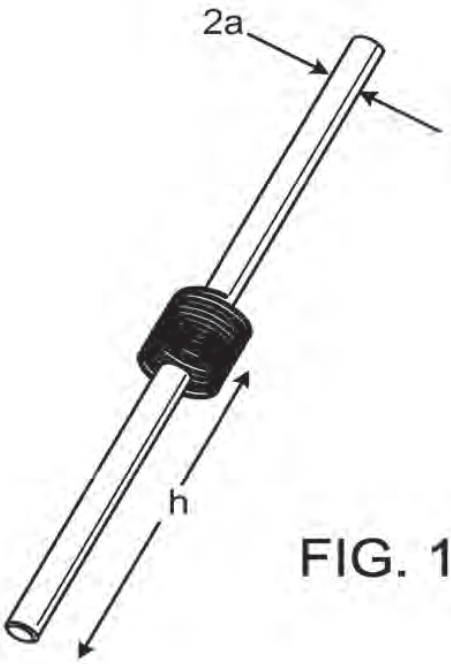


FIG. 14

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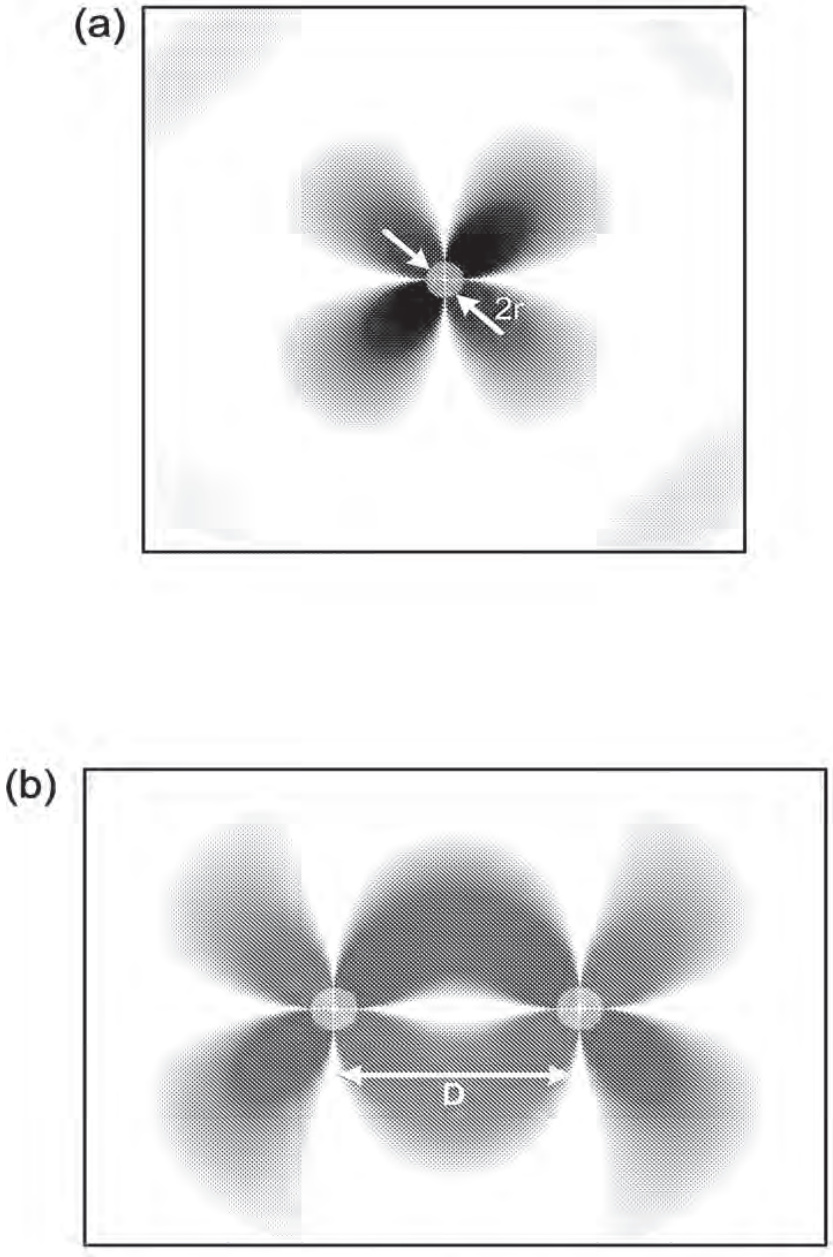


FIG. 15

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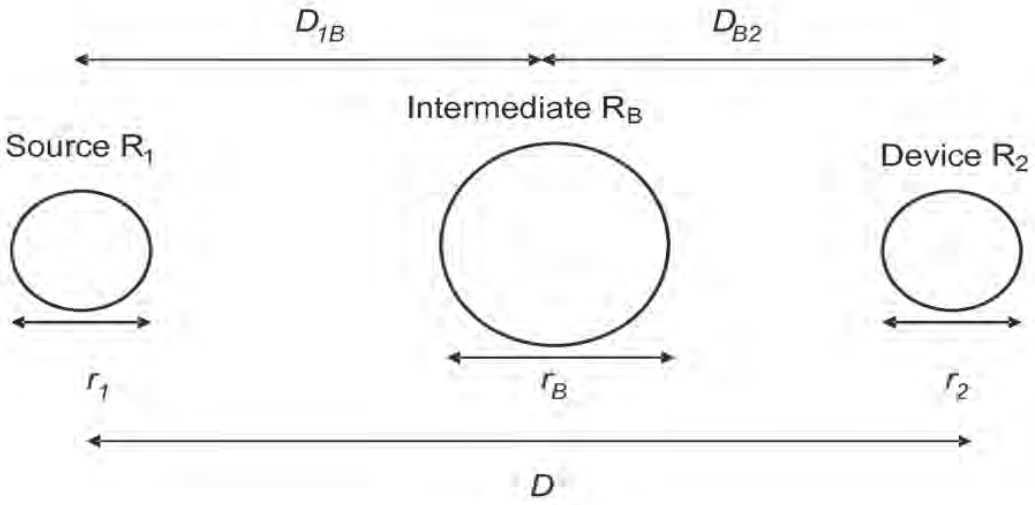


FIG. 16

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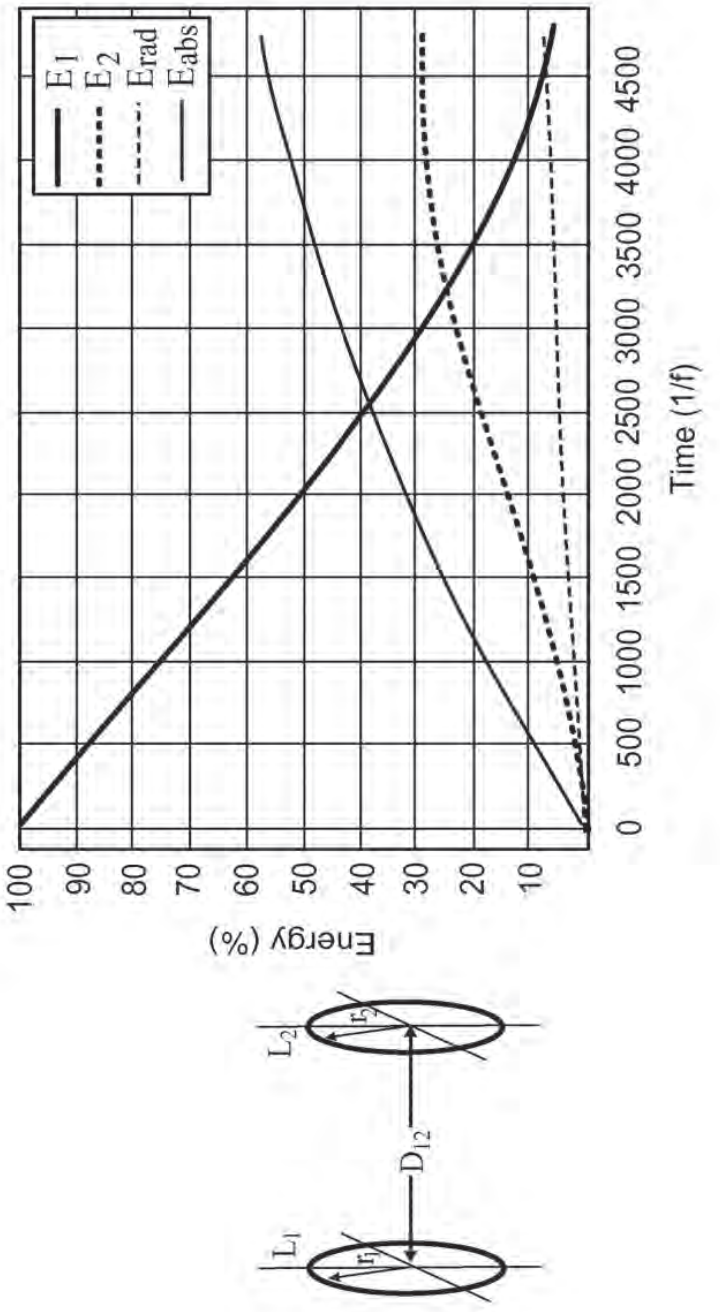


FIG. 17A

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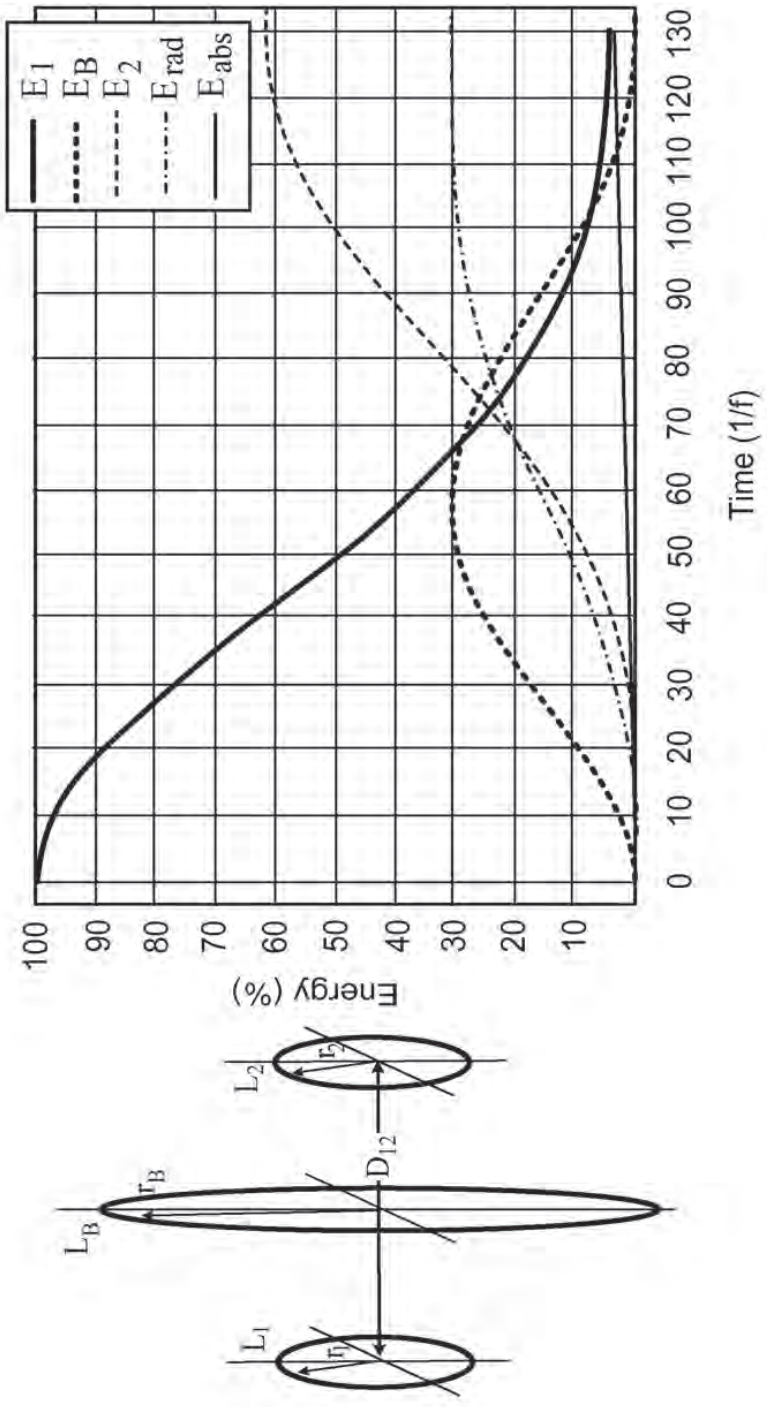


FIG. 17B

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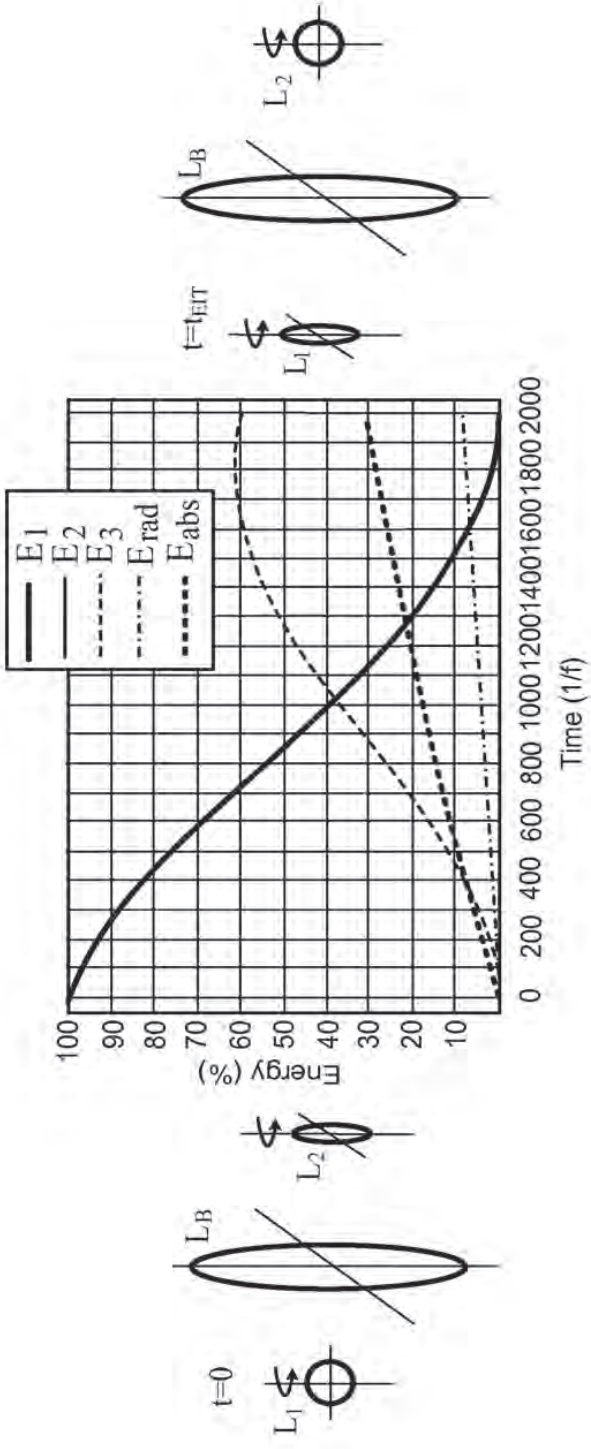


FIG. 17C

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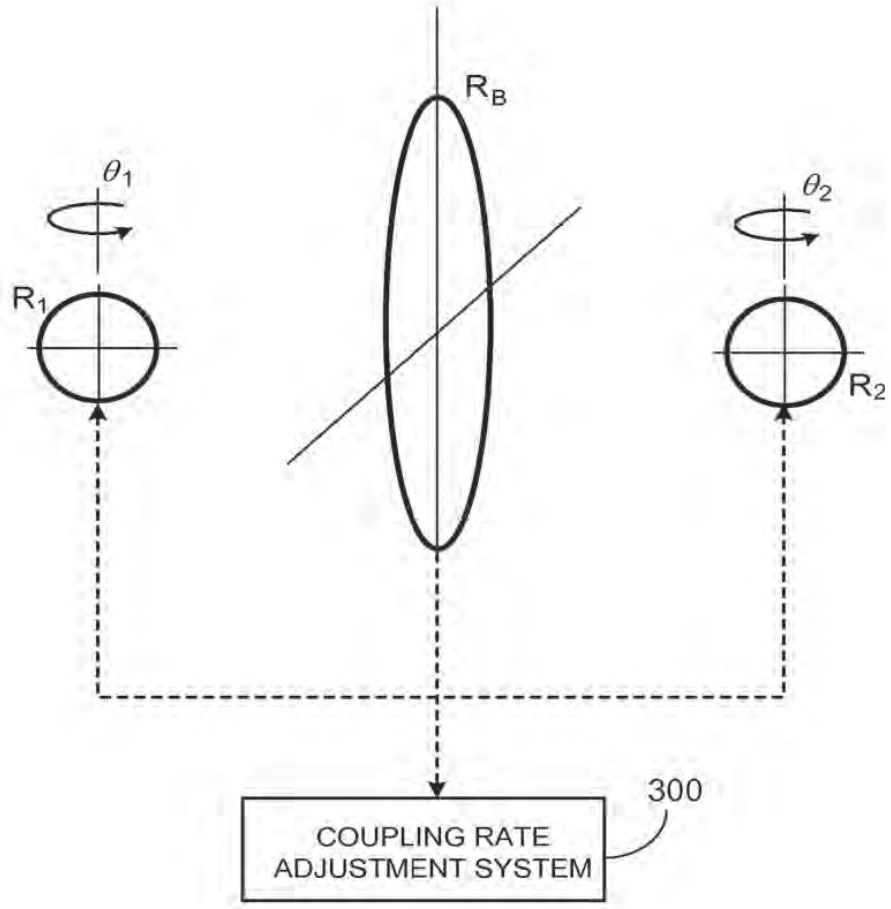


FIG. 18

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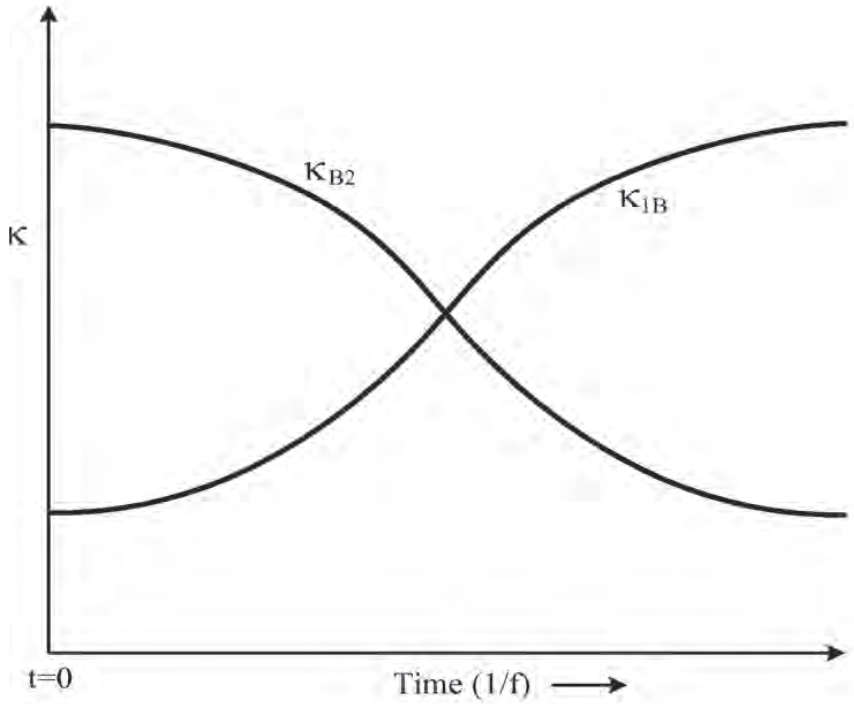


FIG. 19

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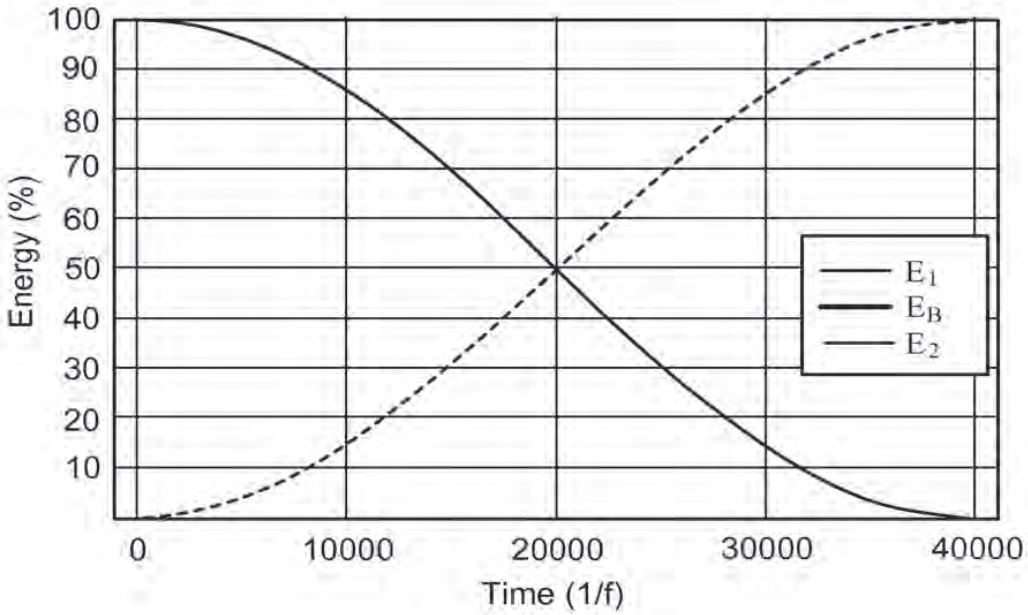


FIG. 20

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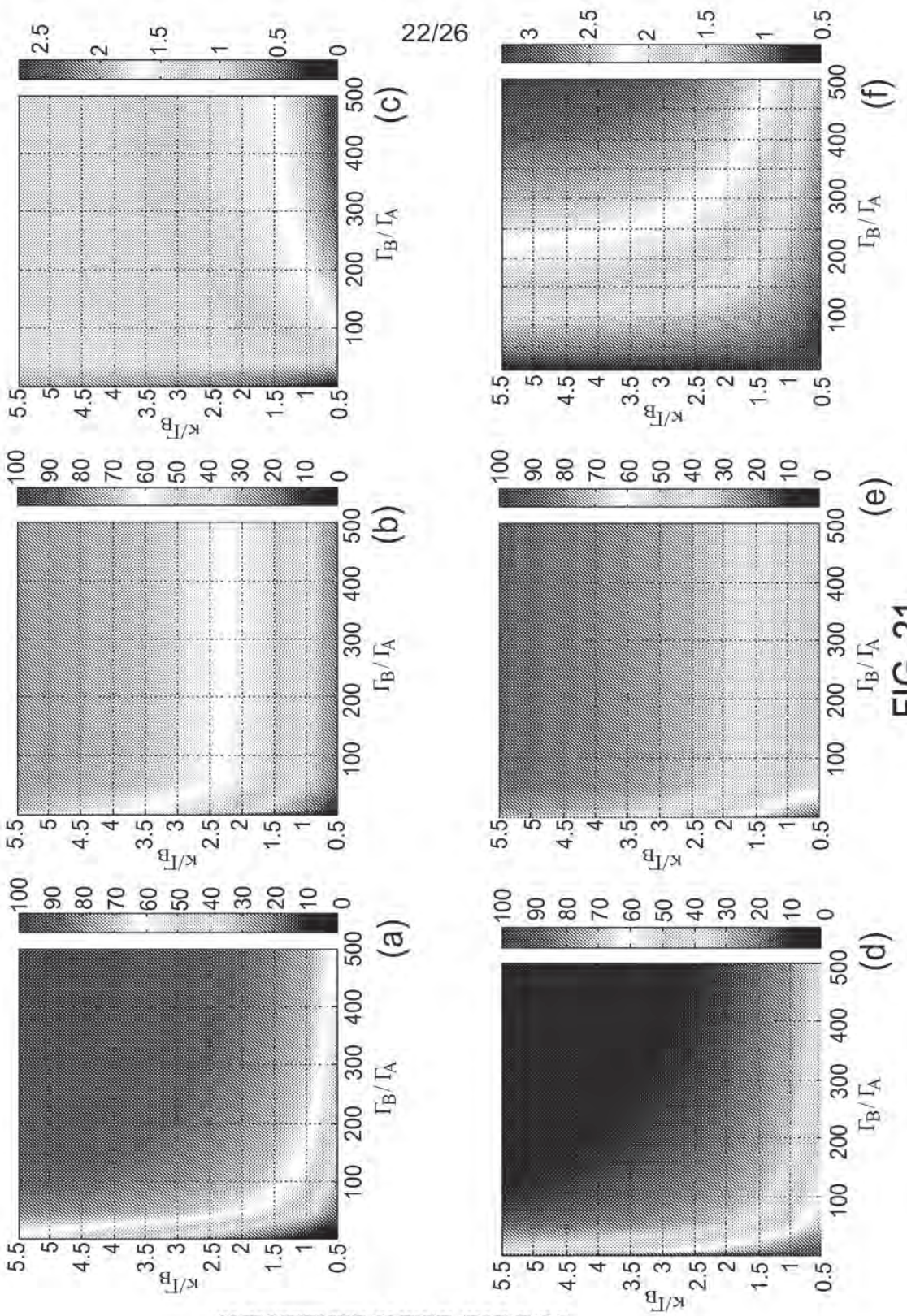


FIG. 21

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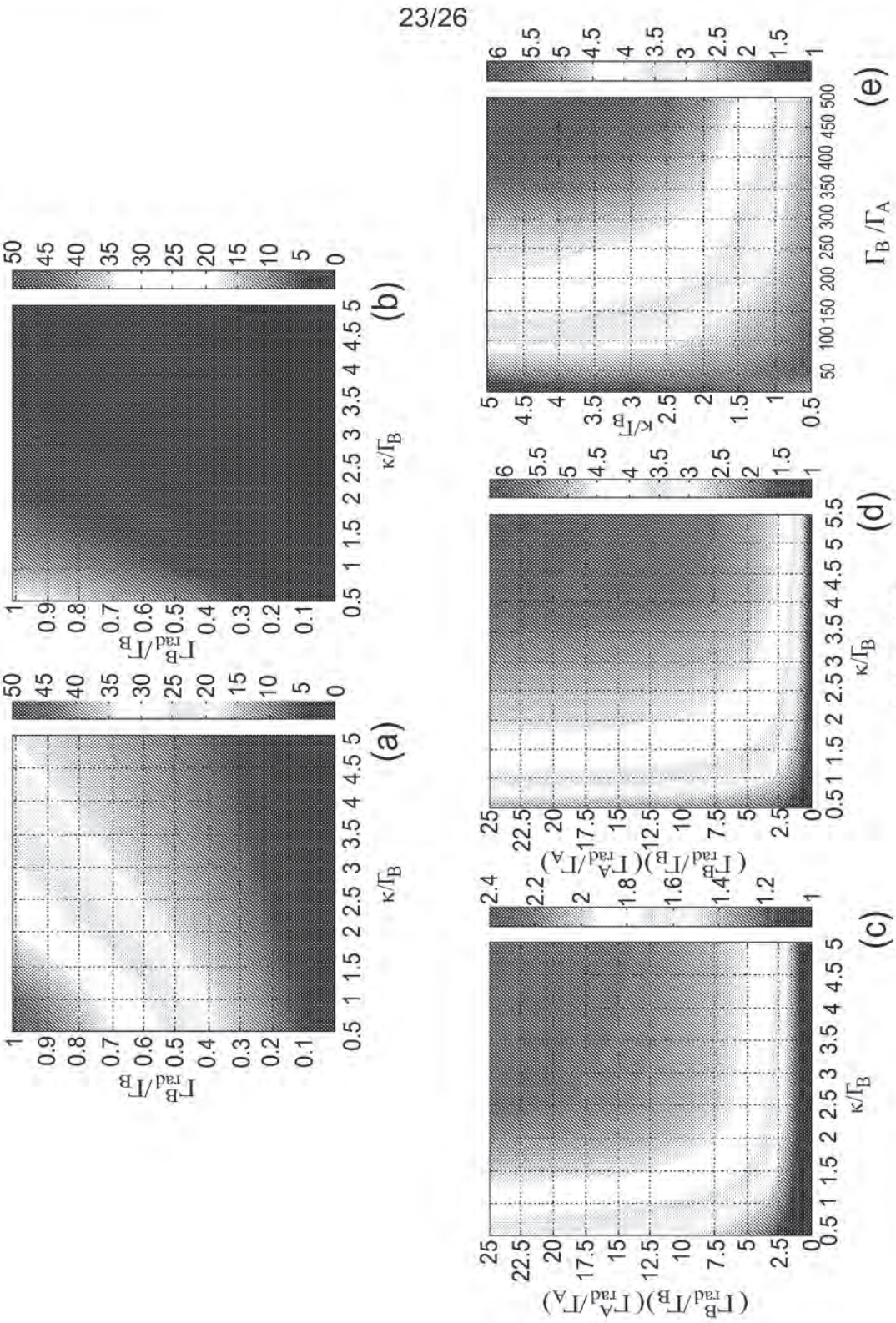


FIG. 22

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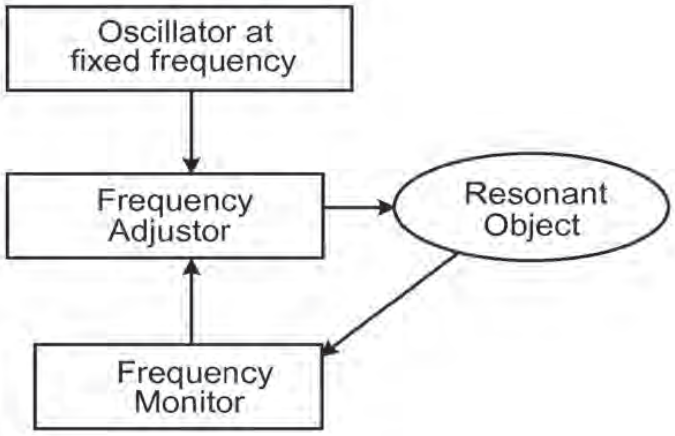


FIG. 23a

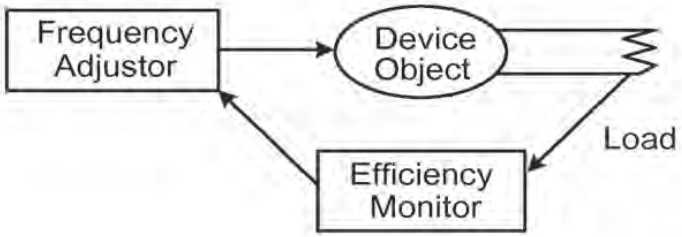
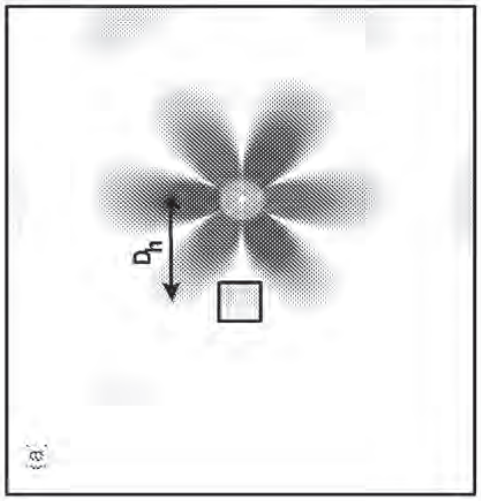


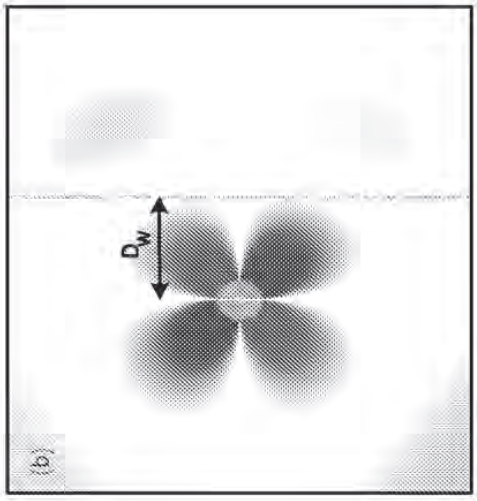
FIG. 23b

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Disk with "human"	D_h/r	$Q_{c\text{-}h}^{abs}$	$Q_{c[h]}^{rad}$	$Q_{c[h]}$
Re{ε}=147.7, m=2	3	230	981	183
$\lambda/r \approx 20$	5	2917	1984	1057
$Q_c^{abs} \approx 10096$	7	11573	2230	1578
	10	41496	2201	1732
Re{ε}=65.6, m=3	3	1827	6197	1238
$\lambda/r \approx 10$	**5**	**58431**	**11808**	**4978**
$Q_c^{abs} \approx 10096$	7	249748	9931	4908
	10	867552	9078	4754

FIG. 24a



Disk with "wall"	D_w/r	$Q_{c\text{-}w}^{abs}$	$Q_{c[w]}^{rad}$	$Q_{c[w]}$
Re{ε}=147.7, m=2	3	16725	1235	1033
$\lambda/r \approx 20$	**5**	**31659**	**1922**	**1536**
$Q_c^{abs} \approx 10098$	7	49440	2389	1859
	10	82839	2140	1729
Re{ε}=65.6, m=3	3	53154	6228	3592
$\lambda/r \approx 10$	5	127402	10988	5053
$Q_c^{abs} \approx 10097$	7	159192	10168	4910
	10	191506	9510	4775

FIG. 24b

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Two disks with "human" and "wall"	D/r	$Q_{c\text{-}h}^{abs}$	$Q_{c\text{-}w}^{abs}$	$Q_{c[hw]}^{rad}$	$Q_{c[hw]} = \omega/2\Gamma_{c[hw]}$	$\omega/2\kappa_{[hw]}$	$\kappa_{[hw]}/\Gamma_{c[hw]}$
Re{ε}=147.7, m=2	3	3300	12774	536	426	48	8.8
$\lambda/r \approx 20$	5	5719	26333	1600	1068	322	3.3
$Q_c^{abs} \approx 10100$	7	13248	50161	3542	2097	973	2.2
	10	18447	68460	3624	2254	1768	1.3
Re{ε}=65.6, m=3	3	2088	36661	6764	1328	141	9.4
$\lambda/r \approx 10$	**5**	**72137**	**90289**	**11945**	**4815**	**2114**	**2.3**
$Q_c^{abs} \approx 10100$	7	237822	129094	12261	5194	8307	0.6

FIG. 24c

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/59244

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01P 7/00 (2009.01)
USPC - 333/219
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC - 333/219

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 333/219; 307/126; 455/522 (keyword limited - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
pubwest (DB=PGPB,USPT,EPAB,JPAB), Google Scholar
Terms - wireless energy, coupling rate, resonate, energy accumulation, near-field, transfer, intermediate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/0222542 A1 (Joannopoulos et al.) 27 September 2007 (27.09.2007), abstract, para [0013], [0015], [0016], [0026], [0027], [0035]	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
Y	US 3,517,350 A (Beaver) 23 June 1970 (23.06.1970), col 2, ln 69-72; col 7, ln 22-39	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
X, P	US 2009/0153273 A1 (Chen) 18 June 2009 (18.06.2009), entire document	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
X, P	WO 2008/118178 A1 (Karalis et al.) 02 October 2008 (02.10.2008), entire document	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
A	US 6,960,968 B2 (Odendaal et al.) 01 November 2005 (01.11.2005), entire document	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
A	US 7,069,064 B2 (Gevorgian et al.) 27 June 2006 (27.06.2006), entire document	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81
A	US 1,119,732 A (Tesla) 01 December 1914 (01.12.1914), entire document	1-4, 6, 13, 20-24, 28-32, 50-53, 80, 81

☐ 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
16 November 2009 (16.11.2009)	07 DEC 2009
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: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/59244

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.: 5, 7-12, 14-19, 25-27, 33-49 and 54-79
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.

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Electronic Patent Application Fee Transmittal

Application Number:	12639963
Filing Date:	16-Dec-2009
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Filer:	Marc M. Wefers/Cheryl Forrest
Attorney Docket Number:	01997-0359009 / MIT 11757

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

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

Electronic Acknowledgement Receipt

EFS ID:	12856550
Application Number:	12639963
International Application Number:	
Confirmation Number:	7811
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Customer Number:	26161
Filer:	Marc M. Wefers/Cheryl Forrest
Filer Authorized By:	Marc M. Wefers
Attorney Docket Number:	01997-0359009 / MIT 11757
Receipt Date:	24-MAY-2012
Filing Date:	16-DEC-2009
Time Stamp:	13:47:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	13202
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		359009-IDS.pdf	130374 ca4be3d1f7930f4a8bc71400986b31d0b95995c	yes	3
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	1	
	Information Disclosure Statement (IDS) Form (SB08)		2	3	
Warnings:					
Information:					
2	Foreign Reference	ART1-JP.pdf	159336 d5e4810bd9708d304321a52d27ed3e0f8e0de18b	no	6
Warnings:					
Information:					
3	Foreign Reference	ART2.pdf	5247723 98d8c46166de00d7a02ec03859b3d6390b668957	no	124
Warnings:					
Information:					
4	Foreign Reference	ART3.pdf	5869525 766afd6077aa80a9620e181355ba73d4b833125	no	128
Warnings:					
Information:					
5	Non Patent Literature	NPL1.PDF	759505 caee3e419a6bb77cdc490016d95088a7541e078	no	17
Warnings:					
Information:					
6	Non Patent Literature	NPL2-13036177.pdf	1975605 c571ee5fe3459f1c2e4b0900cc75a3813354f2bc	no	31
Warnings:					
Information:					
7	Non Patent Literature	NPL3.pdf	1152089 bb3530b7008eb995d77428afc170bf8fab51e0f25	no	24
Warnings:					
Information:					
8	Non Patent Literature	NPL4.pdf	1155419 687f764940beaa2f02be55be0678755159d202	no	24

Warnings:					
Information:					
9	Non Patent Literature	NPL5.pdf	1201125 b6051ffc0036?cidbdbe223528ade1994602b25f	no	26
Warnings:					
Information:					
10	Non Patent Literature	NPL6.pdf	1223512 fbe4e988ac8945f2961e0120fbb21caadb2a4c1591	no	25
Warnings:					
Information:					
11	Fee Worksheet (SB06)	fee-info.pdf	30553 aaae72d5e0b71e5024aff185a467e43da7354746	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	18904766	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Albert W. Paladini
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

INFORMATION DISCLOSURE STATEMENT

Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

This statement is being filed after a first Office action on the merits, but before receipt of a final Office action or a Notice of Allowance. The fees in the amount of $180 in payment of the late submission fee of §1.17(p) are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 5/24/12

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Reg. No. 56,842

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Telephone: (617) 542-5070
Facsimile: (877) 769-7945

22849847.doc

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	2010/0102639	4/29/2010	Joannopoulos et al.			
	2	2010/0117455	5/13/2010	Joannopoulos et al.			
	3	2010/0117456	5/13/2010	Karalis et al.			
	4	2010/0171370	7/8/2010	Karalis et al.			
	5	2010/0181844	7/22/2010	Karalis et al.			
	6	2010/0201205	8/12/2010	Karalis et al.			
	7	2010/0225175	9/9/2010	Karalis et al.			
	8	2010/0231053	9/16/2010	Karalis et al.			
	9	2010/0237706	9/23/2010	Karalis et al.			
	10	2010/0237707	9/23/2010	Karalis et al.			
	11	2010/0237708	9/23/2010	Karalis et al.			
	12	2010/0253152	10/7/2010	Karalis et al.			
	13	2010/0264745	10/21/2010	Karalis et al.			
	14	2010/0277005	11/4/2010	Karalis et al.			
	15	2010/0327660	12/30/2010	Karalis et al.			
	16	2010/0327661	12/30/2010	Karalis et al.			
	17	2011/0012431	1/20/2011	Karalis et al.			
	18	2011/0018361	1/27/2011	Karalis et al.			
	19	2011/0025131	2/3/2011	Karalis et al.			
	20	2011/0049996	3/3/2011	Karalis et al.			
	21	2011/0049998	3/3/2011	Karalis et al.			
	22	2011/0140544	6/16/2011	Karalis et al.			
	23	2011/0148219	6/23/2011	Karalis et al.			
	24	2011/0162895	7/7/2011	Karalis et al.			
	25	2011/0169339	7/14/2011	Karalis et al.			
	26	2011/0181122	7/28/2011	Karalis et al.			
	27	2011/0198939	8/18/2011	Karalis et al.			

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	28	2011/0221278	9/15/2011	Karalis et al.			
	29	2011/0227528	9/22/2011	Karalis et al.			
	30	2011/0227530	9/22/2011	Karalis et al.			
	31	2011/0241618	10/6/2011	Karalis et al.			

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	32	38 24 972	1/12/1989	Germany			Machine Translation	
	33	100 29147	12/20/2001	Germany			Machine Translation	
	34	6-341410	12/13/1994	Japan	F15B	15/18	English Abstract Only	
	35	11-188113	7/13/1999	Japan	A61N	1/378	English Abstract Only	
	36	2006/011769	2/2/2006	WIPO	H04B	7/14		

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	37	

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

Patent Record Full View Tuesday, July 17, 2012 THOMSON INNOVATION

Patent/Publication: DE3824972A1

Bibliography

DWPI Title

Decorative lights for christmas tree or sales display etc. use electromagnetic or IR energy beam for remote supply of each individual lamp

Original Title

Work of art, Christmas tree, decoration and decoration lighting

English Title

Illumination of christmas trees, decorations and artwork

Assignee/Applicant

Standardized: **HIERING ROLAND ILBERG VLADIMIR**

Original: Hiering Roland Ilberg Vladimir, DE

DWPI Assignee/Applicant

HIERING R (HIER-I)

Inventor

Hiering Roland, Ilberg Vladimir, DE

DWPI Inventor

HIERIG R; HIERING R; ILBERG V

Publication Date (Kind Code)

1989-01-12 (A1)

DWPI Accession / Update

1989-025293 / 198904

Application Number / Date

DE3824972A / 1988-07-22

Priority Number / Date / Country

DE3824972A / 1988-07-22 / DE

Abstract

DWPI Abstract

(DE3824972A1)

Novelty

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The decorative lights include one or more lamps which are remotely supplied without any galvanic coupling via an energy source (7) providing an electromagnetic or IR energy beam, e.g. a HF transmitter. The lamps may use electroluminescent elements, vacuum fluorescence elements, LED elements (1), or standard incandescent light bulbs.Each individual lamp has an associated oscillation circuit (2) incorporated in its socket or in a decorative glass ball or decorative item.

Advantage

Provides decorative lighting display without need for trailing leads.

Abstract

To abolish the multiplicity of electrical conductors, wires, double wires or cables, previously necessary for the illumination of christmas trees, decorations and artwork by means of electrical connections, the power supply of light-emitting elements is carried out without any electrical connection. The energy source consists of an RF transmitter which emits a constant frequency (e.g. 27 MHz) with a sufficient power (e.g. 2 watts) continuously or in a pulsed manner or of an infrared radiator, a laser, or a battery of electroluminescent diodes, connected in parallel and in series, which emit infrared light continuously or in a pulsed manner. The light-emitting elements are directly connected to an electrical resonant circuit (tuned circuit) which consists of an inductance and a capacitance (e.g. coil and capacitor). The light-emitting elements can be formed from electroluminescent elements (LE), electroluminescent diodes (LED), vacuum fluorescent diodes (VFE), glow lamps or incandescent lamps of different colours and shapes and can be used to illuminate christmas trees, decorations and artwork.

Classes/Indexing

IPC

IPC Code(1-7) **F21P 1/02** F21V 33/00 F21V 23/02 A44C 15/00 A63H 33/22 A63H 17/28 H01Q 9/28 H02J 17/00 G09F 13/00

(4)

Current IPC	Invention	Version	Additional	Version
Full	A44C 15/00 A47G 33/08 A63H 17/28 A63H 33/22 F21K 99/00 F21S 4/00 F21S 8/00 F21S 9/03 F21V 23/02 F21V 23/04 F21V 33/00 G09F 9/33 G09F 13/00 H01Q 9/28 H02J 17/00	20060101 20060101 20060101 20060101 20100101 20060101 20060101 20060101 20060101 20060101 20060101 20060101 20060101 20060101 20060101	F21W 121/04 F21Y 101/02	20060101 20060101
Main Group	-	-	-	-
Subclass	-	-	-	-

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Page 759

Original IPC	Invention	Version	Additional	Version
Advanced/Full	A47G 33/08 F21K 7/00 F21S 8/00 F21V 23/02 G09F 13/00 H02J 17/00	20060101 20060101 20060101 20060101 20060101 20060101	-	-
Core/Main Group	A47G 33/00 F21K 7/00 F21S 8/00 F21V 23/02 G09F 13/00 H02J 17/00	20060101 20060101 20060101 20060101 20060101 20060101	-	-
Subclass	-	-	-	-

ECLA

F21S 6/00C A47G 33/08 F21K 99/00 F21V 23/02 F21V 23/04R G09F 13/00 H02J 17/00 K47G 33/08E R21Y 101/02

DWPI Class

W05 X26 P23 P36 P85 Q71

DWPI Manual Codes

Collapse DWPI Manual Codes

EPI Manual Codes: W05-D04; W05-E03; X26-X

DWPI Chemistry Resource Numbers

Collapse DWPI Chemistry Resource Numbers

-

DWPI Registry Numbers

Collapse DWPI Registry Numbers

-

Plasdoc Punch Codes

Collapse Plasdoc Punch Codes

-

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Exhibit 1025
Page 760

Expand Plasdoc Key Serial Codes

Enhanced Polymer Indexing

Expand Enhanced Polymer Indexing

Chemical Fragment Codes

Expand Chemical Fragment Codes

Legal Status

INPADOC Legal Status

Gazette Date	Code	Description
1991-12-19	8131 -	REJECTION
1989-08-31	8110 +	REQUEST FOR EXAMINATION PARAGRAPH 44
1989-05-11	8105 +	SEARCH REPORT AVAILABLE
1989-02-16	8122	NONBINDING INTEREST IN GRANTING LICENSES DECLARED
1989-01-12	OR8	REQUEST FOR SEARCH AS TO PARAGRAPH 43 LIT. 1 SENTENCE 1 PATENT LAW
1989-01-12	OAV +	APPLICANT AGREED TO THE PUBLICATION OF THE UNEXAMINED APPLICATION AS TO PARAGRAPH 31 LIT. 2 Z1

Get Family Legal Status

Family

Family

INPADOC Family (0)

Collapse DWPI Family (2)

Publication	DWPI Update	Publication Date	IPC Code	Language
DE3824972A1	198904	1989-01-12	A47G003308	German
US5034658A_	199132	1991-07-23	H01K000700	English

Claims

Claims

Collapse All Claims (20)

Claims (German)

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1. Work of art and Christmas tree, decoration and decoration lighting, **thus characterized,** that at least one or more light-radiating elements from at least one energy source, which sends electromagnetic waves or infra-red light are supplied contactless i.e. without galvanic connection.

2. Christmas tree, decoration, marked work of art and decoration lighting according to requirement 1, by it that the light-radiating elements are attached directly to an electrical resonant circuit, that from an inductance and a capacity (e.g. Coil and condenser) exist.

3. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 2, by characterized that the light-radiating elements from Elektroluminiszenzdioden (LED) are formed, which radiates multi color light.

4. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 2, by characterized that at least two LED are attached antiparallelly to the resonant circuit.

5. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 2, by characterized that the light-radiating elements from Elektroluminiszenzelementen (LE) are formed, Vacuumfluoreszenzelementen (VFE), and/or for plasma lights.

6. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 2, by characterized that the light-radiating elements from fluorescent lamps are formed.

7. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 2, by characterized that the light-radiating elements from lamps are formed.

8. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6 and 7, by characterized that the light-radiating elements with the resonant circuit in form of a candle are formed.

9. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6, 7 and 8, by characterized that the light-radiating elements with the resonant circuit are built into glass balls and/or into objects from glass.

10. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6 and 7, by characterized that the light-radiating elements with the resonant circuit are combined into decoration things.

11. Work of art, Christmas tree, decoration and Schmuckbeleuchtunmg according to requirement 1, 2, 3, 4, 5, 6 and 7, by characterized that the light-radiating elements are built into decoration of works of art from glass, jewels, precious metals, plastics or other materials.

12. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6 and 7, by characterized that the light-radiating elements are inserted consisting in toy, utensils, textiles or other articles, of materials of all kinds.

13. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12, by characterized that the coil of the resonant circuit is implemented as wide loop and makes possible thus different forms of supporters.

14. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, by characterized that the light-radiating elements directly at a solar cell panel, a sufficient tension (e.g. 2 V) and a sufficient river (e.g. 3 milliampere) supplies, to be attached.

15. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, by it characterized that the energy source consists of a HF-transmitter, the one constant frequency (e.g. 27 MHz) with a sufficient achievement (e.g. 2 Watts) continuously and/or impulsweise radiates.

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16. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, by characterized that the energy source consists switched Elektroluminiszenzdioden, which and/or the infra-red light radiates continuously, inpulsweise or modulated of an infrared emitter, laser or a battery of parallel and in series.

17. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 to 15, by characterized that the antenna of the HF-transmitter is designed as staff, dipole or loop.

18. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1 and 15, by characterized that the antenna is covered with a HF-Spannungschutz.

19. Work of art, Christmas tree, decoration and decoration lighting according to requirement 2, 8, 9, 10, 13, 17 and 18, by characterized that the antenna, as well as the coils of the resonant circuit consist of a superconductor working at ambient temperature.

20. Work of art, Christmas tree, decoration and decoration lighting according to requirement 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15 and 19, by characterized that at least the lichtaustrahlenden elements, attached co-ordinated with the frequency of the HF-transmitter in resonance, by the resonant circuits as well as in the proximity or directly in the area at least a wide loop of an auxiliary resonant circuit, which is co-ordinated with the same resonant frequency it is placed.

Description

Background/ Summary

Collapse Background/Summary

-

Drawing Description

Collapse Drawing Description

-

Description

Collapse Description

The invention concerns a lighting for Christmas trees, decorations, works of art and decoration with electrical, light-radiating elements, which are attached, fastened to these articles or built into these articles and for the enterprise of necessary energy are also supplied.

With such Christmas tree, decoration, and work of art lighting is necessary a current supply with sufficient achievement, in order to achieve a desired luminous intensity the most frequent electrical filament small lamp used of at. The filament small lamps are attached by means of electrical leaders and/or cables either to the plug socket with full mains voltage, or to a low tension over a Trafo, rarely to an accumulator or a battery.

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Prior kind

With conventional Christmas tree and decoration lighting it is necessary that all filament small lamps are connected by means of electrical conductors, that are continued to attach with the help of a double wire and/or a cable to the plug socket with 220 V and/or 110 V of alternating voltage, 50 cycles per second and/or 60 cycles per second, or to a lower tension at the secondary winding of a Trafos.

The filament small lamps are switched with the connection at full 220 V and/or 110 V of alternating voltage into row and with connection to a lower tension, e.g. 12 V, parallel switched. With the lighting and/or fluoroscopy of works of art the same arrangement of the current supply is necessary.

The absolutely necessary connection of the individual filament small lamps with one another and up to the convenience outlet by means of galvanic connection with electrical conductors, insulating wires, double wire or cable continues to cause some disadvantages and problems:

The distribution and mounting of the filament small lamps at the branches of Christmas tree are limited and/or difficult by the connecting wires.

During the connection at 220 V and/or 110 V mains voltage with series connection of the filament small lamps when burning a filament small lamp the electric circuit through is interrupted, if not each individual filament small lamp became to provide with a special, bridging protection. Only if the defective filament small lamp is replaced by a new, the electric circuit is again closed.

During the connection to a mains voltage of 220 and/or 110 V particularly good electrical isolation of the wring leads is necessary for safety reasons. During parallel connection of the filament small lamps these must be interconnected with two leaders and/or a double wire. Also the double wire and/or the electrical conductor must exhibit good electrical isolation, in order to prevent a short-circuit, particularly with humidity.

The conventional Christmas tree and work of art lighting by connecting leads and/or leads do not work aesthetically and are only very with difficulty at the desired place to be attached.

Unpacking and regranting particularly of electrical Christmas tree lighting bring substantial disadvantages to the electrical conductor, wires, double wires and cables by constant entangling with itself.

Problem of tons of Solve

The invention is the basis the task, the disadvantages of conventional Christmas tree, specified last to eliminate decoration and work of art lighting.

This task is solved according to invention thereby that during the new work of art, Christmas tree, decoration and decoration lighting at least one or more light-radiating elements from at least one energy source, which sends electromagnetic waves or infra-red light are supplied contactless - i.e. without galvanic connection -.

The light-radiating elements are attached directly according to invention to an electrical resonant circuit, that from an inductance and a capacity - e.g. Coil and condenser - exists. The coil can be provided favorably with a low-loss HF ferrite core and/or a good leader.

The light-radiating elements are according to invention favorably formed from Elektroluminiszenzdioden (LED), those multi color light to radiate and in addition only a low tension (e.g. 1,5 to 4 V) and a river (e.g. 2 to 20 milliamperes) need.

According to invention at least two LED's can be antiparallelly attached to the resonant circuit.

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The light-radiating elements know also according to invention from Elektroluminiszenzleuchten (EL), Vacuumfluoreszenzelementen (VFE) and/or from plasma lights to be formed.

The light-radiating elements from fluorescent lamps and lamps are formed just as according to invention.

Particularly for the Christmas tree and decoration lighting the light-radiating elements with the resonant circuit in form of a candle are according to invention formed.

Favorably the light-radiating elements with the resonant circuit can be built into glass balls and/or into objects from glass.

According to invention the light-radiating elements with the resonant circuit can be combined into decoration things.

The light-radiating elements can be built according to invention to the lighting and/or fluoroscopy into decoration works of art from glass, plastics, jewels, precious metals or other materials.

It is also according to invention possible, the light-radiating elements with the resonant circuit in toy, utensils, textiles or other articles, consisting of materials of all kinds to insert.

Favorably according to invention inductances of the resonant circuit know star, letter, number or another art form as wide loop or in different forms as a supporter like e.g. a circle, square, multiplehit a corner, to be implemented.

The lichtaustrahlenden elements know also according to invention to a solar cell panel, a sufficient tension (e.g. 3 V) and a sufficient river (e.g. 10 milliamperes) supplies, to be attached.

The energy source of the Christmas tree, decoration, work of art and decoration lighting consists favorably according to invention of a high-frequency transmitter, the one constant frequency, (e.g. 27 megahertz) with a sufficient achievement (e.g. 2 Watts) continuously and/or impulsweise radiates.

The energy source of the Christmas tree, decoration, work of art and decoration lighting consists also according to invention of an infrared emitter, a laser or of a battery of parallel and in series switched Elektroluminiszenzdioden, continuously, impulsweise or modulated radiate which and/or the infra-red light. This is appropriate, if the lichausstrahlenden elements are attached directly according to invention to a solar cell panel.

Both energy sources are supplied either by a mains voltage, an accumulator, a battery, by solar cells or other forms of energy.

The antenna of the HF-transmitter of the Christmas tree, decoration, work of art and decoration lighting can be designed according to invention as staff, dipole or loop, whereby it can be covered with higher radiated achievement with a HF-Spannungsschutz from insulation material.

In order to achieve low losses during the wireless power supply of the light-radiating elements of the Christmas tree, decoration, work of art and decoration lighting, the coils of the resonant circuit as well as the antenna can consist according to invention of a material, which works as superconductor at a temperature, which is not many lower than the ambient temperature and thus as superconductor with a resistance close zero works.

So that the resonant circuits are supplied with the attached light-radiating elements additionally and more effectively with the HF-energy from the auxiliary resonant circuit, which has high quality, at least according to invention one of the resonant circuits as well as the attached light-radiating elements in the proximity, co-ordinated with the frequency of the HF-transmitter in resonance, can be placed or directly in the area at least a wide loop of an auxiliary resonant circuit, which is co-ordinated with the same

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resonance.

The following advantages are obtained by the invention:

The current supply of light-radiating elements is accomplished without galvanic connection from the energy source. Thus the problems with wires and cables, which cause much annoyance with conventional Christmas tree, decoration and work of art lighting, do not arise.

During the mounting of the light-radiating elements, particularly in the form of candles at the Christmas tree, as well as when the out and packing up the lighting, one must pay attention not to the connecting wires and/or double wires or cables.

Possible burning of a light-radiating element through has erfindungsemäß no disturbing effect on the remaining light-radiating elements.

It is not possible a short-circuit disturbance, since the connecting double wires and cables are void according to invention.

The aesthetics both with lighting up the Christmas tree and with the lighting and fluoroscopy of Kuntwerken from glass and other transparent materials or plastics is no more disturbed by connecting wires of the current supply according to invention.

The light-radiating elements can be inserted, fastened more simply into or to these works of art or interconnected, whereby beautiful, colored light effects are reached.

The light-radiating elements can be implemented with the resonant circuit in very small dimensions - particularly with Elektroluminiszenzdioden (LED) - and thus substantially more suitably its for the installation, the attachment, the lighting and fluoroscopy of decoration and jewels, as conventional sources of light. Also in this case the esthetic effect is obtained nich disturbed to separate on the contrary a new light-radiating effect by decoration and jewels, what puts the effect out of the object concerned still more.

The coil of the resonant circuit and the antenna can be implemented from a material, which works as superconductor at a Tempratur, which is not many lower than the ambient temperature, whereby a high efficiency of the wireless current supply from the energy source is obtained, since the enormously low resistance of the superconductor a high quality of the coils of the resonant circuit and the antenna effectuation and accordingly very low losses arise.

Working Examples

Some execution examples of the invention are represented and in the following are more near described in the designs to 7. It shows

Fig. 1 Christmas tree lighting,

- a) Arrangement in principle,
- b) LED with resonant circuit as electrical candle.

Fig. 2 electrical circuit of the resonant circuit *LC* with LED at the pick-up of the coil,

- a) with an LED,
- b) with two antiparallelly switched LED's,
- c) wide L-loop for attaching.

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Fig. 3 glass ball for Christmas tree and/or decoration.

Fig. 4 Lampion for decoration purposes.

Fig. 5 work of art Christ at the cross with heart lighting.

Fig. 6 work of art cat with bright eyes.

Fig. 7 decoration earrings with bright jewel.

In **Fig.** 1a is represented the arrangement in principle of a Christmas tree lighting, with the Elektroluminiszenzdioden LED (**1**), which radiate multi color light, ever with that *LC*- Resonant circuit (**2**), that with the resonant frequency is 27 MHz co-ordinated and from an air coil (**3**) and a trimmer capacitor (**4**) exists, together with the mounting plate (**5**) the form of an electrical candle (**6**) form, whereby for the contactless current supply as energy source a HF-transmitter (**7**) serves. The HF-transmitter (**7**) an output of 20 Watts from a /4 radiates is enough for blade antenna (**8**) in the direction of the Christmas tree out, which is distant from the antenna for 0.5 to 5 meters. The antenna (**8**) can with a reflector (**9**) to be provided, in order to cause the radiant emittance in the desired direction. The LED's (**1**) are with a screen (**10**) provide from glass and/or transparent plastic, which is verspiegelt also down, in order to radiate the rays of light more laterally and downward.

In **Fig.** 2 is the electrical circuit of the *LC*- Resonant circuit (**2**) represented with LED's (**1**) at the pick-up of the coil (**3**), in order to create an optimal power adaptation for the delivery of the electricity of the resonant circuit to the LED's.

In **Fig.** 2a is the circuit of the *LC*- Resonant circuit (**2**) with an LED (**1**) at the pick-up of the coil (**3**) represented.

In **Fig.** 2b is that *LC*- Resonant circuit (**2**) represented, with two antiparallelly switched on LED's, which use both half waves of the HF of signal for the power supply favorably.

In **Fig.** 2C is the circuit one *LC*- Resonant circuit (**2**) represented with wide coil loop (**3**), which forms and for attaching be used favorably can sufficient inductance. By the large loop surface of the coil with fewer turns or with a turn a good power supply of the LED's is reached.

Fig. 3 shows a glass ball with a diameter from 6 to 10 cm and/or more largely for Christmas tree or decoration purposes, with than coil (**3**) depending upon ball size two to five turns from a good electrical conductor the surface to be re-clamped and/or the turns directly at the surface be formed and with a chip and/or a trimmer capacitor (**4**), which is 27 MHz co-ordinated with the resonant frequency, one *LC*-Resonant circuit (**2**) form, whereby at the pick-up of the coil (**3**) or two LED's in antiparallel a circuit switching on and in the interior of the glass ball for the fluoroscopy are fastened.

Fig. a Lampion for decoration purposes, with that shows 4 the turns of the coil (**3**) are wound at the Lampionszylinder and with a trimmer capacitor (**4**) with the resonant frequency 27 MHz are co-ordinated. The condenser is fastened to the top of the Lampions and forms one *LC*- Resonant circuit (**2**), whereby as light-radiating elements (**1**) and/or two LED's at the pick-up of the coil (**3**) to be switched on and in the interior of the Lampions to the fluoroscopy be fastened. Fluorescence elements (VFE) and/or plasma elements, which to the full coil, can do in addition, of the coil (3) to be switched on, for the fluoroscopy used.

Fig. a work of art shows 5, in which the Christ body at the cross with light-radiating heart as symbol the love is represented. The light becomes from an LED (**1**) forms radiated and at the pick-up of a coil with several turns (**3**), which are aesthetically as spiral halo circles around the Christ head implemented, with the trimmer capacitor (**4**), which is 27 MHz co-ordinated with the resonant frequency, one *LC*- Resonant

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circuit. The heart can be implemented symbolically also from a polished jewel or from glass and/or another transparent material, which analyzed with the inserted LED. Likewise also two LED's in antiparallel connection for the fluoroscopy can be used.

In **Fig.** another Kustwerk is represented 6, which shows a black cat with green shining eyes. The light becomes from two becomes green to LED's (**1**) radiated or analyzes the cat eyes from green glass or jewels, whereby the LED's directly to a solar cell panel (**11**) to be attached, that when irradiation with infra-red light from an energy source (**7**) a tension of 3 V has and a river of 20 milliamperes supplies. The energy source (**7**) meter consists toward the solar cell panel of an infrared lamp with an achievement more largely than 200 Watts and radiates from a distance smaller than 3 (**11**). Instead of it also possible, e.g. a white rabbit with red shining eyes is to be represented to the cat.

Fig. decoration shows 7 in form of an earring with polished jewel, that by and/or two LED's (**1**) analyzed. The LED is inserted and electrical to inden jewel at the pick-up of a resonant circuit (**2**) attached, the one rectangular, spiral coil (**3**) with a chip and/or a trimmer capacitor (**4**) forms. The coil (**3**) can be formed also as a circle spiral.

As in **Fig.** 1 the LED's becomes (**1**) also in **Fig.** 3, 4, 5 and 7 from an energy source (**7**) supplies, which of a HF-transmitter consists, electromagnetic waves within the range of 27 MHz with an output of 200 Watts from an antenna (**8**) radiates in the direction decoration and of the works of art and over those *LC*- Resonant circuits (**2**) the light-radiating elements contactless with energy supplies.

Citations

Citation

Collapse Citing Patents (25)

	Publication Number	Publication Date	Application Date	Assignee/Applicant	Title
	DE102004006006B4	2005-09-15	2004-02-06	KRINNER INNOVATION GMBH	Tree light arrangement has local switched electrical power supply, electronic module per light, signal input connected by single pole electrical contact to light source clamp attached to tree
	DE102004022759A1	2006-02-02	2004-05-08	KORUK ANDREAS THOROS	Christmas light decoration for a Christmas Tree comprises individual Christmas Tree candles made from light sources which are electrically independent of each other and are supplied with energy via electromagnetic or static waves
	DE102004047562A1	2006-04-06	2004-09-30	LEOPOLD NORBERT	Object illuminating system, has illuminant and object directly connected with one another by complete embedding using light of conducting medium, like clear oil, where illuminant is

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					completely integrated into lighting object
	DE102008024779A1	2009-11-26	2008-05-23	OSRAM GMBH	Drahtlos speisbares Leuchtmodul
	DE102008024780A1	2009-11-26	2008-05-23	OSRAM GMBH	Drahtlos speisbares Leuchtmittel
	DE10209003A1	2003-09-11	2002-02-28	DAIMLER CHRYSLER AG	Anti-jamming device for a closing part for an electrically driven motor vehicle roof has energy store in the closing part which is charged from a base station
	DE19500694A1	1996-08-08	1995-01-12	HAUCK MARTIN	HF image reproduction device
	DE19500694C2	1997-12-11	1995-01-12	HAUCK MARTIN	HF-Bildwiedergabe-Vorrichtung
	DE4120849A1	1993-01-07	1991-06-25	SEITZ LOTHAR	Electrical lighting system for christmas tree or for party illumination - has several single, individually positionable lights, each having its own battery power source and radio receiver
	EP894357B1	2002-01-30	1997-04-15	CIBIE PIERRE	ELECTRICAL INSTALLATION USING ELECTROMAGNETIC INDUCTION
	FR2747519A1	1997-10-17	1996-04-16	CIBIE PIERRE	INSTALLATION ELECTRIQUE A INDUCTION ELECTROMAGNETIQUE
	FR2831031A1	2003-04-25	2001-10-23	DJI DESIGN	Method for illuminating natural or synthetic precious stone, comprises electronically fed laser with beam which is directed at lowest extremity of stone and is housed within press fit stone mounting
	US7741734B2	2010-06-22	2006-07-05	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US7825543B2	2010-11-02	2008-03-26	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer
	US8022576B2	2011-09-20	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US8035255B2	2011-10-11	2009-11-06	WITRICITY CORP	Wireless energy transfer using planar capacitively loaded conducting loop resonators
	US8076800B2	2011-12-13	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US8076801B2	2011-12-13	2009-05-14	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer, including interference enhancement
	US8084889B2	2011-12-27	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer

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	US8097983B2	2012-01-17	2009-05-08	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer
	US8106539B2	2012-01-31	2010-03-11	WITRICITY CORP	Wireless energy transfer for refrigerator application
	WO1997039510A1	1997-10-23	1997-04-15	CIBIE PIERRE	ELECTRICAL INSTALLATION USING ELECTROMAGNETIC INDUCTION
	WO2007008646A2	2007-01-18	2006-07-05	MASSACHUSETTS INST TECHNOLOGY	WIRELESS NON-RADIATIVE ENERGY TRANSFER
	WO2008118178A1	2008-10-02	2007-06-11	MASSACHUSETTS INST TECHNOLOGY	WIRELESS ENERGY TRANSFER
	WO2009141111A2	2009-11-26	2009-05-19	OSRAM GMBH	WIRELESS SUPPLYABLE LIGHTING MODULE

Expand Cited Patents (24)

Expand Cited Non-patents (1)

Other

DWPI Title Terms

DECORATE LIGHT CHRISTMAS TREE SALE DISPLAY ELECTROMAGNET INFRARED ENERGY BEAM REMOTE SUPPLY INDIVIDUAL LAMP

Custom Fields

Test

-

Relevance

-

Product Name

-

Docket number

-

Notes

-

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Patent Record Full View Tuesday, July 17, 2012 THOMSON INNOVATION

Patent/Publication: DE10029147A1

Bibliography

DWPI Title

Installation for supplying toys with electrical energy, preferably for production of light, comprises a sender of electromagnetic waves which is located at a small distance above a play area with the toys

Original Title

Plant for the supply of toys with electricity with the help of a transmitter, which send electromagnetic waves, and a receiver with antenna

English Title

Installation for supplying toys with electrical energy, preferably for production of light, comprises a sender of electromagnetic waves which is located at a small distance above a play area with the toys

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TIEMENS U

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DWPI Accession / Update

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Application Number / Date

DE10029147A / 2000-06-14

Priority Number / Date / Country

DE10029147A / 2000-06-14 / DE

Abstract

DWPI Abstract

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(DE10029147A1)

Novelty

The installation for supplying toys with electrical energy, preferably for production of light, comprises a sender of electromagnetic waves which is located at a small distance above a play area with the toys provided with appropriate receiver antennas and electronic energy conversion circuits.

Use

For toys which are to emit light.

Advantage

Need for batteries is eliminated.

Drawing Description

The drawing shows the proposed installation.

1 - Signal generator.

2 - Sender antenna.

5 - Play area.

6 - Toy.

7 - Receiver antenna.

8, 9, 10 - Energy conversion unit.

11 - Light source.

Technology Focus

POLYMERS - The toys incorporate acrylic light guides for conducting light to required points on the toys.

Abstract

The installation for supplying toys with electrical energy, preferably for production of light, comprises a sender of electromagnetic waves which is located at a small distance above a play area with the toys provided with appropriate receiver antennas and electronic energy conversion circuits.

German Abstract

Mit einem Generator 1 und einer Antenne 2 wird ein Sendesignal erzeugt, das eine Modellfläche 5 bestrahlt. Auf der Modellfläche stehen Spielzeuge, in denen sowohl die Empfangsantennen 7 als auch je eine nachgeschaltete Elektronik integriert sind. Die Sendeenergie wird von der Empfangsantenne empfangen und entweder direkt an Glühlampen 11 weitergeleitet, um diese zum Leuchten zu bringen, oder über die nachgeschaltete Elektronik, bestehend aus dem Empfänger-Eingangskreis 8, dem Gleichrichter 9 und der Anpaßelektronik 10, an die Licht emittierenden Dioden 11 weitergegeben, um diese zum Leuchten anzuregen.

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IPC

IPC Code(1-7) **A63H 17/28** A63H 17/00 A63H 19/20 H02J 17/00

(7)

Current IPC	Invention	Version	Additional	Version
Full	A63H 17/28 A63H 19/20 H02J 17/00	20060101 20060101 20060101	-	-
Main Group	-	-	-	-
Subclass	-	-	-	-

Original IPC	Invention	Version	Additional	Version
Advanced/Full	A63H 17/28 A63H 19/20 H02J 17/00	20060101 20060101 20060101	-	-
Core/Main Group	A63H 17/00 A63H 19/00 H02J 17/00	20060101 20060101 20060101	-	-
Subclass	-	-	-	-

ECLA

A63H 17/28 A63H 19/20 H02J 17/00

DWPI Class

A89 U24 X12 P36

DWPI Manual Codes

Collapse DWPI Manual Codes

CPI Manual Codes: A99-A
EPI Manual Codes: U24-H; X12-H01X

DWPI Chemistry Resource Numbers

Collapse DWPI Chemistry Resource Numbers

-

DWPI Registry Numbers

Collapse DWPI Registry Numbers

-

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Plasdoc Punch Codes

Collapse Plasdoc Punch Codes

-

Plasdoc Key Serial Codes

Expand Plasdoc Key Serial Codes

Enhanced Polymer Indexing

Expand Enhanced Polymer Indexing

Chemical Fragment Codes

Expand Chemical Fragment Codes

Legal Status

INPADOC Legal Status

Gazette Date	Code	Description
2004-04-15	8139 -	DISPOSAL/NON-PAYMENT OF THE ANNUAL FEE
2003-12-04	8170 +	REINSTATEMENT OF THE FORMER POSITION
2003-04-10	8139 -	DISPOSAL/NON-PAYMENT OF THE ANNUAL FEE
2002-01-31	8122	NONBINDING INTEREST IN GRANTING LICENSES DECLARED

Get Family Legal Status

Family

Family

INPADOC Family (0)

Collapse DWPI Family (1)

Publication	DWPI Update	Publication Date	IPC Code	Language
DE10029147A1	200210	2001-12-20	A63H001728	German

Claims

Claims

Collapse All Claims (11)

Claims (German)

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1. Plant for the supply of toys with electricity, preferably for the production of light, consisting of a transmitter, which sends and mdst a signal with a certain frequency. with a receiver equipped toy, **thus characterized**that the transmitter from a small distance (preferably in the meter range) is directed in a model surface, and that on this surface the positioned take up and with one receiver each provided toys the energy radiated from the transmitter over an antenna and convert this taken up transmitting power by means of an electronic circuit into light.

2. Plant according to requirement 1, by the fact characterized that the broadcasting signal is an oscillation with adjustable amplitude, adjustable in the frequency, which is produced by a generator.

3. Plant according to requirement 1, by the fact characterized that the oscillation is preferably a sinus oscillation.

4. Plant after requirement 1 and one following, thereby marked that the transmitter frequency is selected dependant on the size of the mechanical extents of the toys, into which the receiving antenna is integrated.

(With toys, which have a size of few cm, a transmitter frequency is necessary in the GHz range) because of the optimal antenna size.

5. Plant after requirement 1 and one the following, by the fact characterized that the sensitivity of the receiver to the broadcasting signal is maximally co-ordinated.

6. Plant after requirement 1 and one the following, by the fact characterized that the transmitter is so dimensioned that it sends energy essentially only to the toys placed in the model surface.

7. Plant after requirement 1 and one the following, by the fact characterized that the complete receiver, including which antenna with electronics downstream, in the toy is integrated.

8. Plant according to requirement 1 to 7, by the fact characterized that the taken up energy with a memory (e.g. Reservoir capacitors, so-called one buffers gold caps, or accumulators) buffered, and/or, so that brief interruptions of the energy transmission can be bridged.

9. Plant according to requirement 1 to 7, by the fact characterized that from switching the broadcasting signal on and off the impression of a flashing source of light results.

10. Plant after requirement 1 and one the following, thereby marked that the light of the source of light with light conductors (e.g. particularly bent acrylic glass) is steered to the places of the toy, at which the light it is to appear.

11. Plant after requirement 1 and one the following, by the fact characterized that also different aggregates/components than a source of light, e.g. Relay, engines etc., with the help of which transferred electricity are operated.

Description

Background/ Summary

Collapse Background/Summary

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DWPI Drawing Description

The drawing shows the proposed installation.

1 - Signal generator.

2 - Sender antenna.

5 - Play area.

6 - Toy.

7 - Receiver antenna.

8, 9, 10 - Energy conversion unit.

11 - Light source.

Drawing Description

Collapse Drawing Description

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Description

Collapse Description

The invention concerns a plant for the wireless supply of toys with electricity, which transfers electromagnetic waves with the help of a transmitter, which will receive from a receiver with an antenna, and which brings a source of light to shining. With this kind of the supply it is important that the toys themselves do not need an own current supply, like batteries, accumulators or the like, and that the supply takes place localindependently. A further substantial characteristic of this kind of supply is the simple production of the broadcasting signal by a function table with an adjustable frequency. The antenna input of the receiver is optimized on the given frequency.

The wireless energy transmission by means of an alternating field is in principle well-known from EP-B1-91-971. With a such plant the magnetic field in parallel to a distance covered led staff leaders is produced, whereby driving toys can be led.

A further procedure is described, in which "control signals" will transfer over a transmitter/a receiver system (DE 39 03 535 A1). These control signals will transfer a receiving coil over an air coil as transmitters and to the toy, then however with relatively complex means (band filter, microprocessor, signal molder etc.) for the controlling of the toy used. The toys for their part are operated with external supply terminals.

A further procedure of the wireless energy transmission by means of induced tensions is described in the patent application 100 24 648,6.

All these procedures use the principle of the induction for the transmission of energy or information.

The invention is the basis from there the task, in a defined clearance, the model surface, to transfer with the help of in the spatial proximity (within the meter range) of the clearance of arranged transmitter over a transmitting antenna energy to the electrical consumer integrated in a toy. The toys do not need to have thereby own supply terminals. The energy is preferably used for the lighting of the toys.

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In the case of use of today's technology, e.g. Low current LEDs (light-along-animal-end diodes), are needed for the enterprise an LED only approx. 2 mW. With an obtained tension of only approx. 2 V an low current LED can be operated with a river by 1 mA. If it concerns a red LED, this light can be used e.g. in a miniature car as taillight. The light can be steered with a passive light conductor (e.g. consisting of acrylic glass) at each desired place.

For the solution of this task the characteristics and measures marked by requirement 1-11 are suggested. The subject of the invention is below described on the basis an execution example, which is schematically illustrated in the design. In the design show:

Fig. 0 overview, principle picture;

Fig. 1 arrangement of the transmitter relative to the Spielfläche;

Fig. 2 schematic representation of the receiver;

Fig. 3 execution example of the conversion of the received energy to light.

With that below the arrangement according to invention of the wireless supply of a toy with energy, which is used e.g. for the operation of a source of light, serves specified execution example.

In addition becomes **Fig.** 1 an antenna **2** voh a generator **1** with a transmission Rome with a given frequency operated, so that a model surface **5** evenly from direction **4** one illuminates. In the model surface **5** becomes as in **Fig.** 2 suggested, a toy **6** arranged, in that a complete receiver computer unit eischließlich the receiving antenna **7**, is integrated. This receiver computer unit consists of a receiving antenna **7**, and electronics downstream, those again from the antenna input circle **8**, the electric rectifier **9** and adjustment electronics **10** exists. At this adjustment electronics are the sources of light **11** attached. In **Fig.** 3 one shows again, how in the execution example the transformation transmitting power takes place in light. In the antenna **7** taken up energy to electronics downstream one passes on. Adjustment electronics **8** with resonant circuit (L1, L2, C) it ensures for the fact that the tension and/or the river the attached source of light **11** does not overload. In a simple case is sufficient for the operation a light of an emitting diode an adapted pre-resistor. In addition the transmitting power of the generator must **1** out **Fig.** 1 to be regulated in such a way that the received energy becomes parallel and at the connections of the electric rectifier **9** remains constant. There is conceivable in addition, further executions of adjustment electronics, as would e.g. bring in a breakdown diode for voltage stabilization and/or would bring in a reservoir capacitor for bridging voltage fluctuations.

During sufficient power transmission also the direct connection of a lamp is enough to the contacts of the antenna input circle **8** out. In this case the electric rectifier becomes **9** and adjustment electronics **10** does not use. **Figure legend1** Generator for the supply of the transmitting antenna

2 Transmitting antenna

3 By the transmitter of caused radiation cones and surface illuminated

4 Radiation pattern of the transmitter

5 Spielfläche/model surface

6 Toy

7 Receiving antenna

8 Electric rectifier

9 Adjustment electronics

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10 Source of light

Citations

Citation

Collapse Citing Patents (11)

	Publication Number	Publication Date	Application Date	Assignee/Applicant	Title
	US7741734B2	2010-06-22	2006-07-05	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US7825543B2	2010-11-02	2008-03-26	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer
	US8022576B2	2011-09-20	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US8035255B2	2011-10-11	2009-11-06	WITRICITY CORP	Wireless energy transfer using planar capacitively loaded conducting loop resonators
	US8076800B2	2011-12-13	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US8076801B2	2011-12-13	2009-05-14	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer, including interference enhancement
	US8084889B2	2011-12-27	2009-03-31	MASSACHUSETTS INST TECHNOLOGY	Wireless non-radiative energy transfer
	US8097983B2	2012-01-17	2009-05-08	MASSACHUSETTS INST TECHNOLOGY	Wireless energy transfer
	US8106539B2	2012-01-31	2010-03-11	WITRICITY CORP	Wireless energy transfer for refrigerator application
	WO2006109360A1	2006-10-19	2005-04-15	KATO KENICHI	RADIO POWER SUPPLY TERMINAL
	WO2008118178A1	2008-10-02	2007-06-11	MASSACHUSETTS INST TECHNOLOGY	WIRELESS ENERGY TRANSFER

Cited Patents (0)

Cited Non-patents (0)

Other

DWPI Title Terms

INSTALLATION SUPPLY TOY ELECTRIC ENERGY PREFER PRODUCE LIGHT COMPRISE SEND ELECTROMAGNET WAVE LOCATE DISTANCE ABOVE PLAY AREA

DWPI Related Accession Numbers

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Custom Fields

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Relevance

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Product Name

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Notes

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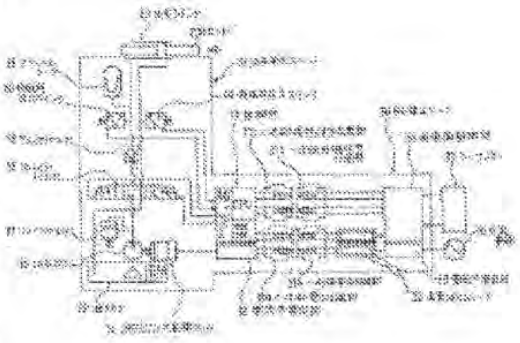
Bibliographic data: JP6341410 (A) — 1994-12-13

UNIVERSAL HYDRAULIC DEVICE

Inventor(s):	HIRAI ATSUYUKI; HIRAGA YOSHIJI; AOYAMA YOSHIO +	
Applicant(s):	YASKAWA ELECTRIC CORP; AOYAMA YOSHIO +	
Classification:	**- international:**	***F15B1/00; F15B11/00; F15B15/18; H02J17/00;*** (IPC1-7): F15B1/00; F15B11/00; F15B15/18: H02J17/00
	- European:	
Application number:	JP19930132088 19930602	
Priority number (s):	JP19930132088 19930602	
Also published as:	JP3207294 (B2)	

Abstract of JP6341410 (A)

PURPOSE:To enable a hydraulic actuator to mode freely and to be replaced without generation of problem in hydraulic piping and electric wiring between a hydraulic actuator and its driving means and with a simple structure. CONSTITUTION:A feeder unit 30 has a primary side power transmission part 31a and primary side information signal transmission part 31b to which high frequency voltage is applied by a high frequency inverter 32 and a feeding side control part 34 respectively.; A hydraulic pressure generation unit 10 has a hermetical structure and is provided with a hydraulic circuit composed of a hydraulic pump 15, solenoid valve 16 and check valve 18, a hydraulic cylinder 23 controlled by the hydraulic circuit, and a secondary side power transmission part 11a and a secondary side information signal transmission part 11b to which part 11a power is supplied and to which part 11b



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information signal is transmitted
respectively from the primary side information signal transmission part 31b and the primary side power transmission part 31a, by a noncontact manner by high frequency electromagnetic induction.

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	1/00	Ａ	9235－3H		
	11/00	Ｄ	8512－3H		
Ｈ０２Ｊ	17/00	Ｂ	9061－5G		
		Ｘ	9061－5G		

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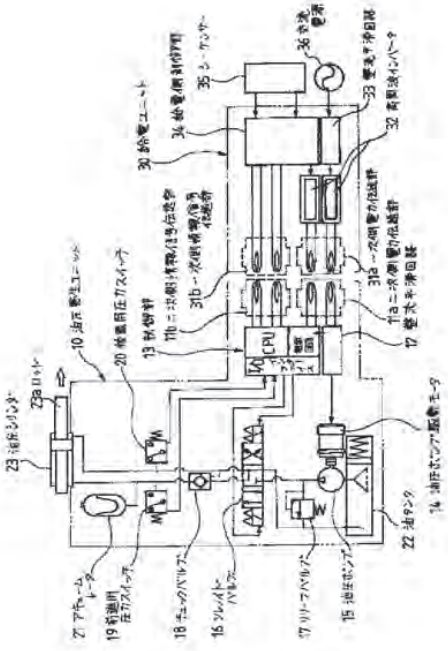
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(54)【発明の名称】　自在油圧装置

(57)【要約】

【目的】　油圧アクチュエータとその駆動手段との間の油圧配管や電気配線の問題を生じることなく、しかも簡単な構成で油圧アクチュエータの自律移動や交換を行なえるようにする。

【構成】　給電ユニット３０は、それぞれ高周波インバータ３２および給電側制御部３４より高周波電圧が印加される一次側電力伝送部３１ａおよび一次側情報信号伝送部３１ｂを有する。油圧発生ユニット１０は密閉構造で、油圧ポンプ１５、ソレノイドバルブ１６、およびチェックバルブ１８等からなる油圧回路と、油圧回路により制御される油圧シリンダ２３と、高周波電磁誘導により無接触で、一次側情報信号伝送部３１ｂおよび一次側電力伝送部３１ａから、電力が供給される二次側電力伝送部１１ａおよび情報信号が伝送される二次側情報信号伝送部１１ｂとを有する。



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【特許請求の範囲】
【請求項１】　高周波電圧が印加される一次側伝送部を有する給電ユニットと、
前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットとからなり、
該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、該二次側伝送部を経由して前記給電ユニットから供給される電力により駆動される油圧ポンプと、該油圧ポンプと前記油圧シリンダとの間に設けられ、前記二次側伝送部を経由して前記給電ユニットから伝送される情報信号により制御されるソレノイドバルブと、該ソレノイドバルブと前記油圧シリンダとの間に設けられたチェックバルブと、前記油圧シリンダとが一つの密閉された構造体の中に設けられていることを特徴とする自在油圧装置。
【請求項２】　前記給電ユニットに、前記一次側伝送部へ高周波電圧を印加する手段を駆動するためのバッテリを内蔵した請求項１に記載の自在油圧装置。
【請求項３】　高周波電圧が印加される一次側伝送部を有する給電ユニットと、
前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットからなり、
該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、前記給電ユニットからの電力の供給および情報信号の伝送により制御される油圧回路と、前記油圧シリンダとが一つの密閉された構造体の中に設けられるとともに、
前記給電ユニットおよび前記油圧発生ユニットには、前記一次側伝送部と前記二次側伝送部とが互いに対向して配置されるように、前記給電ユニットと前記油圧発生ユニットとを機械的にかつ着脱自在に結合する結合手段が設けられていることを特徴とする自在油圧装置。
【請求項４】　前記油圧発生ユニットは、産業用ロボットのアーム部の先端に、前記結合手段により結合可能となっている請求項３に記載の自在油圧装置。
【請求項５】　高周波電圧が印加される、細長いループ状の一次側巻線が基台上に固定して配置された一次側伝送部を有する給電ユニットと、
前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットからなり、
該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、前記給電ユニットからの電力の供給および情報信号の伝送により制御される油圧回路と、前記油圧シリンダとが一体となって設けられているとともに、
前記二次側伝送部は、前記一次側巻線を二つの中空部に遊嵌して、前記基台上を前記一次側巻線の長手方向に移動自在に設けられた二次側コアと、前記一次側巻線に対向して前記二次側コアに巻回された二次側巻線とを有することを特徴とする自在油圧装置。
【請求項６】　前記一次側巻線を基台上に複数設けるとともに、前記油圧発生ユニットを前記各一次側巻線毎に設け、
前記一次側巻線へ高周波電圧を印加する手段を、高周波電磁誘導を利用して電力および情報信号を無接触で伝送する、さらにもう１段の一次側伝送部および二次側伝送部を介して設けた請求項５に記載の自在油圧装置。
【請求項７】　前記給電ユニットには、前記一次側伝送部に印加する高周波電圧の周波数を複数種に変換する周波数変換手段が設けられるとともに、
前記油圧発生ユニットには、前記高周波電磁誘導により前記二次側伝送部に生じた高周波電圧の周波数を測定する周波数測定回路と、該周波数測定回路で測定された高周波電圧の周波数に対応して、前記油圧回路の制御を行なうための情報信号を発生させるデコーダとが設けられている請求項１ないし６のいずれか１項に記載の自在油圧装置。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、自在油圧装置に関する。
【０００２】
【従来の技術】近年、工作機械を取り扱う職場の多くは、作業環境が厳しいことによる労働者の不足と、多品種少量生産への生産形態という社会背景のもとで、工作機械の段取り工程の自動化は着実に進んできている。自動化治具や産業用ロボットの先端ツールなど大きな力を発生する必要のあるアクチュエータの駆動源は未だ油圧が中心である。油圧アクチュエータの駆動は、一般に電動機で油圧ポンプを加圧して行なっているが、そのためには必ず油圧配管や電気配線が必要となる。これは、自動化治具を自律移動させる場合すなわち油圧アクチュエータの駆動手段に対する自律移動を考えた場合や、産業用ロボットの先端ツールの交換対応を考えた場合、油圧配管や電気配線の接続の問題が生じることになるが、最近は自動油圧カップラなどの実用化が進められその解決が図られようとしている。
【０００３】

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【発明が解決しようとする課題】しかしながら、油圧カップラを用いても依然として油圧アクチュエータと駆動手段との間の油圧配管や電気配線の必要性はあり、油のリークの問題などが完全に解決されているわけではないし、油圧カップラ操作自体も自動化が容易でなく、駆動手段に対する油圧アクチュエータの自律移動や産業用ロボットの先端ツールの交換対応を考えた場合に、信頼性の不安が残る。また、情報信号の伝送を平行して行なわないと、動作させる治具アクチュエータの数が増えるにつれてカップラの数も増え、信頼性低下と装置の大型化につながることになる。そこで本発明は、油圧アクチュエータとその駆動手段との間の油圧配管や電気配線の問題を生じることなく、しかも簡単な構成で油圧アクチュエータの自律移動や交換を行なえる自在油圧装置を提供することを目的とする。

【０００４】

【課題を解決するための手段】上記目的を達成するため本発明の自在油圧装置は、高周波電圧が印加される一次側伝送部を有する給電ユニットと、前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットとからなり、該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、該二次側伝送部を経由して前記給電ユニットから供給される電力により駆動される油圧ポンプと、該油圧ポンプと前記油圧シリンダとの間に設けられ、前記二次側伝送部を経由して前記給電ユニットから伝送される情報信号により制御されるソレノイドバルブと、該ソレノイドバルブと前記油圧シリンダとの間に設けられたチェックバルブと、前記油圧シリンダとが一つの密閉された構造体の中に設けられていることを特徴とする。

【０００５】この場合、前記給電ユニットに、前記一次側伝送部へ高周波電圧を印加する手段を駆動するためのバッテリを内蔵したものであってもよい。また、高周波電圧が印加される一次側伝送部を有する給電ユニットと、前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットからなり、該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、前記給電ユニットからの電力の供給および情報信号の伝送により制御される油圧回路と、前記油圧シリンダとが一つの密閉された構造体の中に設けられるとともに、前記給電ユニットおよび前記油圧発生ユニットには、前記一次側伝送部と前記二次側伝送部とが互いに対向して配置されるように、前記給電ユニットと前記油圧発生ユニットとを機械的にかつ着脱自在に結合する結合手段が設けられていることを特徴とするものとし、前記油圧発生ユニットは、産業用ロボットのアーム部の先端に、前記結合手段により結合可能となっているものでもよい。

【０００６】さらに、高周波電圧が印加される、細長いループ状の一次側巻線が基台上に固定して配置された一次側伝送部を有する給電ユニットと、前記給電ユニットからの電力が供給され、該電力により油圧力を発生させて油圧アクチュエータに所定の作業を行なわせるための油圧シリンダを駆動する油圧発生ユニットからなり、該油圧発生ユニットは、前記高周波電圧の印加により生じる高周波電磁誘導を利用して前記一次側伝送部と無接触で前記給電ユニットから電力の供給および情報信号の伝送が行なわれる二次側伝送部と、前記給電ユニットからの電力の供給および情報信号の伝送により制御される油圧回路と、前記油圧シリンダとが一体となって設けられているとともに、前記二次側伝送部は、前記一次側巻線を二つの中空部に遊嵌して、前記基台上を前記一次側巻線の長手方向に移動自在に設けられた二次側コアと、前記一次側巻線に対向して前記二次側コアに巻回された二次側巻線とを有するものであってもよく、この場合には、前記一次側巻線を基台上に複数設けるとともに、前記油圧発生ユニットを前記各一次側巻線毎に設け、前記一次側巻線へ高周波電圧を印加する手段を、高周波電磁誘導を利用して電力および情報信号を無接触で伝送する、さらにもう１段の一次側伝送部および二次側伝送部を介して設けたものとしてもよい。

【０００７】そして、上記本発明の各自在油圧装置において、前記給電ユニットには、前記一次側伝送部に印加する高周波電圧の周波数を複数種に変換する周波数変換手段が設けられるとともに、前記油圧発生ユニットには、前記高周波電磁誘導により前記二次側伝送部に生じた高周波電圧の周波数を測定する周波数測定回路と、該周波数測定回路で測定された高周波電圧の周波数に対応して、前記油圧回路の制御を行なうための情報信号を発生させるデコーダとが設けられているものでもよい。

【０００８】

【作用】上記のとおり構成された請求項１に記載の発明では、給電ユニットから油圧発生ユニットへは、高周波電磁誘導を利用して無接触で電力の供給および情報信号の伝送が行なわれるので、給電ユニットと油圧発生ユニットとの間には油圧配管や電気配線が必要なくなり、油の漏れや電気回路の接続不良がなくなる。また、ソレノイドバルブと油圧シリンダとの間にチェックバルブが設けられているので、給電ユニットから油圧発生ユニットへの電力の供給およびソレノイドバルブの制御信号の入出力は、油圧シリンダの動作の開始時と終了時以外は必要なくなる。よって、それ以外には給電ユニットと油圧発生ユニットとを分離しても、油圧シリンダはその状態

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を維持し続け、油圧アクチュエータの機能を維持した状態で油圧発生ユニットを自在に移動できる。

【０００９】

【実施例】次に、本発明の実施例について図面を参照して説明する。

（第１実施例）図１は、本発明の自在油圧装置の第１実施例の概略構成図である。図１に示すように、この自在油圧装置は密閉構造の油圧発生ユニット１０と、油圧発生ユニット１０と分離可能な給電ユニット３０とに大別される。まず、油圧発生ユニット１０について説明する。油圧発生ユニット１０は、油圧ポンプ駆動モータ１４からの駆動力により油タンク２２内の油を汲み上げて油圧力を発生させ、この油圧力により油圧シリンダ２３のロッド２３ａを図示矢印方向に前進させたり、その逆方向に後退させるものであり、ロッド２３ａの移動方向を切り換えるためのソレノイドバルブ１６を有する。油タンク２２は、油温の変化による容積変化と、アクチュエータの移動に伴う容積変化に追従するために、容積変化型のものが用いられている。

【００１０】また、ソレノイドバルブ１６と油圧シリンダ２３のロッド前進側油室とを連通する配管には、チェックバルブ１８と、ロッド２３ａの前進移動が完了したことを検知するための前進用圧力スイッチ１９と、油圧回路を密閉構造の中に収めた場合の温度変化による油量の変化を吸収し、油圧発生特性の変化が生じないようにするためのアキュームレータ２１とが設けられている。一方、ソレノイドバルブ１６と油圧シリンダ２３のロッド後退側油室とを連通する配管には、ロッド２３ａの後退移動が完了したことを検知するための後退用圧力スイッチ２０が設けられている。さらに、油圧ポンプ１５とソレノイドバルブ１６とを連通する配管にはリリーフバルブ１７が設けられている。ここで、前進用圧力スイッチ１９と、後退用圧力スイッチ２０は、それぞれマイクロスイッチ等を用いた近接スイッチで代用することができる。

【００１１】二次側電力伝送部１１ａおよび二次側情報信号伝送部１１ｂは、それぞれ後述する給電ユニット３０から高周波電磁誘導により電力および情報信号を授受するためのものであり、コアと、それに巻回された巻線とからなる。二次側情報信号伝送部１１ｂを通じて伝送された情報信号は制御部１３のＣＰＵに入力され、この情報信号に基づいて制御部１３では、Ｉ／Ｏインターフェイスを介してソレノイドバルブ１６を制御したり、各圧力スイッチ１９、２０の確認信号を二次側情報信号伝送部１１ｂを介して給電ユニットにフィードバックする。情報信号伝送の点数が少ないときには、制御部１３のＣＰＵによるシリアル通信ではなく、信号点数分の高周波電磁カップリングを備えてＣＰＵを用いない並列通信を行なうことができる。一方、二次側電力伝送部１１ａを通じて伝送された高周波電圧は、制御部１３の電源回路に供給されるとともに、整流平滑回路１２において整流および平滑されて直流電圧に変換された後油圧ポンプ駆動モータ１４に供給される。また、整流平滑回路１２で生成された直流電圧の一部は、必要に応じて制御部１３の電源回路に供給される。

【００１２】次に、給電ユニット３０について説明する。給電ユニット３０は、上位コントローラであるシーケンサー３５からの信号が入力される給電側制御部３４と、給電側制御部３４で生成された情報信号を高周波電磁誘導により二次側情報信号伝送部１１ｂに無接触で伝送するための、二次側情報信号伝送部１１ｂに対向して配置された一次側情報信号伝送部３１ｂと、交流電源３６からの交流電圧を整流および平滑して直流電圧に変換する整流平滑回路３３と、給電側制御部３４および整流平滑回路３３からの直流電圧をそれぞれ高周波電圧に変換する二つの高周波インバータ３２と、各高周波インバータ３２からの高周波電圧を高周波電磁誘導により二次側電力伝送部１１ａに無接触で供給するための、二次側電力伝送部１１ａに対向して配置された一次側電力伝送部３１ａとを有する。一次側電力伝送部３１ａおよび一次側情報信号伝送部３１ｂについても、二次側電力伝送部１１ａおよび二次側情報信号伝送部１１ｂと同様に、それぞれコアと、それに巻回された巻線とからなる。

【００１３】ここで、給電ユニット３０から油圧発生ユニット１０への電力供給の原理について説明する。高周波インバータ３２で作られた高周波電圧が一次側電力伝送部３１ａの巻線に加えられると、二次側電力伝送部１１ａの巻線との巻線比に従って、電磁結合により二次側電力伝送部１１ａの巻線に高周波電圧を生じさせる。そして、この誘導電圧が整流平滑回路１２で整流、平滑化され、油圧ポンプ駆動モータ１４に供給される。また、供給側制御部３４と制御部１３との間での情報信号の伝送も、電力供給と同様の原理で行なわれる。上述した自在油圧装置において油圧シリンダ２３のロッド２３ａを前進させる際には、交流電源３６から供給されて給電ユニット３０で変換された高周波電圧は、一次側電力伝送部３１ａから二次側電力伝送部１１ａに高周波電磁誘導により無接触で供給される。二次側電力伝送部１１ａに供給された高周波電圧は、整流平滑回路１２で直流電圧に変換されて油圧ポンプ駆動モータ１４を駆動させる。油圧ポンプ駆動モータ１４の駆動により、油タンク２２に蓄えられた油が油圧ポンプ１５で汲み上げられ、油圧が発生する。油圧を発生させた後に、ソレノイドバルブ１６のロッド前進側バルブをオンするための信号が、給電側制御部３４から制御部１３へ、一次側情報信号伝送部３１ｂと二次側情報信号伝送部１１ｂとの間の高周波電磁誘導により無接触で伝送される。これにより、油圧シリンダ２３のロッド前進側油室に加圧油が供給され、ロッド２３ａが前進する。ロッド２３ａの前進端までの移動完了は前進用圧力スイッチ１９の信号を確認するこ

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とによって行なわれるが、この信号は二次側情報信号伝送部１１ｂと一次側情報信号伝送部３１ｂとの間の高周波電磁誘導により無接触で給電側制御部３４にフィードバックされる。

【００１４】ロッド２３ａの前進端までの移動完了の確認後に、ソレノイドバルブ１６をオフするための信号を、給電側制御部３４から制御部１３へ、一次側情報信号伝送部３１ｂと二次側情報信号伝送部１１ｂとの間の高周波電磁誘導により伝送すると、ソレノイドバルブ１６がオフされるが、このとき、チェックバルブ１８の働きにより油圧シリンダ２３内の油圧は保持される。従って、油圧発生ユニット１０と給電ユニット３０とを分離しても、油圧発生ユニット１０はサポートやジャッキなどの強度メンバ、あるいはチャックやバイス、クランプ装置として機能し続けることができるため、油圧配管も電気配線もない自律した治具が形成される。このような構成によって、加工物や被支持物と一体となって移動することもできる、自在で有効な支持物が構成される。

【００１５】一方、治具としての機能を解除する場合、すなわち油圧シリンダ２３のロッド２３ａを後退させる場合には、再度、油圧ポンプ駆動モータ１４を駆動させた後、ソレノイドバルブ１６のロッド後退側バルブをオンし、油圧シリンダ２３のロッド２３ａを後退させる。ロッド２３ａの後退完了の確認は後退用圧力スイッチ２０からの信号を二次側情報信号伝送部１１ｂから一次側情報信号伝送部３１ｂを経た情報信号の伝送によって行なわれる。この信号が給電側制御部３４に送られた時点でソレノイドバルブ１６をオフし、その後、油圧ポンプ駆動モータ１４を停止させる。そして、油圧発生ユニット１０と給電ユニット３０とを分離し、機能解除動作が完了する。以上の動作において、油圧ポンプ駆動モータ１４の駆動と停止、およびソレノイドバルブ１６のオンとオフの制御は、いずれも給電側制御部３４からの信号による、一次側電力伝送部３１ａから二次側電力伝送部１１ａへの高周波電圧の供給、および一次側情報信号伝送部３１ｂから二次側情報信号伝送部１１ｂへの情報信号の伝送を経て行なわれる。

【００１６】図１に示したものでは、ソレノイドバルブ１６によって、油圧シリンダ２３のロッド２３ａの前進および後退を制御していたが、ソレノイドバルブ１６に代えて、図２に示すようにシングルソレノイドバルブ１６’を設け、ソレノイド操作をばねの反力による単動操作とすることで、制御を簡略することができるとともに、アキュームレータ２１（図１参照）をも省略できる。なお、給電ユニット３０および油圧発生ユニット１０のその他の構成は図１に示したものと同様であるので、その説明は省略する。本実施例では、油圧ポンプ駆動モータ１４の回転制御やソレノイドバルブ１６（またはシングルソレノイドバルブ１６’）の制御のために、油圧発生ユニット１０と給電ユニット３０との間での情報信号の伝送を、電力の供給と同様に高周波電磁誘導により行なっているが、装置構成の単純簡素化のためには、供給電力上に情報信号を重畳する方法が有効である。

【００１７】以下に、図３を参照して供給電力上に情報信号を重畳する方法について説明する。図３は、図１に示した自在油圧装置において供給電力上に情報信号を重畳する場合の要部ブロック図であり、油圧回路については省略している。図３において、給電ユニット６０は、シーケンス指令スイッチパネル６５と、シーケンス指令スイッチパネル６５からの指令に基づいて所定の周波数の高周波電圧を発生する高周波インバータ６２と、一次側伝送部６１とを有する。一方、油圧発生ユニット４０は、二次側伝送部４１と、二次側伝送部４１に生じた高周波電圧を整流、平滑化し直流電圧に変換する整流平滑回路４２と、整流平滑回路４２から得た信号用電源で駆動する周波数測定回路５４と、デコーダ５５とを有する。上記構成に基づき、供給電力上への情報信号の重畳は、電力伝送周波数を伝送特性が変化しない範囲で変化させることで容易に行なうことができる。すなわち、シーケンス指令スイッチパネル６５によりｎ（ｎ＝０，，±１，±２，・・・，±ｋ）の値を指定し、このｎの値に基づき、高周波インバータ６２では周波数がf_0＋ｎΔｆ（ただし、f_0＝インバータ中心周波数、Δｆは十分にf_0よりも小さい、とする）なるパルス波形が作られる。例えば、本実施例ではシーケンス指令は３ビット（８通り）程度で十分であるので、整流平滑回路４２での直流電圧変換後の供給電力が変化しない範囲で高周波励磁周波数を８通りに変化させる。そして、周波数測定回路５４によって、分圧後の高周波励磁電圧の周波数を測定し、周波数に対応する指令シーケンス信号をデコーダ５５で発生させることによって情報信号を供給電力上に重畳して伝送することができる。

【００１８】一方、電力供給が間違いなくなされていることや、油圧ポンプ駆動モータ１４により正常に油圧力が発生し、油圧シリンダ２３が所定の動作を行なっているかなどのシーケンスフィードバック確認は、電力供給と同様の原理により、しかも別の無接触伝送ユニットにより行なうこともできるが、人の目視確認で十分な場合には外部から見えるＬＥＤなどの表示で十分である。本実施例では、図１に示したようにソレノイドバルブ１６と油圧シリンダ２３との間にチェックバルブ１８を設けたものの例を示したが、特に、油圧シリンダ２３をグリッパなど、機能解除動作時に油圧力を保持する必要のない用途に用いる場合おいては、チェックバルブ１８のような圧力保持機能は不要である。

（第２実施例）図４は、本発明の自在油圧装置の第２実施例の概略構成図である。本実施例の自在油圧装置は、ロボット先端のＡＴＣ（自動工具交換）対応工具やＡＨＣ（自動ヘッド交換）に適用することを考えた例であ

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り、油圧発生ユニット１１０が、二次側電力伝送部１１１と、整流平滑回路１１２と、油圧ポンプ駆動モータ１１４と、油圧ポンプ１１５と、ロッド１２３ａを後退させる向き（図示右向き）に付勢するばね１２３ｂを内蔵した油圧シリンダ１２３と、油圧シリンダ１２３と油圧ポンプ１１５との間に設けられたリリーフバルブ１１６と、油量調整のためのリザーバタンク１１７とを有する。このため、油は油圧ポンプ１１５と油圧シリンダ１２３との間で循環して使われ、油タンクを使わない構造となっている。さらに、第１実施例で述べたようなクランプ治具やグリッパ用のものとは異なり、圧着や切断など、油圧シリンダ１２３が移動している間のみ油圧が発生していればよく、油圧シリンダ１２３が定位置において力を保持する必要のないものに用いる構造となっている。

【００１９】また、油圧発生ユニット１１０と給電ユニット１３０とは、互いにプルスタッド方式のチャックで着脱自在に結合される構造となっており、二次側電力伝送部１１１にはスタッド部１２４が一体的に設けられる一方、給電ユニット１３０の一次側電力伝送部１３１にはスタッド部１２４が着脱自在に嵌合されるソケット部１３５が一体的に設けられている。そして、スタッド部１２４がソケット部１３５に嵌合することにより、二次側電力伝送部１１１が一次側電力伝送部１３１の内周面に空隙を介して互いに対向配置される構成となっている。この自在油圧装置の動作開始時には、油圧シリンダ１２３のロッド１２３ａはばね１２３ｂの力によって後退端（図示右端）に位置しているが、スタッド部１２４とソケット部１３５との嵌合が確認された時点で、給電ユニット１３０で生じた高周波電圧が、一次側電力伝送部１３１と二次側電力伝送部１１１との間で生じる高周波電磁誘導により油圧発生ユニット１１０に供給される。油圧発生ユニット１１０に供給された高周波電圧は整流平滑回路１１２で直流電圧に変換された後、油圧ポンプ駆動モータ１１４を駆動させる。これにより、油圧ポンプ１１５内の油が圧縮されて油圧シリンダ１２３内に送り込まれる。油圧シリンダ１２３内に油が充填されると、ロッド１２３ａはばね１２３ｂの力に抗して図示矢印方向に前進し始め、前進端まで移動する。このロッド１２３ａの前進移動を利用して加工物の圧縮や切断などの作業を行なう。

【００２０】また、本実施例では油圧の保持機能を有していないので、油圧シリンダ１２３が圧力を持続して発生させるためにはリリーフバルブ１１６の開放後も油圧ポンプ駆動モータ１１４を駆動し続ける必要があるが、油圧ポンプ駆動モータ１１４が過負荷状態に達するおそれがある場合は、給電ユニット１３０側において電流の大きさと通電時間とを監視することによってその状態を検出し、一次側電力伝送部１３１への電圧供給を停止する。油圧ポンプ駆動モータ１１４の駆動を停止すれば、油圧ポンプ１１５内部の隙間を通して油圧シリンダ１２３内の油圧が開放されるので油圧アクチュエータの発生力はゼロに落ちる。

（第３実施例）図５は、本発明の自在油圧装置の第３実施例の概略斜視図である。本実施例では、給電ユニット２３０は、高周波インバータ２３２と、高周波インバータ２３２に接続され、細長いループ状に巻回された一次側巻線２３１とを有する。一方、油圧発生ユニット２１０は、一次側巻線２３１を遊嵌する２つの中空部が形成され、かつテーブル（不図示）上を一次側巻線２３１の長手方向に直線移動可能に設けられた二次側コア２１１ａと、二次側コア２１１ａの２つの中空部間にまたがって巻回され、一次側巻線２３１と対向する二次側巻線２１１ｂとを有し、これら二次側コア２１１ａと二次側巻線２１１ｂとによって、二次側伝送部が構成されている。また、油圧発生ユニット２１０の内部には、図１または図２に示した油圧回路および油圧回路からの油圧力で動作する油圧シリンダ（不図示）を有し、このシリンダのロッド２２３ａの前進および後退移動により駆動されるクランパ２２５が搭載されている。そして、油圧発生ユニット２１０の油圧回路の制御は、図３に示した回路によって、給電ユニット２３０から供給される電力上に油圧回路を制御するための情報信号を重畳して行なわれる構成となっている。

【００２１】これにより、油圧発生ユニット２１０の移動可能な範囲内であれば任意の位置において給電ユニット２３０からの電力および情報信号を無接触で油圧発生ユニット２１０に伝送することができ、加工物の大きさや形状に応じて加工物のクランプ位置を変えられる自在治具を構成することができる。また、油圧発生ユニット２１０をテーブル上に固定するために、油圧発生ユニット２１０で発生した油圧を使ってくさびを打ち込むことによる固定アクチュエータ（ロッカ２２７）を必要に応じて設けてもよい。さらに、油圧発生ユニット２１０に、ロッド２２３ａの動作に連動して開閉動作を行なうグリッパ２２６を搭載すれば、加工物を把持しながら搬送する装置を構成することができる。また、図６に示すように、パレット２４０上に、３つの一次側巻線２３１を電気的に並列に接続して放射状に配置するとともに、各一次側巻線２３１に沿って移動可能に、クランパ２２５とロッカ２２７とが搭載された３つの油圧発生ユニット２１０を設ける。そして、各一次側巻線２３１への高周波電圧の印加を、図３に示したものと同様の給電ユニット６０により、さらにもう１段の一次側伝送部６１と二次側伝送部２４１とを介して無接触で行なう。これにより、パレット２４０に加工物２４５を固定した状態でパレット２４０を移動させることができ、ＦＭＳ対応のフレキシブルな治具パレットを構成することができる。

【００２２】ここで、図５および図６に示した油圧発生ユニット２１０の移動機構について図７を参照して説明

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する。図７は、図５および図６に示した油圧発生ユニットの移動機構の概略斜視図である。図７において、サーボモータ２５０にはカップリング２５１およびサポート軸受２５２を順次介してボールねじ２５３が連結されている。一方、油圧発生ユニット２１０は、ボールねじナット２５６が固定された移動クランプ台２５５に搭載されており、ボールねじナット２５６にボールねじ２５３が螺合している。これにより、サーボモータ２５０を駆動してボールねじ２５３を回転させることで、油圧発生ユニット２１０が図示矢印方向に往復移動可能な構成となっている。また、図５および図６には示していないが、油圧発生ユニット２１０にはワーク基準面２１５を有し、このワーク基準面２１５上に加工物（不図示）を載置する。

【００２３】なお、図５および図６では、油圧発生ユニット２１０の固定をロッカ２２７により行なうものを示したが、図７では、位置決め後の固定ボルトの代用としてＴナット方式クランプを用いた場合の例を示す。以下に、これについて説明する。移動クランプ台２５５には、油圧発生ユニット２１０で発生した油圧の一部を駆動源とするＴナットクランプシリンダ２５７が設けられている。Ｔナットクランプシリンダ２５７にはＴナット方式クランプ片２５８が連結されている。Ｔナット方式クランプ片２５８は、パレット２４０（図６参照）に、油圧発生ユニット２１０の移動方向に沿って形成された溝（不図示）に摺動自在に嵌合するものである。サーボモータ２５０で油圧発生ユニット２１０の位置決めを精密に行なった後に、油圧発生ユニット２１０で発生する油圧の一部を使ってＴナットクランプシリンダ２５７を駆動することで、Ｔナット方式クランプ片２５８がパレット２４０の溝に押し付けられて油圧発生ユニット２１０が固定される。このように、Ｔナット方式クランプを用いることで、油圧発生ユニット２１０をより確実に固定することができる。

【００２４】図７において、油圧発生ユニット２１０への給電方法は示していないが、図５および図６に示したように直動式の無接触給電を移動ストローク内で連続的に行なったり、あるいは定位置における無接触給電によってもよい。信号の伝送に関しても同様である。さらに、油圧発生ユニット２１０を回転テーブル（不図示）上に搭載し、回転型の給電装置と組み合せて駆動することで、外部の油圧発生設備および従来から回転体への油圧供給に用いられてきた回転カップラを用いずに、回転テーブル上の油圧アクチュエータを制御することも可能である。

（第４実施例）図８は、本発明の自在油圧装置の第４実施例の概略斜視図であり、ロボット先端ＡＴＣ対応のグリッパに適用した例である。図８において、油圧発生ユニット３１０は、図４に示したものと同様の油圧回路が構成されているとともに、内蔵された油圧シリンダ（不図示）に連動して加工物３６０を把持するグリッパ３２０を有する。一方、給電ユニットも図４に示したものと同様な構成を有し、その一次側伝送部３３１はロボットアーム３４０の先端に設けられている。

【００２５】また、油圧発生ユニット３１０とロボットアーム３４０とは、互いにプルスタッド方式のチャックで着脱自在に結合される構造となっており、二次側伝送部３１１にはスタッド部３２４が一体的に設けられる一方、ロボットアーム３４０の一次側伝送部３３１にはスタッド部３２４が着脱自在に嵌合されるソケット部３３５が一体的に設けられている。そして、スタッド部３２４がソケット部３３５に嵌合することにより、二次側伝送部３１１が一次側伝送部３３１の内周面に空隙を介して互いに対向配置される構成となっている。以上説明したように構成することにより、グリッパ３２０とロボットアーム３４０との間の油圧配管や電気配線の必要がなくなるため、自在な交換に対応できるツール（グリッパ）を構成することができる。

【００２６】（第５実施例）図９は、本発明の自在油圧装置の第５実施例の給電ユニットの概略構成図である。この給電ユニット４３０は、シーケンス指令スイッチ４３５からの指令で所定の周波数の高周波を発振する高周波発振回路４３６と、高周波インバータ４３２と、高周波磁性材料製の一次側コア４３１ａおよび一次側巻線４３１ｂからなる一次側伝送部４３１とを有する。しかも、高周波発振回路４３６および高周波インバータ４３２に電力を供給するためのバッテリ４３７も内蔵されており、持ち運び自由となっている。これにより、図１０に示すような油圧発生ユニット４１０を用い、油圧発生ユニット４１０によって基台４５０の所定の位置に加工物４６０、４６０’を保持させることができる。保持の際には、給電ユニット４３０の一次側伝送部４３１と油圧発生ユニット４１０の二次側伝送部４１１を対向させて、油圧配管や電気配線を行なわずに油圧発生ユニット４１０に電力の供給および情報信号の伝送を行ない、油圧シリンダアクチュエータ４２０を動作させることによって行なう。なお、油圧発生ユニット４１０は図３に示したような周波数測定回路およびデコーダを有し、情報信号は供給電力上に重畳して行なわれる。また、給電ユニット４３０は持ち運び自由なので、油圧発生ユニット４１０の位置や向きに関わらず、油圧発生ユニット４１０へ電力の供給や情報信号の伝送を行なうことができる。従って、工作機械加工の段取り工程、あるいは車両や船舶をはじめとする重量物の組立や、建設現場において、油圧配管も電気配線もない状況のもとで大トルクを発生させ、短時間に強度メンバを作り上げる必要のある場合には、非常に有効である。

【００２７】

【発明の効果】本発明は以上説明したとおり構成されているので、以下に記載する効果を奏する。請求項１に記

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載の発明では、給電ユニットから油圧発生ユニットへは、高周波電磁誘導を利用して無接触で電力の供給および情報信号の伝送が行なわれるので、給電ユニットと油圧は性ユニットとの間には油圧配管や電気回路をなくすることができる。また、ソレノイドバルブと油圧シリンダとの間にはチェックバルブが設けられているので，油圧シリンダの動作開始時と終了時以外には給電ユニットと油圧発生ユニットとを分離しても、油圧シリンダはその状態を維持することができ、さらに、油圧発生回路には二次側伝送部、油圧回路、および油圧シリンダが一つの構造体の中に設けられているので、給電ユニットと油圧発生ユニットとを分離しても外部には油圧配管や電気配線がない状態となる。その結果、油圧シリンダにより油圧アクチュエータの機能を維持した状態で、油圧発生ユニットを自在に移動させることができる。

【００２８】請求項２に記載の発明では、給電ユニットに、一次側伝送部へ高周波電圧を印加する手段を駆動するためのバッテリを内蔵することで、給電ユニットをポータブルなものとすることができ、重量物組立や建設の現場において、油圧配管や電気配線も状況のもとで重量物を支持する必要がある場合にも使用することができる。請求項３および４に記載の発明では、結合手段により給電ユニットと油圧発生ユニットとを着脱自在に結合することで、特に油圧発生ユニットを産業用ロボットの先端ツールとして使用した場合、先端ツール交換時の油圧配管や電気配線の問題がなくなり、自在な交換に対応できる。請求項５および６に記載の発明では、給電ユニットの一次側伝送部の巻線を細長いループ状とし、この巻線の長手方向に沿って油圧発生ユニットを移動可能に設けることで、加工物の大きさや形状に応じて油圧アクチュエータの作用点の位置を自由に変えられる自在治具を構成することができる。

【００２９】請求項７に記載の発明では、給電ユニットに周波数変換手段を設けるとともに、ゆあつ発生ユニットに周波数測定回路とデコーダとを設けることにより、油圧発生ユニットの油圧回路を制御する情報信号を、一次側伝送部から二次側伝送部への電力の供給に重畳して伝送することができるので、装置構成を簡略化することができる。

【図面の簡単な説明】

【図１】本発明の自在油圧装置の第１実施例の概略構成図である。

【図２】図１に示した自在油圧装置を簡略した一例を示す概略構成図である。

【図３】図１に示した自在油圧装置において伝送電力上に情報信号を重畳する場合の要部ブロック図である。

【図４】本発明の自在油圧装置の第２実施例の概略構成図である。

【図５】本発明の自在油圧装置の第３実施例の概略斜視図である。

【図６】図５に示した自在油圧装置の応用例の概略平面図である。

【図７】図５および図６に示した油圧発生ユニットの移動機構の概略斜視図である。

【図８】本発明の自在油圧装置の第４実施例の概略斜視図である。

【図９】本発明の自在油圧装置の第５実施例の給電ユニットの概略構成図である。

【図１０】図８に示した給電ユニットの使用状態の一例を示す図である。

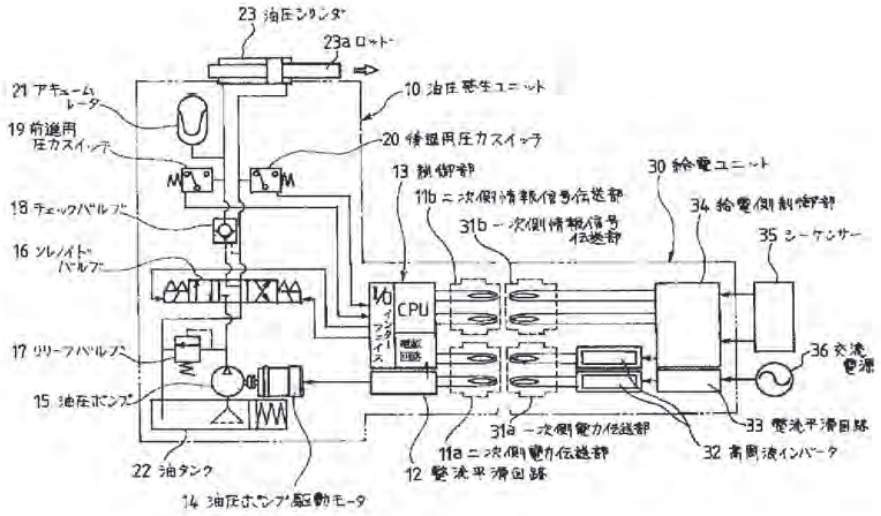
【符号の説明】

１０、４０、１１０、２１０、３１０、４１０　油圧発生ユニット
１１ａ、１１１　二次側電力伝送部
１１ｂ　二次側情報信号伝送部
１２、３３、４２、１１２　整流平滑回路
１３　制御部
１４、１１４　油圧ポンプ駆動モータ
１５、１１５　油圧ポンプ
１６　ソレノイドバルブ
１６’　シングルソレノイドバルブ
１７、１１６　リリーフバルブ
１８　チェックバルブ
１９　前進用圧力スイッチ
２０　後退用圧力スイッチ
２１　アキュームレータ
２２　油タンク
２３、１２３　油圧シリンダ
２３ａ、１２３ａ、２２３ａ　ロッド
３０、６０、１３０、２３０、４３０　給電ユニット
３１ａ、１３１　一次側電力伝送部
３１ｂ　一次側情報信号伝送部
３２、６２、２３２、４３２　高周波インバータ
３４　給電側制御部
３５　シーケンサー
３６　交流電源
４１、２４１、３１１、４１１　二次側伝送部
５４　周波数測定回路
５５　デコーダ
６１、３３１、４３１　一次側伝送部
６５　シーケンス指令スイッチパネル
１１７　リザーバタンク
１２３ｂ　ばね
１２４、３２４　スタッド部
１３５、３３５　ソケット部
２１１ａ　二次側コア
２１１ｂ　二次側巻線
２１５　ワーク基準面
２２５　クランパ
２２６、３２０　グリッパ

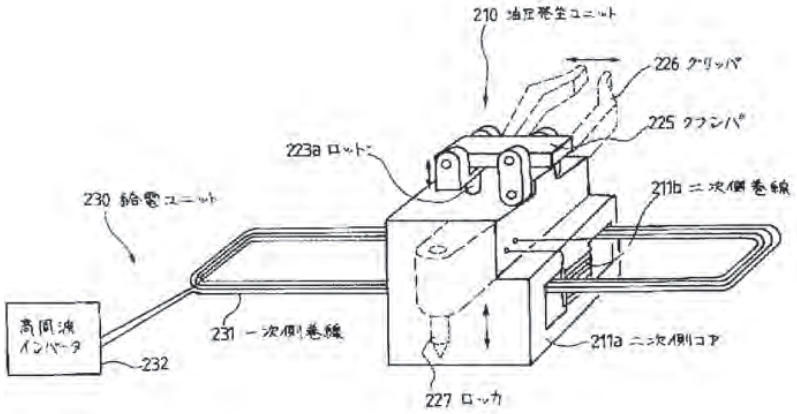
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２２７　ロッカ
２３１、４３１ｂ　一次側巻線
２４０　パレット
２４５、３６０、４６０、４６０’　加工物
２５０　サーボモータ
２５１　カップリング
２５２　サポート軸受
２５３　ボールねじ
２５５　移動クランプ台
２５６　ボールねじナット
２５７　Ｔナットクランプシリンダ
２５８　Ｔナット方式クランプ片
３４０　ロボットアーム
４２０　油圧シリンダアクチュエータ
４３５　シーケンス指令スイッチ
４３６　高周波発振回路
４３７　バッテリ
４３１ａ　一次側コア
４５０　基台

【図１】

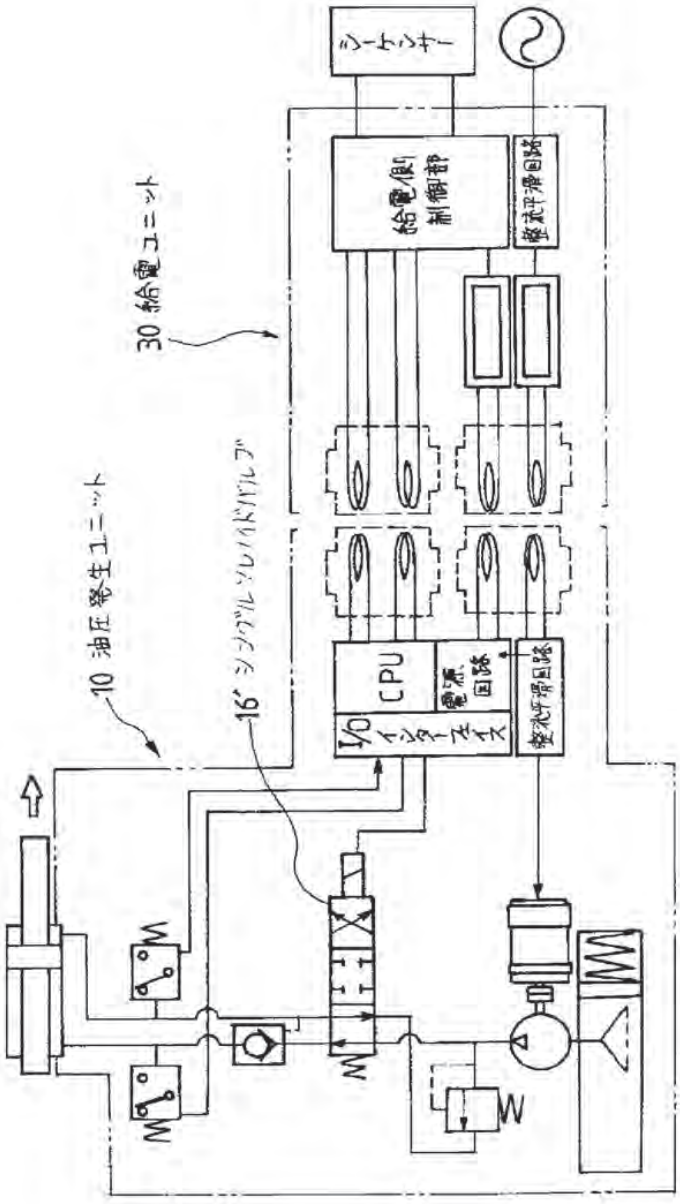


【図５】



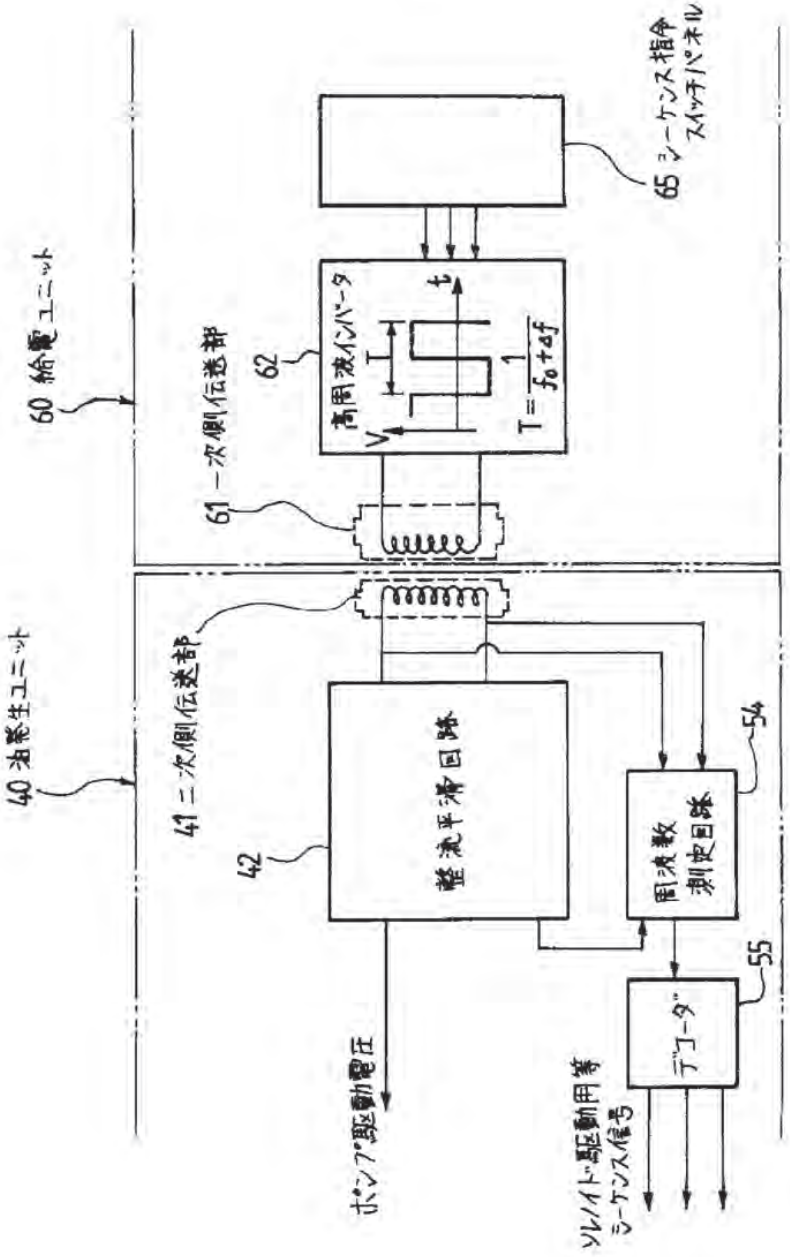
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【図２】



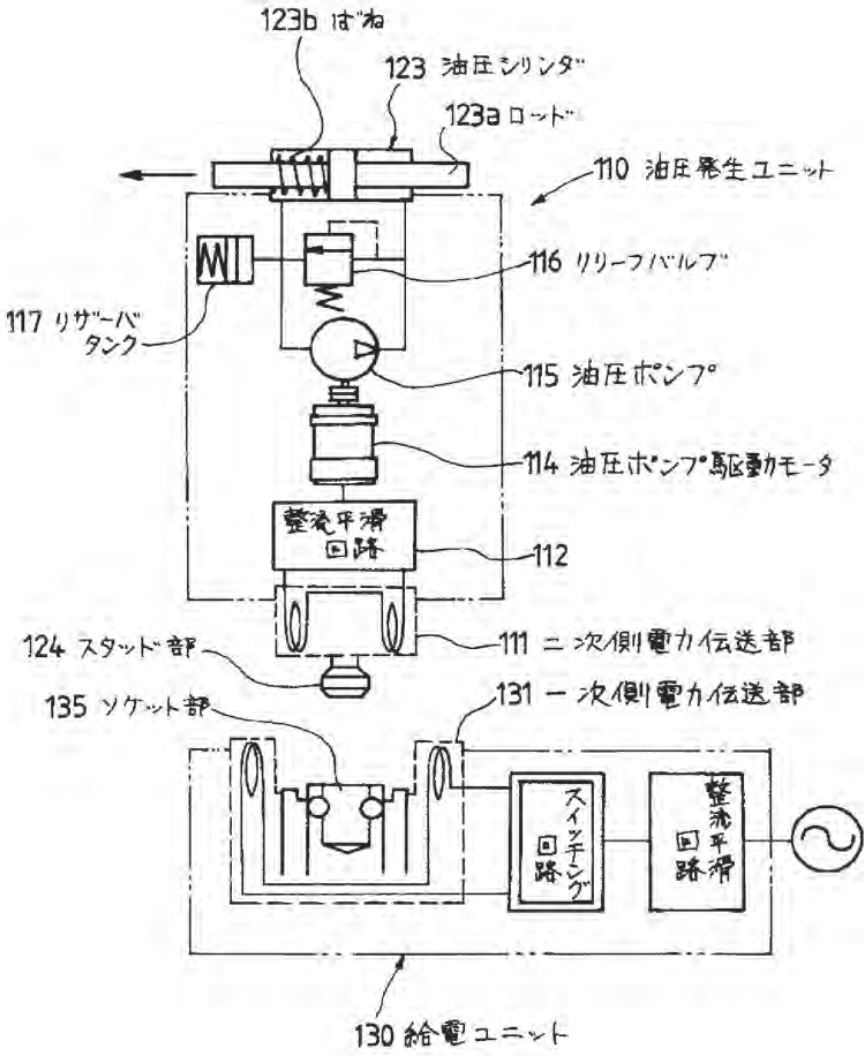
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【図３】



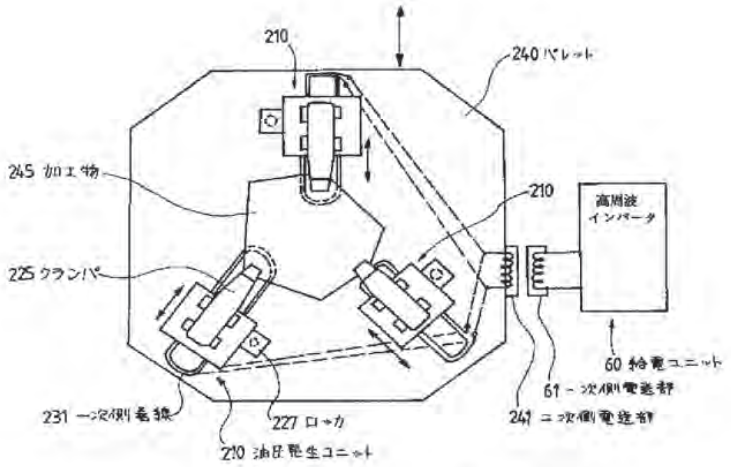
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【図４】

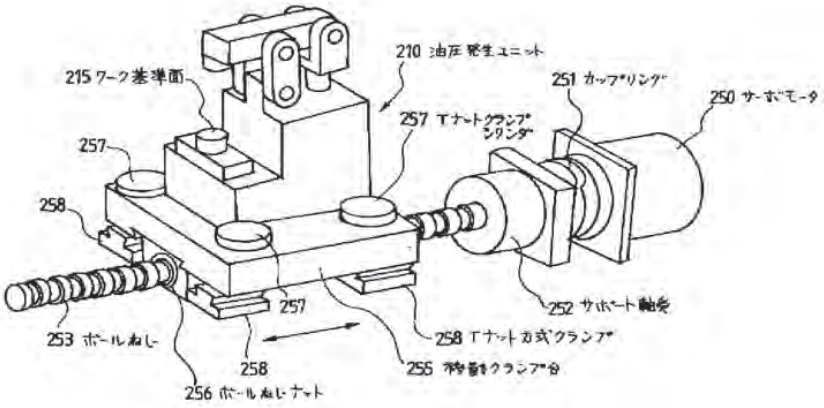


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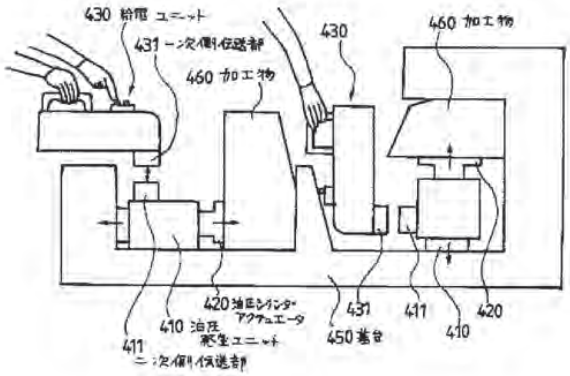
【図６】



【図７】

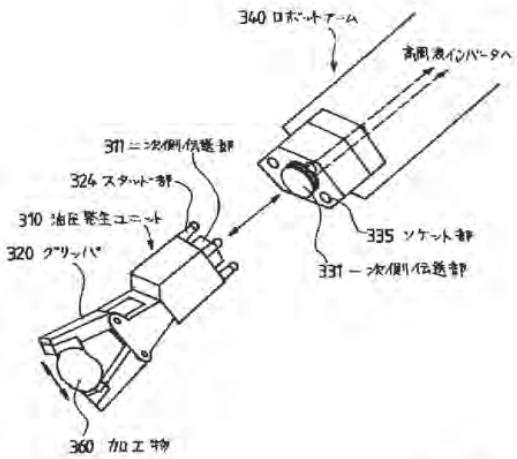


【図１０】

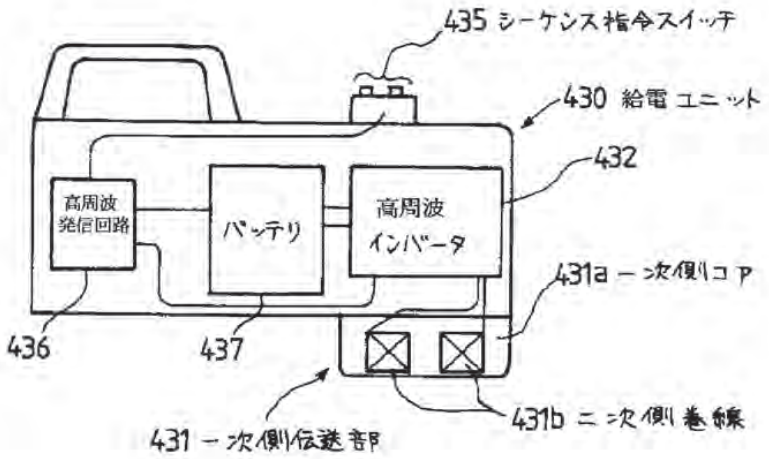


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【図８】



【図９】



フロントページの続き

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Espacenet

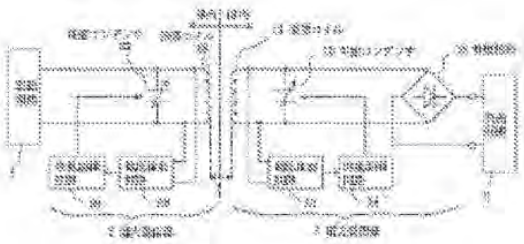
Bibliographic data: JP11188113 (A) — 1999-07-13

POWER TRANSMISSION SYSTEM, POWER TRANSMISSION METHOD AND ELECTRIC STIMULATION DEVICE PROVIDED WITH THE POWER TRANSMISSION SYSTEM

Inventor(s):	ISHIKAWA SEIICHI ±
Applicant(s):	NEC CORP; JAPAN SCIENCE & TECH CORP; HOSHIMIYA NOZOMI; HANDA YASUNOBU; MATSUKI HIDETOSHI ±
Classification:	**- international:** ***A61N1/378; H02J17/00;*** (IPC1-7): A61N1/378 **- European:**
Application number:	JP19970359519 19971226
Priority number (s):	JP19970359519 19971226

Abstract of JP11188113 (A)

PROBLEM TO BE SOLVED: To stably transmit power without destroying the resonance state of a coil even when the distance of transmission and reception coils fluctuates. SOLUTION: This system is provided with a transmission coil 21 and a reception coil 11 oppositely arranged holding skin between them, a variable capacitor 22 for constituting a resonance circuit by being connected to the transmission coil 21, a variable capacitor 12 for constituting the resonance circuit by being connected to the reception coil 11, voltage detection circuits 23 and 13 for respectively detecting voltage levels in the transmission coil 21 and the reception coil 11, a capacity control circuit 24 for inputting the voltage level detected in the voltage detection circuit 23 and varying the capacity of the variable capacitor 22 so that the detected voltage level takes a highest value at all times and a capacity control circuit 14 for inputting the voltage level detected in



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the voltage detection circuit 13 and varying the capacity of the variable capacitor 12 so that the detected voltage level takes the highest value at all times.

(last updated) 14.03.2012 Worldwide Database 5.7.38.32p

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(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平11－188113

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審査請求　未請求　請求項の数８　ＯＬ　（全６頁）

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(22)出願日　平成９年(1997)12月26日

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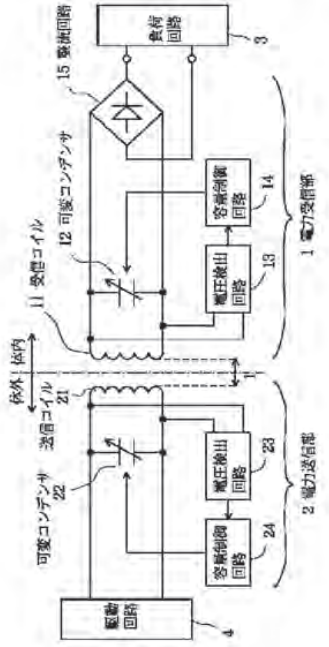
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(54)【発明の名称】　電力伝送システムおよび電力伝送方法ならびにその電力伝送システムを備えた電気刺激装置

(57)【要約】

【課題】送受コイルの距離が変動しても、コイルの共振状態がくずれることがなく、安定した電力伝送を行うことができるようにする。

【解決手段】皮膚を挟んで対向配置された送信コイル２１、受信コイル１１と、送信コイル２１と接続されて共振回路を構成する可変コンデンサ２２と、受信コイル１１と接続されて共振回路を構成する可変コンデンサ１２と、送信コイル２１、受信コイル１１における電圧レベルをそれぞれ検出する電圧検出回路２３、１３と、電圧検出回路２３にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように可変コンデンサ２２の容量を可変する容量制御回路２４と、電圧検出回路１３にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように可変コンデンサ１２の容量を可変する容量制御回路１４とを有する。



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【特許請求の範囲】
【請求項１】　対向配置された１対の電力供給コイルを備え。一方を送信コイル、他方を受信コイルとして電力が誘導的に伝送される電力伝送システムにおいて、
前記送信コイルと接続されて共振回路を構成する第１の可変コンデンサと、
前記受信コイルと接続されて共振回路を構成する第２の可変コンデンサと、
前記送信コイルにおける電圧レベルを検出する第１の電圧検出手段と、
前記受信コイルにおける電圧レベルを検出する第２の電圧検出手段と、
前記第１の電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第１の可変コンデンサの容量を可変する第１の容量制御手段と、
前記第２の電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第２の可変コンデンサの容量を可変する第２の容量制御手段と、を有することを特徴とする電力伝送システム。
【請求項２】　請求項１に記載の電力伝送システムにおいて、
前記第１の容量制御手段が、電力搬送波の周波数で前記送信コイルおよび第１の可変コンデンサからなる共振回路が共振するように制御し、
前記第２の容量制御手段が、電力搬送波の周波数で前記受信コイルおよび第２の可変コンデンサからなる共振回路が共振するように制御することを特徴とする電力伝送システム。
【請求項３】　対向配置された１対の電力供給コイルを備え、一方を送信コイル、他方を受信コイルとして電力が誘導的に伝送される電力伝送システムにおいて、
前記送信コイルと接続されて共振回路を構成する第１の可変コンデンサと、
前記受信コイルと接続されて共振回路を構成する第２の可変コンデンサと、
前記受信コイルにおける電圧レベルを検出する電圧検出手段と、
前記電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第１および第２の可変コンデンサの容量をそれぞれ可変する容量制御手段と、を有することを特徴とする電力伝送システム。
【請求項４】　請求項３に記載の電力伝送システムにおいて、
前記電力供給コイル対とは異なる、対向配置された送信コイルおよび受信コイルと、
前記送信コイルと接続されて第１の共振回路を構成する第１のコンデンサと、
前記受信コイルと接続されて第２の共振回路を構成する第２のコンデンサと、
前記容量制御手段から出力される制御信号を入力とし、該入力信号を前記第１の共振回路へ供給する信号送信手段と、
前記第２の共振回路を介して受信される前記制御信号を入力とし、該入力制御信号を前記第１の可変コンデンサへ出力する信号受信手段と、をさらに有することを特徴とする電力伝送システム。
【請求項５】　請求項１乃至請求項４のいずれかに記載の電力伝送システムを備える電気刺激装置であって、
前記受信コイルとともに体内に埋め込まれ、該受信コイルを介して電力供給を受けて生体の麻痺した部分を電気的に刺激する刺激手段と、
前記送信コイルに接続され、体外から前記刺激手段に電力を供給して刺激動作を制御する制御手段と、を有することを特徴とする電気刺激装置。
【請求項６】　対向配置された１対の電力供給コイル間で、一方を送信コイル、他方を受信コイルとして電力を誘導的に伝送する電力伝送方法において、
前記送信コイルおよび受信コイルにおける電圧レベルをそれぞれ検出し、それぞれの検出電圧レベルが常に最高値をとるように前記送信コイルおよび受信コイルの共振状態を制御することを特徴とする電力伝送方法。
【請求項７】　対向配置された１対の電力供給コイル間で、一方を送信コイル、他方を受信コイルとして電力を誘導的に伝送する電力伝送方法において、
前記受信コイルにおける電圧レベルを検出し、該検出電圧レベルが常に最高値をとるように前記送信コイルおよび受信コイルの共振状態を制御することを特徴とする電力伝送方法。
【請求項８】　請求項６または請求項７に記載の電力伝送方法において、
電力搬送波の周波数で前記送信コイルおよび受信コイルが共振するように制御することをことを特徴とする電力伝送方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、対向配置された１対の電力供給コイルを用いて、両コイル間で電気エネルギーを伝送する電力伝送システムおよび電力伝送方法に関する。より具体的には、種々の生体機能の外的制御を行う装置、例えば脳卒中や脊髄損傷等、中枢性神経障害で麻痺した生体の機能を電気的刺激で治療、再建する電気刺激装置などに適用される電力伝送システムおよび電力伝送方法に関する。ここでいう電力伝送とは、電力の伝送だけでなく制御信号などの伝送をも含む。
【０００２】
【従来の技術】麻痺した身体の機能を電気的刺激で治療、再建する電気刺激装置は、基本的には、体内に埋め

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込まれて生体の麻痺した部分を電気的に刺激する刺激装置と、体外に配置され、体内に埋め込まれた刺激装置に電力や信号を伝送して駆動する装置本体とから構成される。このような電気刺激装置において、装置本体側から体内に埋め込まれた刺激装置に電力や信号を伝送する電力伝送システムとしては、皮膚を挟んで対向配置された電力供給コイル対（例えば、空芯コイルや磁芯コイルなどにより構成される）を用い、体外の電力供給コイルから体内の電力供給コイルへ電力や信号を伝送することにより、体内に埋め込まれた刺激装置に電力や信号を伝送するようにしたものが知られている。その一例として、例えば特開平5-317434号公報には、非接触型電力供給コイルを備えたものが開示されている。

【０００３】上記公報に開示されたシステムは、電気刺激装置とともに体内に完全に埋め込まれる第１の電力供給コイルと、その第１の電力供給コイルと皮膚を介して平行に対向配置される第２の電力供給コイルとを備えており、体外に置かれた第２の電力供給コイルに高周波電力を供給することにより、その供給された高周波電力が体内の第１の電力供給コイルへ誘導的に伝送され、第１の電力供給コイルで所望の周波数に変換されるようになっている。

【０００４】この他、特開平4-285436号公報には、外部の送出コイルから、植え込まれた容量性要素に接続されているターゲットコイルへ電力を誘導的に伝送するシステムで、両コイル間の共振結合を維持できるようにしたものが開示されている。

【０００５】

【発明が解決しようとする課題】上述したような、対向配置された１対の電力供給コイル間で電力伝送が行われる電力伝送システムにおいては、両コイルを共振状態として電力伝送が誘導的に行われる。しかしながら、このような従来のシステムでは、送受側のコイルの共振パラメータは固定で一定とされるため、例えば両コイル間の距離が変わったり、あるいはコイルが横ずれしたりすると、両コイルの相互インダクタンスが変化してしまい、コイルの共振状態がくずれてしまう。この結果、受信側コイルにおける受信電圧が低くなり、受信コイルに接続された刺激装置などの負荷回路が動作しなくなるという問題が生じる。

【０００６】本発明の目的は、送受コイルの距離が変動しても、コイルの共振状態がくずれることがなく、安定した電力伝送を行うことができる電力伝送システムおよび電力伝送方法を提供することにある。さらには、その電力伝送システムを備えた電気刺激装置を提供することにある。

【０００７】

【課題を解決するための手段】上記目的を達成するため、本発明の第１の電力伝送システムは、対向配置された１対の電力供給コイルを備え、一方を送信コイル、他方を受信コイルとして電力が誘導的に伝送される電力伝送システムにおいて、前記送信コイルと接続されて共振回路を構成する第１の可変コンデンサと、前記受信コイルと接続されて共振回路を構成する第２の可変コンデンサと、前記送信コイルにおける電圧レベルを検出する第１の電圧検出手段と、前記受信コイルにおける電圧レベルを検出する第２の電圧検出手段と、前記第１の電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第１の可変コンデンサの容量を可変する第１の容量制御手段と、前記第２の電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第２の可変コンデンサの容量を可変する第２の容量制御手段と、を有することを特徴とする。

【０００８】本発明の第２の電力伝送システムは、対向配置された１対の電力供給コイルを備え、一方を送信コイル、他方を受信コイルとして電力が誘導的に伝送される電力伝送システムにおいて、前記送信コイルと接続されて共振回路を構成する第１の可変コンデンサと、前記受信コイルと接続されて共振回路を構成する第２の可変コンデンサと、前記受信コイルにおける電圧レベルを検出する電圧検出手段と、前記電圧検出手段にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように前記第１および第２の可変コンデンサの容量をそれぞれ可変する容量制御手段と、を有することを特徴とする。

【０００９】上記の場合、前記電力供給コイル対とは異なる、対向配置された送信コイルおよび受信コイルと、前記送信コイルと接続されて第１の共振回路を構成する第１のコンデンサと、前記受信コイルと接続されて第２の共振回路を構成する第２のコンデンサと、前記容量制御手段から出力される制御信号を入力とし、該入力信号を前記第１の共振回路へ供給する信号送信手段と、前記第２の共振回路を介して受信される前記制御信号を入力とし、該入力制御信号を前記第１の可変コンデンサへ出力する信号受信手段と、をさらに有するものとしてもよい。

【００１０】本発明の電気刺激装置は、上述のいずれかの電力伝送システムを備える電気刺激装置であって、前記受信コイルとともに体内に埋め込まれ、該受信コイルを介して電力供給を受けて生体の麻痺した部分を電気的に刺激する刺激手段と、前記送信コイルに接続され、体外から前記刺激手段に電力を供給して刺激動作を制御する制御手段と、を有することを特徴とする。

【００１１】本発明の第１の電力伝送方法は、対向配置された１対の電力供給コイル間で、一方を送信コイル、他方を受信コイルとして電力を誘導的に伝送する電力伝送方法において、前記送信コイルおよび受信コイルにおける電圧レベルをそれぞれ検出し、それぞれの検出電圧レベルが常に最高値をとるように前記送信コイルおよび

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受信コイルの共振状態を制御することを特徴とする。

【００１２】本発明の第２の電力伝送方法は、対向配置された１対の電力供給コイル間で、一方を送信コイル、他方を受信コイルとして電力を誘導的に伝送する電力伝送方法において、前記受信コイルにおける電圧レベルを検出し、該検出電圧レベルが常に最高値をとるように前記送信コイルおよび受信コイルの共振状態を制御することを特徴とする。

【００１３】（作用）本発明によれば、送信コイルと第１の可変コンデンサにより共振回路が構成され、受信コイルと第２の可変コンデンサにより共振回路が構成されており、各共振回路の共振周波数はそれぞれの可変コンデンサの容量を可変することにより制御可能になっている。したがって、例えば送受コイル間の距離が変動して、送受コイルの相互インダクタンスが変化しても、その変化に応じて各共振回路の共振状態を制御することができ、送受コイル間における電力伝送を常に最適な状態で行うことができる。

【００１４】

【発明の実施の形態】次に、本発明の実施形態について図面を参照して説明する。

【００１５】（実施形態１）図１は、本発明の第１の実施形態の電力伝送システムの概略構成を示すブロック図である。この電力伝送システムは、生体の機能を電気的刺激で治療、再建する電気刺激装置に適用されるもので、生体の麻痺した部分を電気的に刺激する負荷回路３（刺激装置）が接続され、該負荷回路３とともに体内に埋め込まれる電力受信部１と、体内に埋め込まれた負荷回路３に電力や信号を伝送して刺激動作を制御する駆動回路４（装置本体）が接続され、該駆動回路４とともに体外に設置される電力送信部２とを有する。

【００１６】電力受信部１は、体外から供給される電力を受信するための受信コイル１１とこれに並列に接続された可変コンデンサ１２とからなるＬＣ回路（共振回路）と、受信コイル１１にて受信される電圧レベルを検出する電圧検出回路１３と、該電圧検出回路１３にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように可変コンデンサ１２の容量を可変する容量制御回路１４と、受信コイル１１にて受信される電圧を交流から直流に整流する整流回路１５とを有する。

【００１７】電力送信部２は、体内に埋め込まれた受信コイル１１と平行に対向して配置され、該受信コイル１１へ誘導的に電力を伝送する送信コイル２１とこれに並列に接続された可変コンデンサ２２とからなるＬＣ回路（共振回路）と、送信コイル２１にて伝送される電圧レベルを検出する電圧検出回路２３と、該電圧検出回路２３にて検出された電圧レベルを入力とし、該検出電圧レベルが常に最高値をとるように可変コンデンサ２２の容量を可変する容量制御回路２４とを有する。

【００１８】送受信コイル１１，２１は、両コイル間で誘導的に電力伝送が可能であればどのようなものを用いてもよく、例えば空芯コイル、磁芯コイルなど種々のコイルを使用することができる。

【００１９】上述のように構成された電力伝送システムでは、駆動回路４から負荷回路３を駆動するための電力が電力送信部２の送信コイル２１に供給されると、送信コイル２１から電力受信部１の受信コイル１１に誘導的に電力が伝送される。このとき、電力搬送波の周波数に電力受信部１および電力送信部２の各共振回路が共振した状態になっていれば、駆動回路４から供給される電力のほとんどが負荷回路３にて使用され、共振していない場合には、電力受信部１の受信コイル１１とこれに接続された各回路（電圧レギュレータ）で浪費される。受信コイル１１にて受信された電力は整流回路１５を介して負荷回路３へ供給される。

【００２０】いま、電力搬送波の周波数に電力受信部１および電力送信部２の各共振回路が共振した状態で電力伝送が行われている状態とする。ここで、送信コイル２１と受信コイル１１間の距離ｌが変化すると、これら送受コイルの相互インダクタンスが変化し、これにより共振パラメータも変化する。共振パラメータが変化すると、電力搬送波の電圧レベルが小さくなり、この電圧レベルの変化が電力受信部１および電力送信部２の各電圧検出回路１３，２３で検出される。

【００２１】電圧レベルが低下すると、容量制御回路１４は、電圧検出回路１３の出力を基に、その検出電圧レベルが最高値になるように可変コンデンサ１２の容量を可変する。同様に、容量制御回路２４は、電圧検出回路２３の出力を基に、その検出電圧レベルが最高値になるように可変コンデンサ２２の容量を可変する。これにより、送受コイルの相互インダクタンスが変化しても、常に電力搬送波の周波数に共振した状態で電力伝送を行うことができる。

【００２２】以上のように、本実施形態の電力伝送システムでは、送信電圧、受信電圧の検出をそれぞれ送信部、受信部個々に設けられた電圧検出部で行い、送信部、受信部の個々の共振回路のコンデンサの容量を共振状態を維持するように自動的に補正するようになっているので、最適の状態で電力伝送が行われる。

【００２３】なお、以上の説明では、生体機能の外的制御を行う装置に適用される例について説明したが、本発明はこれに限定されるものではなく、対向配置された１対の電力供給コイルを用いて、電気エネルギーを誘導的に伝送することにより電力供給を行うことが可能な装置であればどのようなものにも適用可能である。

【００２４】（実施形態２）上述した第１の実施形態では、送信部、受信部個々に独立して送受コイルの共振状態を制御するようになっているが、受信コイルの電圧レベルを検出して、その検出結果に基づいて送受コイルの

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共振状態を制御することもできる。

【００２５】図２は、本発明の第２の実施形態の電力伝送システムの概略構成を示すブロック図である。同図中、図１に示した第１の実施形態の構成と同じ構成には同じ符号を付してある。

【００２６】本形態の電力伝送システムは、上述の第１の実施形態の電力送信部２側の電圧検出回路２３および容量制御回路２４を取り除き、電力受信部１側の容量制御回路１４が電圧検出回路１３にて検出された電圧レベルに基づいて、可変コンデンサ１２，２２の容量をそれぞれ制御するようになっている。そのための構成として、電力受信部１側に、送信コイル１７とコンデンサ１８からなる共振回路と、該共振回路に容量制御回路１４から送出された制御信号をフィードバック信号（電力送信部２側の可変コンデンサ２２の容量を制御するための制御信号）として供給するフィードバック信号送信回路１９とを備え、電力送信２側に、送信コイル１７に平行に対向して配置された受信コイル２７とコンデンサ２８からなる共振回路と、受信コイル２７を介して受信される容量制御回路１４から送出されたフィードバック信号を受け、該受信信号を制御信号として可変コンデンサ２２へ出力するフィードバック信号受信回路２９とを備える。

【００２７】上述のように構成された電力伝送システムでは、第１の実施形態の場合と同様に、駆動回路４から負荷回路３を駆動するための電力が電力送信部２の送信コイル２１に供給されると、送信コイル２１から電力受信部１の受信コイル１１に誘導的に電力が伝送される。受信コイル１１にて受信された電力は整流回路１５を介して負荷回路３へ供給される。

【００２８】いま、電力搬送波の周波数に電力受信部１および電力送信部２の各共振回路が共振した状態で電力伝送が行われている状態とする。ここで、送信コイル２１と受信コイル１１間の距離１が変化すると、これら送受コイルの相互インダクタンスが変化し、これにより共振パラメータも変化する。共振パラメータが変化すると、電力搬送波の電圧レベルが小さくなり、この電圧レベルの変化が電力受信部１の電圧検出回路１３で検出される。

【００２９】電圧レベルが低下すると、容量制御回路１４は、電圧検出回路１３の出力を基に、その検出電圧レベルが最高値になるように可変コンデンサ１２の容量を可変するとともに、可変コンデンサ２２の容量を可変するためフィードバック信号をフィードバック信号送信回路１９へ送出する。フィードバック信号を受けたフィードバック信号送信回路１９は、該フィードバック信号を所定の周波数で変調して各共振回路を介してフィードバック信号受信回路２９へ送信する。フィードバック信号受信回路２９は、受信した変調信号を復調して、これを制御信号として可変コンデンサ２２へ出力する。これにより、可変コンデンサ２２は電力受信部１の容量制御回路１４によって制御されることになる。

【００３０】上述のようにして、電力受信部１側の容量制御回路１４は、電圧検出回路１３にて検出された電圧レベルに基づいて、検出電圧レベルが最高値になるように可変コンデンサ１２，２２の容量を可変する。これにより、送受コイル１１，２１の相互インダクタンスが変化しても、常に電力搬送波の周波数に共振した状態で電力伝送を行うことができる。

【００３１】本実施形態では、送信コイル１７と受信コイル２７における信号伝送は、送信コイル２１と受信コイル１１間で行われる誘導的な電力伝送と同じ原理で行われるが、これら送受コイル１７，２７と接続されるコンデンサ１８，２８は変調周波数に応じて所定の容量のものが用いられる。このようなフィードバック系では、共振パラメータが固定であるため、送受コイル１７，２７間の距離が変動すると、受信されるフィードバック信号の電圧レベルが変動することが予想されるが、この変動は刺激装置への電力の供給に直接影響するものではないので問題とはならない。しかも、フィードバック信号を受信する部分は体外に設けられる装置本体側に設けられるので、増幅回路など付加することができ、これによりフィードバック信号の電圧レベルの変動を回避することもできる。

【００３２】

【発明の効果】以上説明したように構成される本発明によれば、送受コイルの相互インダクタンスの変化に応じてコイルの共振状態を制御することができるので、送受コイルの距離が変動しても、コイルの共振状態がくずれることがなく、安定した電力伝送を行うことができるという効果がある。

【００３３】受信コイルにおける電圧レベルを検出し、該電圧レベルが常に最高値をとるように送受コイルの共振状態を制御する発明においては、より確実に受信コイルを電力搬送波の周波数で共振するようにでき、より安定的に電力伝送を行うことができるという効果がある。

【００３４】本発明の電力伝送システムを備える電気刺激装置においては、体内に埋め込まれた刺激装置に安定して電力供給を行うことができるので、従来のような受信側コイルにおける受信電圧が低下して刺激装置などの負荷回路が動作しなくなるといった問題を防止でき、信頼性の高い電気刺激装置を提供することができる。

【図面の簡単な説明】

【図１】本発明の第１の実施形態の電力伝送システムの概略構成を示すブロック図である。

【図２】本発明の第２の実施形態の電力伝送システムの概略構成を示すブロック図である。

【符号の説明】

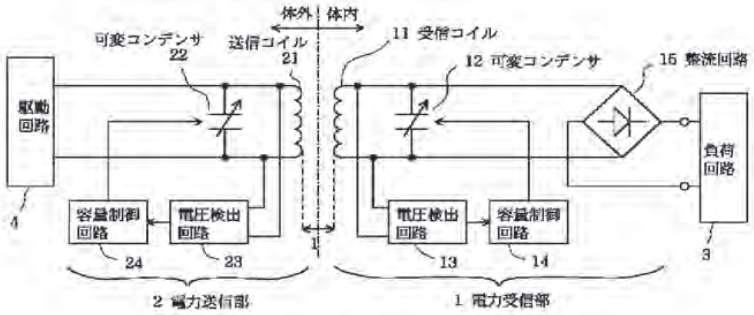
１　電力受信部

２　電力伝送部

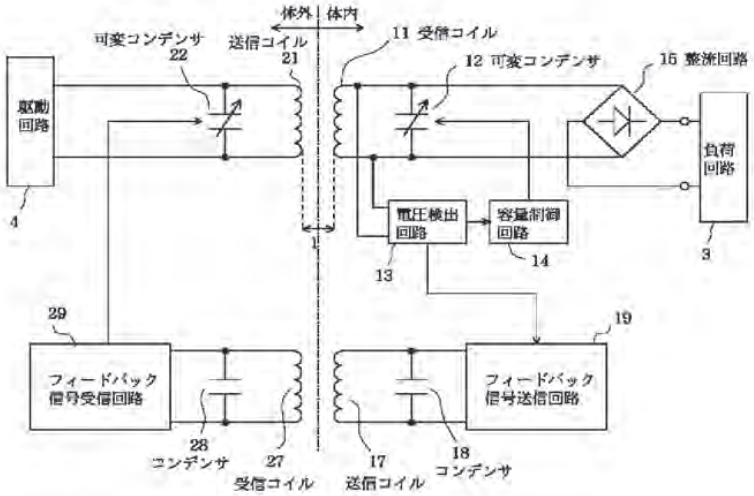
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３　負荷回路
４　駆動回路
１１，２７　受信コイル
１２，２２　可変コンデンサ
１３，２３　電圧検出回路
１４，２４　容量制御回路
１５　整流回路
１７，２１　送信コイル
１８，２８　コンデンサ
１９　フィードバック信号送信回路
２９　フィードバック信号受信回路

【図１】



【図２】



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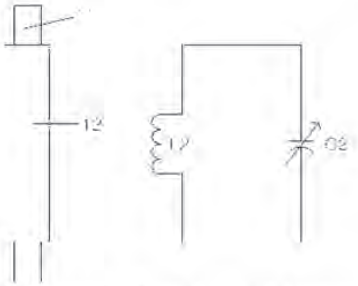
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(54) Title: AN AMPLIFICATION RELAY DEVICE OF ELECTROMAGNETIC WAVE AND A RADIO ELECTRIC POWER CONVERSION APPARATUS USING THE ABOVE DEVICE



(57) Abstract: The present invention provides an amplifying repeater, which is constructed in such a manner that a ferrite core is inserted into a coil with a predetermined number of winds to increase an induced electromotive force caused by an increase in flux linkage using a time- varying magnetic field of electromagnetic waves at a position distant from various electromagnetic wave generating sources by a predetermined distance and the induction coil and a variable condenser for inducing resonance are connected to each other to increase current while reducing a resistant component existing in the induction coil to intensify and amplify the magnetic field of elec¬ tromagnetic waves. Furthermore, the present invention provides a wireless power conversion charging device using the magnetic field of electromagnetic waves, which is located between an electromagnetic wave generating source transmitter and a receiving coil or attached to the transmitter and receiving coil. The wireless power conversion charging device includes a rectifying diode for rectifying an electromotive force induced in a construction in which a resonance and impedance matching variable condenser is connected to a coil in series or in parallel in order to transmit maximum induced power to a charging battery that is a load using electromagnetic waves amplified by the amplifying repeater, and a smoothing condenser for smoothing the rectified voltage. Accordingly, charging power required for various small power electronic devices can be provided and power can be supplied to various loads.

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Description

AN AMPLIFICATION RELAY DEVICE OF ELECTROMAGNETIC WAVE AND A RADIO ELECTRIC POWER CONVERSION APPARATUS USING THE ABOVE DEVICE

Technical Field

[1] The present invention relates to an amplifying repeater, which is constructed in such a manner that a ferrite core is inserted into a coil with a predetermined number of winds to increase an induced electromotive force caused by an increase in flux linkage using a time-varying magnetic field of electromagnetic waves at a position distant from an electromagnetic wave generating source by a predetermined distance, and that the coil and a variable condenser for inducing resonance are connected to each other to intensify and amplify the magnetic field of electromagnetic waves, and a wireless power converter using electromagnetic waves, which is located at a predetermined distance from the amplifying repeater, connects a resonance and impedance matching variable condenser to a coil to effectively transmit an induced power to a load, and rectifies and smoothes the induced power using a diode to supply the power to a charging battery or various loads.

Background Art

[2] The induced electromotive force obtained from a time variation of the magnetic field of electromagnetic waves using Faraday's law is generated in proportion to the number of winds of an induction coil and a time variation of flux linkage. However, the intensity of the magnetic field is abruptly decreased in response to a distance from an electromagnetic wave generating source. Thus, the induced electromotive force is hardly induced to the induction coil at more than a predetermined distance so that energy according to wireless power conversion cannot be obtained. Furthermore, the induction coil must be disposed within a very short range from the electromagnetic wave generating source in a prior art so that its installation position is greatly restricted or it cannot be installed because of its bad appearance.

Disclosure of Invention

Technical Problem

[3] Accordingly, the present invention has been made in view of the above□mentioned problem, and it is an object of the present invention to provide an electromagnetic wave amplifying repeater, which is constructed in such a manner that a ferrite core is inserted into a coil with a predetermined number of winds to increase an induced electromotive force caused by an increase in flux linkage using a time-varying magnetic

field of electromagnetic waves at a position distant from an electromagnetic wave generating source by a predetermined distance, connect the induction coil to a variable condenser for inducing resonance to construct an amplifying repeater that maximizes a current while reducing a resistant component existing in the induction coil to intensify and amplify the magnetic field of electromagnetic waves, and to provide a wireless power converter using the amplifying repeater, which includes a rectifying diode for rectifying an electromotive force induced in a structure in which a resonance and impedance matching variable condenser is connected in parallel with a coil to effectively transmit an induced electromotive force using the electromagnetic waves amplified by the amplifying repeater, having a predetermined distance from the amplifying repeater, and a smoothing condenser for smoothing the rectified voltage.

[4] Another object of the present invention is to provide an amplifying repeater located at a very short distance from an electromagnetic wave generating source or attached to a wireless power converter to intensify and amplify the magnetic field of electromagnetic waves such that the amplifying repeater is installed unrestrictedly and an amplifying repeater and wireless power converter are applied in various ways according to wireless power conversion using the amplified electromagnetic waves.

Technical Solution

[5] To achieve the above objects, according to the present, there is provided an electromagnetic wave amplifying repeater capable of amplifying and repeating the magnetic field of electromagnetic waves generated artificially or generated from various electromagnetic wave generating sources, including: an induction coil formed by winding a coil with a predetermined thickness in a desired size and form by a predetermined number of winds; a magnetic substance having a predetermined size and form, the magnetic substance being combined with the induction coil to increase flux; and a variable condenser connected to the induction coil to construct a resonance circuit.

Brief Description of the Drawings

[6] Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[7] FIG. 1 illustrates the appearance and configuration of an amplifying repeater according to the present invention;

[8] FIG. 2 illustrates a wireless power converter having a charging function according to the present invention;

[9] FIG. 3 illustrates a construction for measuring a charging voltage, a charging current and a charging power using only a wireless power converter without using an

amplifying repeater;

[10] FIG. 4 illustrates a construction for measuring a charging voltage, a charging current and a charging power using a single magnetic field amplifying repeater and a wireless power converter;

[11] FIG. 5 illustrates a construction for measuring a charging voltage, a charging current and a charging power using two magnetic field amplifying repeaters and a wireless power converter (combined with one of the amplifying repeaters);

[12] FIG. 6 illustrates a construction for measuring a charging voltage, a charging current and a charging power using two magnetic field amplifying repeaters and a wireless power converter (independent);

[13] FIG. 7 illustrates a construction for measuring a charging voltage, a charging current and a charging power using magnetic field amplifying repeaters, a repeating amplifier and a wireless power converter, which are combined with each other;

[14] FIG. 8 illustrates a construction in which a transmission coil generates a magnetic field, and a voltage, current and power are measured using an amplifying repeater, a receiving coil and a wireless power converter;

[15] FIG. 9 illustrates a construction in which a transmission coil generates a magnetic field, and a voltage, current and power are measured at an output terminal using an amplifying repeater, a receiving coil wound on the upper part of a common core, and an amplifying repeater disposed at the lower part of the common core;

[16] FIG. 10 illustrates a transmitter and a receiver constructed in such a manner that an amplifying repeater and a transmission coil or a receiving coil are wound around a single core;

[17] FIG. 11 illustrates a construction in which an amplifying repeater composed of a spiral coil is attached onto a spiral coil, and a voltage, current and power are measured at an output terminal of a receiving coil;

[18] FIG. 12 illustrates a construction in which an amplifying repeater composed of a spiral coil is located between a transmission coil and a receiving coil, and a voltage, current and power are measured at an output terminal;

[19] FIG. 13 illustrates a construction in which an amplifying repeater is located outside a transmission coil, and a voltage, current and power are measured at an output terminal of a receiving coil; and

[20] FIG. 14 illustrates a construction in which an amplifying repeater is located outside each of a transmission coil and a receiving coil, and a voltage, current and power are measured at an output terminal of the receiving coil

[21] 11; Core, 12; Inducing Coil

[22] 20; AC Power Generator

[23] 21; Eectromagnetic Wave Generating Source

[24] 22; Receiver 23; Output Part

[25] 24; Ruler

[26] 25,26,27,28,30,32,34; Amplifying Repeater

[27] 29; Transmission Coil

[28] 31; Receiver1 , 33; Receiving Coil

[29] 51; Spiral Coil Type Receiving Coil

[30] 52; Spiral Coil Type Amplifying Repeater

[31] 53; Spiral Coil Type Transmission Coil

[32] L1: Receiving Coil,

[33] C1: Condenser for Impedance Matching,

[34] C2: Smoothing Condenser,

[35] 1.3V: Battery Voltage for Charging

Mode for the Invention

[36] The present invention will now be described in detail in connection with preferred embodiments with reference to the accompanying drawings. For reference, like reference characters designate corresponding parts throughout several views.

[37] The present invention provides an amplifying repeater, which is constructed in such a manner that a ferrite core is inserted into a coil with a predetermined number of winds to increase an induced electromotive force caused by an increase in flux linkage using a time-varying magnetic field of electromagnetic waves using Faraday's law at a position distant from an electromagnetic wave generating source by a predetermined distance and the induction coil and a variable condenser for inducing resonance are connected to each other to maximize an induced current while reducing a resistant component existing in the induction coil to amplify the magnetic field of electromagnetic waves. Furthermore, the present invention provides a wireless power converter located at a predetermined distance from the amplifying repeater or attached to the amplifying repeater. The wireless power converter includes a rectifying diode for rectifying an electromotive force induced in a construction in which a magnetic core such as a ferrite core is inserted in an induction coil with a predetermined number of winds for transmitting maximum induced power to a charging battery that is a load using electromagnetic waves amplified by the amplifying repeater and the induction coil is connected to a variable condenser for controlling resonance and impedance matching, a smoothing condenser for smoothing the rectified voltage, and a receiving coil having a predetermined DC voltage and current.

[38] In receiving electromagnetic power using Faraday's law, the present invention amplifies the magnetic field of time-varying electromagnetic waves generated in a television receiver or a monitor or electromagnetic waves artificially generated by

connecting a transmission coil to a load of an AC power generating circuit using an amplifying repeater to obtain an induced electromotive force using an induction coil at a position distant from an electromagnetic wave generating source by a predetermined distance and maximizes the obtained induced voltage and current, to thereby provide a magnetic field amplifying repeater for receiving electromagnetic power, which enables high efficiency electric energy conversion, and a high efficiency wireless power converter using the amplifying repeater.

[39] The construction of the amplifying repeater for amplifying an induced magnetic field of electromagnetic waves will now be described.

[40] The electromagnetic wave amplifying repeater according to the present invention obtains an induced electromotive force using electromagnetic waves generated from an electromagnetic wave generating source and emits the obtained induced power to the air. The present invention winds a coil round a bobbin having a predetermined diameter and size (having an internal diameter of 10mm and an external diameter of 15mm) by a predetermined number of times and a ferrite core is inserted in the bobbin to manufacture an induction coil. The diameter and the number of winds of the induction coil and the size of the ferrite core are designed such that the induced electromotive force is maximized. The induction coil can be constructed in parallel or in series in consideration of its resistance value. In the present invention, the diameter and length of the ferrite core are 9mm and 110mm, respectively, and two induction coils each have a diameter of 0.3mm and a number of winds of 160 are connected in parallel with each other. The induction coils are wound round the aforementioned bobbin, the ferrite core is inserted into the bobbin and a variable condenser is connected in parallel with the induction coils to construct a resonance circuit to maximize induced power and emit electromagnetic waves.

[41] The wireless power converter according to the present invention is located at a predetermined distance from the amplifying repeater or attached to the amplifying repeater and includes a ferrite core having a diameter of 9mm and a length of 110mm and two induction coils having a diameter of 0.3mm and a number of winds of 100, connected in parallel with each other. The induction coils are wound round a bobbin having a predetermined size (an internal diameter of 10mm and an external diameter of 15mm), the ferrite core is inserted into the bobbin and a variable condenser is connected in parallel with the induction coils to impedance-match with a resonance and load electronic circuit to maximize an induced electromotive force. The wireless power converter further includes a diode for rectifying the induced electromotive force and a smoothing condenser for smoothing the rectified voltage. The wireless power converter can be used as a power supply of a charging device because it generates a DC voltage having a specific current.

[42] FIG. 1 illustrates the electromagnetic field amplifying repeater manufactured according to the present invention on the left and a circuit constructing the amplifying repeater on the right. FIG. 2 is a circuit diagram of the wireless power converter constructed to obtain an electric energy using electromagnetic waves amplified by the amplifying repeater. In FIG. 2, L1 denotes a receiving coil, C1 represents a capacitor for impedance matching of resonance and maximum power transmission, C2 denotes a smoothing capacitor, and 1.3V represents a charging battery voltage. Table 1 represents a charging voltage, a charging current and a charging power obtained when the wireless power converter of FIG. 2 is located having a predetermined distance from an electromagnetic wave generating source 21, as shown in FIG. 3, without using the electromagnetic field amplifying repeater. From Table 1, it can be known that the charging current and charging power are hardly induced when the distance of a ruler 24 exceeds 4cm.

[43]

[44] Table 1 : A charging voltage, a charging current and a charging power Using the wireless power converter in Fig2.

[45]

Distance(cm)	ChargingVoltage(V)	Charging Current (mA)	ChargingPower(mW)
0	1.3	27	35.1
1	1.3	18.4	23.9
2	1.3	10.7	13.9
3	1.3	4	5.2
4	1.3	0	0

[46]

[47] FIG. 4 illustrates a construction in which a single electromagnetic field amplifying repeater 25 designed and manufactured according to the present invention is located in proximity to the electromagnetic wave generating source 21 and a charging voltage, a charging current and a charging power are measured using a receiver wireless power converter according to the present invention while varying the distance between the electromagnetic field amplifying repeater and the wireless power converter. The measurement result is represented in Table 2. Referring to Table 2, the charging current and charging power can be obtained even at a point at which the distance of the ruler is approximately 10cm.

[48]

[49] Table 2 : A charging voltage, a charging current and a charging power Using the wireless power converter in Fig4.

[50]

Distance(cm)	Charging Voltage(V)	Charging Current(mA)	ChargingPower(mW)
5	1.3	44.0	57.2
6	1.3	26.2	34.1
7	1.3	21.7	28.2
8	1.3	15.7	20.4
9	1.3	10.7	13.9
10	1.3	4.9	6.4
11	1.3	0	0
12	1.3	0	0

[51] FIG. 5 illustrates a construction using two electromagnetic field amplifying repeaters 25 and 26 according to the present invention. One of the amplifying repeaters is located having a predetermined distance from the electromagnetic wave generating source 21 and the other one is disposed in proximity of the receiver 22 and the wireless power converter. Here, the amplifying repeater 26 and the receiver 22 are combined with each other. Table 3 represents a charging voltage, a charging current and a charging power measured using this construction while varying the distance between the electromagnetic wave generating source and the amplifying repeater 26 and the receiver 22 attached to each other. Referring to Table 3, the charging current and charging power can be obtained even at a point distant from the electromagnetic wave generating source 21 by 12cm.

[52] Table 3 : A charging voltage, a charging current and a charging power Using the wireless power converter in Fig5.

[53]

Distance(cm)	Charging Voltage(V)	Charging Current(mA)	ChargingPower(mW)
5	1.3	51.2	66.5
6	1.3	36.8	47.8
7	1.3	29.2	37.9
8	1.3	21.4	27.8
9	1.3	16.6	21.5
10	1.3	12.7	16.5
11	1.3	4.7	6.1
12	1.3	1.2	1.6

[54] FIG. 6 illustrates a construction using two electromagnetic field amplifying repeaters 25 and 27 designed and manufactured according to the present invention. In this construction, one of the amplifying repeaters is located having a predetermined distance from the electromagnetic wave generating source 21, the other one is disposed having a distance of 5cm from the electromagnetic wave generating source 21, and a charging voltage, a charging current and a charging power are measured using the wireless power converter while varying the distance between the wireless power converter and the amplifying repeaters. Table 4 represents the measurement result. Referring to Table 4, a slightly increased charging power can be obtained and a specific charging current and charging power can be obtained even at a point distant from the electromagnetic wave generating source 21 by 13cm.

[55]

[56] Table 4 : A charging voltage, a charging current and a charging power Using the wireless power converter in Fig6.

[57]

Distance(cm)	Charging Voltage(V)	Charging Current(mA)	Charging Power(mW)
10	1.3	34	44.2
11	1.3	22.3	29.0
12	1.3	6.3	8.2
13	1.3	1.7	2.2

[58] FIG. 7 illustrates a construction in which an electromagnetic field amplifying repeater 25 is manufactured in such a manner that a coil having the same diameter as the aforementioned coil is wound round a bobbin having the same size as the aforementioned bobbin by a number of winds of 200 to connect two induction coils in

parallel, a ferrite core is inserted into the induction coils and a variable condenser is connected in parallel with the induction coils to construct a resonance circuit, and the amplifying repeater 25 is located having a predetermined distance from the electromagnetic wave generating source 21. In addition, another amplifying repeater 27 identical to those used in FIGS. 3, 4, 5 and 6 is located at a point corresponding to 5cm of the ruler, and an amplifying repeater 28 and the wireless power converter are attached to each other to measure a charging voltage, a charging current and a charging power while varying the distance between the electromagnetic wave generating source and the wireless power converter. Table 5 represents the measured charging voltage, charging current and charging power. It can be known from Table 5 that a specific charging current and charging power can be obtained even at a point distant from the electromagnetic wave generating source 21 by 16cm.

[59] Table 5 : A charging voltage, a charging current and a charging power Using the wireless power converter in Fig7.

[60]

Distance(cm)	Charging Voltage(V)	Charging Current(mA)	Charging Power(mW)
10	1.3	41.0	53.3
11	1.3	29.8	38.7
12	1.3	20.2	26.2
13	1.3	15.8	20.5
14	1.3	10.7	13.9
15	1.3	3.2	4.1
16	1.3	1	1.3

[61] Various experiments were made using the electromagnetic field amplifying repeater designed and manufactured as above and the wireless power converter according to the present invention, as shown in FIGS. 3 through 7. In the case where only the wireless power converter is installed without having the amplifying repeater, as shown in FIG. 3, the induced electromotive force is hardly generated from the induction coil when the wireless power converter is located distant from the electromagnetic wave generating source by 4cm, as represented in Table 1. Thus, a charging current does not flow in a charging battery that is a load and charging battery power indicates zero. In the case where the amplifying repeater is added, as shown in FIG. 4, the maximum charging current of 44mA and charging power of 57.2mW are obtained when the wireless power converter is located distant from the electromagnetic wave generating source by 5cm and charging power of 6.4mW is obtained when the wireless power converter is

located distant from the electromagnetic wave generating source by 10cm, as represented in Table 2.

[62] When the wireless power converter is combined with the amplifying repeater, as shown in FIG. 5, the charging current and charging power are higher than those obtained from the construction of FIG. 4 at the same distance. When the two amplifying repeaters are used as shown in FIG. 6, the charging power at the point distant from the electromagnetic wave generating source by 10cm is 44.2mW as represented in Table 4, which is approximately seven times the charging power of 6.4mW obtained using only one amplifying repeater in FIG. 4. Furthermore, the charging current and charging power can be obtained even at a point distant from the electromagnetic wave generating source by a distance corresponding to 12cm of the ruler. Thus, it can be known that electromagnetic power is transmitted and induced-converted into an electrical energy to be transmitted to a load even at a distance four times the distance when the wireless power converter is used without using any amplifying repeater.

[63] In the construction in which two different amplifying repeaters 25 and 27 are in stalled and the amplifying repeater 28 is combined with a receiving coil and the wireless power converter, as shown in FIG. 7, increased charging current and charging power are measured at the same distance in the construction having no amplifying repeater of FIG. 6 and a distance capable of obtaining the charging current and charging power is increased to 16cm, as represented in Table 5.

[64] In another embodiment of the present invention, a transmission coil is connected to a load of an AC power generating circuit of a TV receiver, which is an artificial electromagnetic generating source, to construct a source of generating AC power waveform having a frequency of 130kHz, and the transmission coil, a repeater and coils used in first and second receivers are constructed, as shown in Table 6, to measure a receiving voltage, a receiving current and a receiving power in response to a ruler distance using the wireless power converter of FIG. 2.

[65] Table 6 : Coil Construction of Transmission coil, Repeater, Receiver1, Receiver2

[66]

	Transmission Coil	Repeater	Receiver1	Receiver2
Coil	0.3	0.3	0.3	0.3
Core(mm) (Dia.*Length)	9*55	7*45	7*45	7*45
No. of winding	40 회	40 회	15	Upper Receiver(10Times) Lower Repeater(40Times)

[67] In Table 6, the first receiver is constructed of a general solenoid coil constructed such that a coil is wound round a core and the second receiver includes a receiving coil wound round the upper part of a common core ten times and a repeater constructing a resonance circuit of a coil wound round the lower part of the common core forty times and a capacitor.

[68] FIG. 10 illustrates a transmitter and a receiver constructed by winding a transmission coil outputting power generated from the electromagnetic wave generating source or a receiving coil receiving electromagnetic waves round a common core provided with an electromagnetic wave amplifying repeater. This construction can obtain high wireless power conversion efficiency because it can maximize generation and reception of electromagnetic waves in the resonance circuit of the amplifying repeater.

[69] Table 7 represents the voltage, current and power measured at an output load terminal (tens of parallel LEDs) of a receiver 31 when a transmission coil 29, an amplifying repeater 30 and the receiver 31 manufactured as shown in Table 6 are installed as shown in FIG. 8. The amplifying repeater is located in proximity to an electromagnetic wave generating source. The voltage, current and power are measured while moving the receiver from the electromagnetic wave generating source to distances 5cm, 10cm and 15cm.

[70] Table 7 : A receiving voltage, current and power measured at an output load terminal of a receiver1.

[71]

Distance(cm)	Receiving voltage (V)	Receiving current (A)	Receiving power(W)
5	3.9	1.900	7.410
10	2.6	1.000	2.600
15	1.4	0.200	0.280

[72] Table 8 represents the voltage, current and power measured at an output load terminal of receivers 33 and 34 when the transmission coil 29, amplifying repeater 32 and receivers 33 and 34 manufactured as shown in Table 6 are installed as shown in FIG. 9. The amplifying repeater is located in proximity to an electromagnetic wave generating source. The voltage, current and power are measured while moving the receivers from the electromagnetic wave generating source to distances 5cm, 10cm, 15cm and 20cm.

[73] Table 8 : A receiving voltage, current and power measured at an output load terminal of a receiver2.

[74]

Distance(cm)	Receiving voltage(V)	Receiving current(A)	Receiving power (W)
5	4.6	3.500	16.100
10	4.4	3.500	15.400
15	2.7	1.700	4.590
20	2.0	0.700	1.400

[75] It can be known from Tables 7 and 8 that the receiving voltage, receiving current and receiving power in response to a distance are much larger when they are obtained using the receiver 31 manufactured by winding only an induction coil round a core than when they are obtained using the receivers 33 and 34 including an induction coil and a repeater constructed of a resonance circuit, which are attached to a single common core.

[76] Another embodiment of the present invention constructs induction coils by winding coils having various diameters round bobbins having various sizes by different numbers of winds in consideration of the size and scale of an electromagnetic wave generating source, connects the induction coils in series or in parallel, inserts ferrite cores having diameters and lengths fitted into the internal diameters of the bobbins, and connects the induction coils to a variable condenser to construct a resonance circuit. In this manner, an electromagnetic field amplifying repeater can be constructed

in various sizes and forms and an apparatus capable of obtaining charging voltage, charging current and charging power with various levels can be realized using the amplifying repeater and the wireless power converter.

[77] Another embodiment of the present invention constructs a transmission coil, a repeater and a receiver using the spiral structure disclosed in Korean Patent Application No. 10-2004-0000528 applied by the Applicant. In this case, an electromagnetic wave generating source that generates a voltage of AC 220V and 60Hz converted into an AC voltage waveform having a frequency of 120kHz through an AC-AC adapter is connected to the transmission coil in a spiral form, a receiving coil is connected to a charging circuit, and a received charging current and voltage are measured. The distance between the transmission coil and the receiving coil is 5cm. FIG. 11 shows a case where the amplifying repeater is located on the transmission coil in proximity to the transmission coil. Table 9 represents the internal diameters, external diameters, types and numbers of winds of the spiral transmission coil, repeater coil and receiving coil.

[78] Table 9 : Internal diameters, external diameters, types and numbers of winds of the spiral transmission coil, repeater coil and receiving coil.

[79]

	Internal diameters (mm)	External diameters (mm)	Coil spec.	Numbers of winds
Receiving coil	30	80	0.2*9	24
Repeater coil	30	80	0.2*9	24
Transmission coil	30	40	0.2*9	4

[80] In FIG. 11, transmission power output through the transmission coil of the electromagnetic wave generating source is 16W, charging voltage measured by the wireless power converter of FIG. 2 is 1.4V, charging current is 0.36A, and charging power is 0.50W. When the amplifying repeater is located between the transmission coil and the receiver, which are spiral coils having the dimension represented in Table 6, as shown in FIG. 12, charging voltage is 1.4V, charging current is 0.4A and charging power is 0.56W. In this case, current and power slightly higher than those obtained in the case of FIG. 11 can be obtained. For reference, when only the transmission coil 53

and receiving coil 51 are used without using the repeater and the distance between the transmission coil and the receiving coil is 5cm, charging voltage is 1.4V, charging current is 0.01A and charging power is 0.014W, which are very small.

[81] FIG. 13 shows a case where the amplifying repeater surrounds the transmission coil. Here, the repeater is not connected to the transmission coil through wire. Table 10 represents the internal diameters, external diameters, types and numbers of winds of the spiral transmission coil, repeater and receiver used in the construction shown in FIG. 13.

[82] In FIG. 13, transmission power output through the transmission coil of the electromagnetic wave generating source is 16W, charging voltage measured by the wireless power converter of FIG. 2 is 1.4V, charging current is 0.9A, and charging power is 1.26W. When the amplifying repeaters respectively surround the transmission and receiving coils, which are spiral coils having the dimension of Table 10, as shown in FIG. 14, charging voltage is 1.4V, charging current is 1.0A and charging power is 1.4W. That is, the highest current and power can be obtained in the experiments using the spiral coils. Here, the distance between the transmission coil and the receiving coil is 5cm.

[83] Table 10 : Internal diameters, external diameters, types and numbers of winds of the spiral transmission coil, repeater coil and receiving coil.

[84]

	Internal diameters (mm)	External diameters (mm)	Coil spec.	Numbers of winds
Receiving coil	30	30	0.2*9	24
Repeater coil	40	80	0.2*9	20
Transmission coil	30	40	0.2*9	4

[85] Furthermore, the present invention can construct a wireless charging device that generates an induced voltage and current with high efficiency and charges the induced voltage and current in a charger using a rectifying diode and a smoothing condenser by simultaneously winding two wires of the spiral coil disclosed in Korea Patent Application No. 10-2004-0000528 in the form of plate such that they are located in parallel vertically, placing a ferromagnetic substance in a doughnut shape on the coil in order to increase flux caused by flux linkage per hour and connecting a variable condenser to the coil in series or in parallel to construct a resonance circuit. Here, an

electromagnetic field amplifying repeater can be manufactured by constructing the resonance circuit using the spiral plate type coil, ferromagnetic substance in a doughnut shape and variable condenser. A method of manufacturing the electromagnetic field amplifying repeater is described in detail in Korea Patent Application No. 10-2004-0000528.

[86] The present invention constructs a magnetic field amplifying repeater for amplifying a magnetic field at a position having a predetermined distance from an electromagnetic wave generating source and locates an electromagnetic wave amplifying repeater and a wireless power conversion charging device converter at a position distant from the amplifying repeater by a predetermined distance. The wireless power conversion charging device include a rectifying diode that rectifies an electromotive force induced in a structure in which a resonance and impedance matching variable condenser and a coil are connected in parallel with each other to induce maximum power using electromagnetic waves amplified by the amplifying repeater to transmit the induced power to a load and a smoothing condenser smoothing the rectified voltage and a wireless power. Accordingly, the present invention can repeat power to a predetermined distance from the electromagnetic wave generating source and convert electromagnetic power to improve industrial applicability. For example, the present invention can be used to charge contactless wireless battery or transmit power in real time at a short distance in the air or an insulator of a small power electronic device.

[87] The present invention can locate the magnetic field amplifying repeater at a position having a predetermined distance from the electromagnetic wave generating source to install the wireless power converter using electromagnetic waves, and thus the wireless power converter can be freely located and applied in various ways.

[88] While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

Claims

[1] An electromagnetic wave amplifying repeater capable of amplifying and repeating the magnetic field of electromagnetic waves generated artificially or generated from various electromagnetic wave generating sources, comprising:
an induction coil formed by winding a coil with a predetermined thickness in a desired size and form by a predetermined number of winds;
a magnetic substance having a predetermined size and form, the magnetic substance being combined with the induction coil to increase flux; and
a variable condenser connected to the induction coil to construct a resonance circuit.

[2] The electromagnetic wave amplifying repeater as claimed in claim 1, wherein the induction coil wound by the predetermined number of winds is designed and manufactured in a solenoid or spiral form.

[3] The electromagnetic wave amplifying repeater as claimed in claim 1 or 2, wherein the magnetic substance combined with the induction coil to increase flux is a ferrite core or a substance having magnetism.

[4] The electromagnetic wave amplifying repeater as claimed in claim 3, wherein induction coils wound by a predetermined number of winds are connected in series or in parallel to control the resistance and inductance of the induction coils, to thereby effectively generate the magnetic field of electromagnetic waves.

[5] The electromagnetic wave amplifying repeater as claimed in claim 4, wherein the variable condenser constructing the resonance circuit is connected to the induction coil in series or in parallel to amplify the magnetic field of electromagnetic waves.

[6] A wireless power converter comprising:
an electromagnetic wave amplifying repeater including an induction coil formed by winding a coil with a predetermined diameter in a desired size and form by a predetermined number of winds, a magnetic substance, and a variable condenser, the electromagnetic wave amplifying repeater serving to amplify and repeat the magnetic field of electromagnetic waves generated artificially or generated from various electromagnetic wave generating sources;
an induction coil and a magnetic substance for generating an induced electromotive force using the magnetic field amplified by the amplifying repeater;
a variable condenser for performing resonance and impedance matching, the variable condenser being connected to the induction coil to improve power conversion efficiency;

a rectifying diode for rectifying a voltage induced by the induction coil and the variable condenser; and

a condenser for smoothing the voltage to form a voltage having a desired DC component.

[7] The wireless power converter as claimed in claim 6, wherein induction coils wound by a predetermined number of winds are connected in series or in parallel to control the resistance and inductance of the induction coils, to thereby improve power conversion efficiency.

[8] The wireless power converter as claimed in claim 6 or 7, wherein the amplifying repeater is attached to an electromagnetic wave generating source transmission coil and a receiving coil or to one of the electromagnetic wave generating source transmission coil and the receiving coil, and at least one amplifying repeater is installed between the electromagnetic wave generating source transmission coil and the receiving coil in consideration of the distance between the electromagnetic wave generating source and the receiving coil.

[9] The wireless power converter as claimed in claim 8, wherein the amplifying repeater and the receiving coil are designed and manufactured in a solenoid or spiral form.

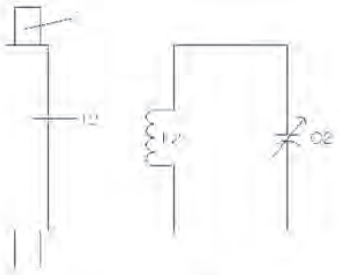
[10] The wireless power converter as claimed in claim 6, wherein the amplifying repeater and the wireless power converter including the amplifying repeater further comprise an electromagnetic wave generating source to which a spiral or solenoid transmission coil artificially generating electromagnetic waves is attached.

[11] The wireless power converter as claimed in claim 6, wherein the wireless power converter is constructed in such a manner that an induction coil is wound round one side of a core wound by a transmission coil of an artificial electromagnetic wave generating source and the induction coil is connected to a capacitor to construct an amplifying repeater, that an induction coil is wound round one side of a core wound by a receiving coil and the induction coil is connected to a capacitor to construct an amplifying repeater, or that amplifying repeaters are respectively set at both sides of the core of the transmission coil and receiving coil.

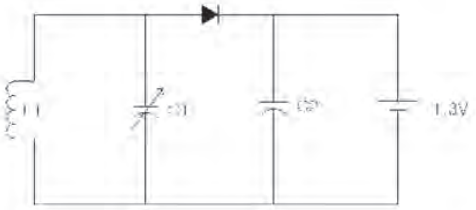
[12] The wireless power converter using an electromagnetic wave amplifying repeater as claimed in claim 6, wherein the wireless power converter is constructed in such a manner that a spiral coil is wound round the outside of a transmission spiral coil of an artificial electromagnetic wave generating source and connected to a capacitor to construct an amplifying repeater, that a spiral coil is wound round the outside a receiving spiral coil and connected to a capacitor to construct an amplifying repeater, and that spiral coils are respectively wound around the

outsides of transmission and receiving spiral coils and connected to a capacitor to construct an amplifying repeater.

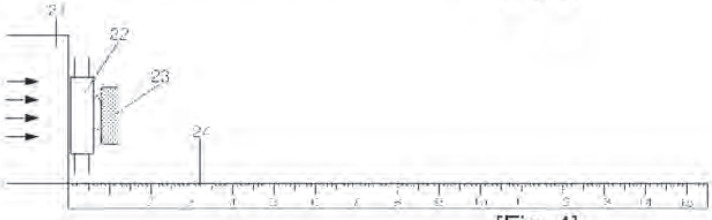
[Fig. 1]



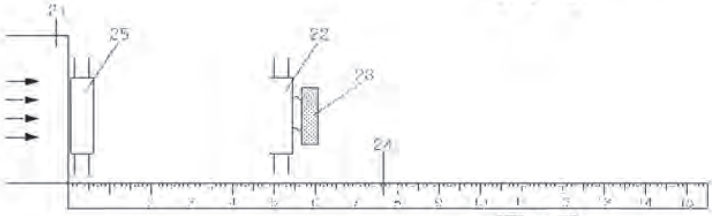
[Fig. 2]



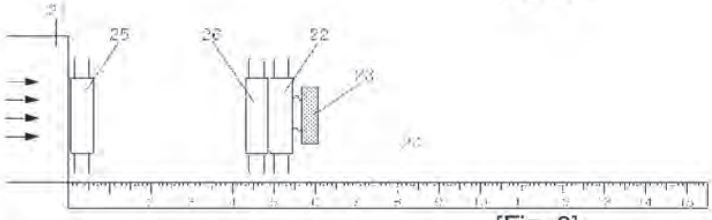
[Fig. 3]



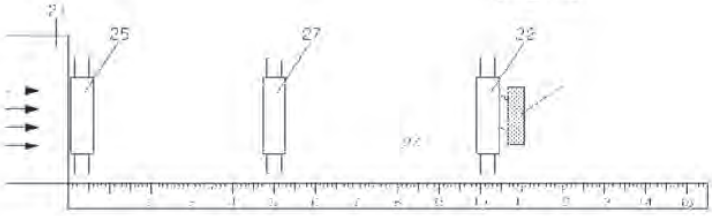
[Fig. 4]



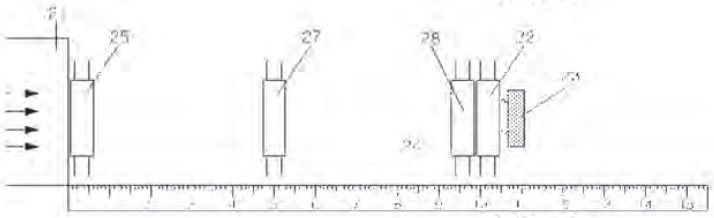
[Fig. 5]



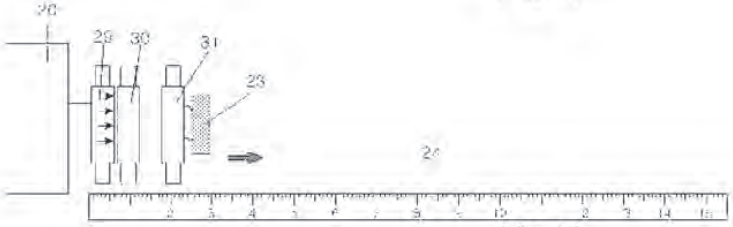
[Fig. 6]



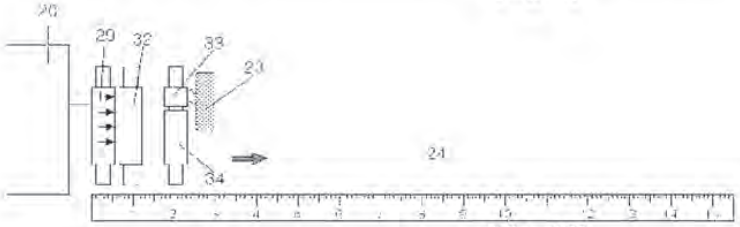
[Fig. 7]



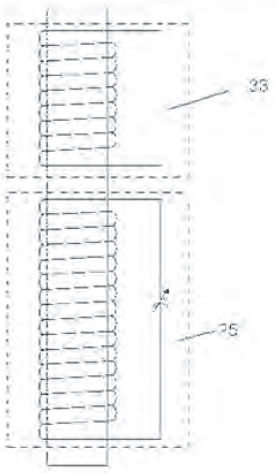
[Fig. 8]



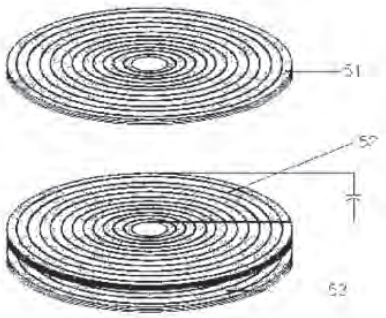
[Fig. 9]



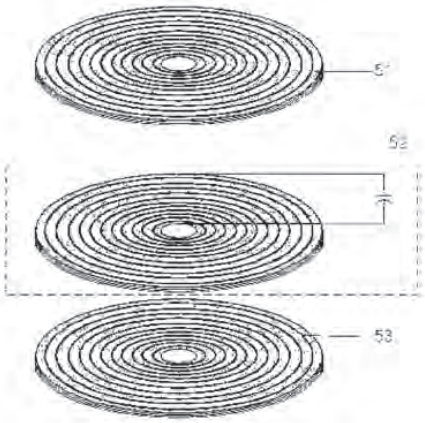
[Fig. 10]



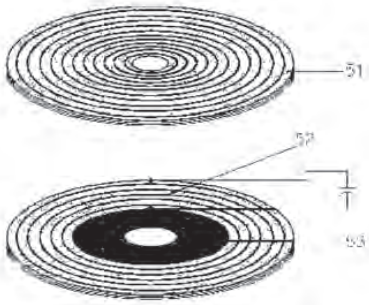
[Fig. 11]



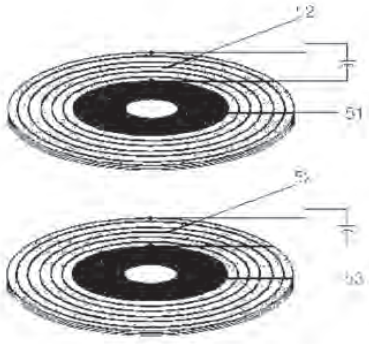
[Fig. 12]



[Fig. 13]



[Fig. 14]



PATENT COOPERATION TREATY

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
PCT_E0502		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/KR2005/002468	**29 JULY 2005 (29.07.2005)**	29 JULY 2004 (29.07.2004)
Applicant		
JC PROTEK CO.,LTD. et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      ☐ The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. ☐ 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(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      ☒ as suggested by the applicant.
      ☐ because the applicant failed to suggest a figure.
      ☐ because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

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Exhibit 1025
Page 826

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/002468

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H04B 7/14

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)
H04B, H02J,H05F, H02M, G09G

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)
SEARCH TERMS : RECHAEGE, BATTERY, WIRELESS, POWER

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 533 247 A1 (ERICSSON RADIO SYSTEMS B.V) 09-09-1992 SEE ABSTRACT; FIGURES 1&2; column 4;	1-5, 6
Y	JP 10-257697 (HITACHI ELECTRON SERVICE CO LTD) 25-09-1998 SEE THE WHOLE DOCUMENT	1-5, 6
Y	JP 2003-88005 A (SEIKO INSTR KK) 20-03-2003 SEE ABSTRACT; FIGURES 2; CLAIMS;	1-5, 6
A	US 2003/0048254 A1 (PRIMAX ELECTRONICS LTD) SEE ABSTRACT; FIGURES 1&2;	1-12

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
29 NOVEMBER 2005 (29.11.2005)	**29 NOVEMBER 2005 (29.11.2005)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer JANG, JIN HWAN Telephone No. 82-42-481-5711

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2005/002468

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0 533 247 A1	09-09-1992	DE 69207313 C0	15-02-1996
		NL 9101590 A	16-04-1993
		US 5367242	22-11-1994
JP 10-257697	25-09-1998	NONE	
JP 2003-88005 A	20-03-2003	EP 1263114 A2	04-12-2002
		US 20020190689 A1	19-12-2002
US 2003/0048254	12-03-2003	DE 10253662 A1	27-05-2004
		TW 535341 B	01-06-2003

InductEV, Inc.
Exhibit 1025
Page 828

Electronic Patent Application Fee Transmittal

Application Number:	12639963
Filing Date:	16-Dec-2009
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Filer:	Marc M. Wefers/Cheryl Forrest
Attorney Docket Number:	01997-0359009 / MIT 11757

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

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

Electronic Acknowledgement Receipt

EFS ID:	13382170
Application Number:	12639963
International Application Number:	
Confirmation Number:	7811
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Customer Number:	26161
Filer:	Marc M. Wefers/Cheryl Forrest
Filer Authorized By:	Marc M. Wefers
Attorney Docket Number:	01997-0359009 / MIT 11757
Receipt Date:	31-JUL-2012
Filing Date:	16-DEC-2009
Time Stamp:	14:08:23
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	538
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		359009-IDS.pdf	152631 f91fdbe7312bcb6e2e4532a808d0c088c8b1a7d9	yes	6
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	4	
	Information Disclosure Statement (IDS) Form (SB08)		5	6	
Warnings:					
Information:					
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Warnings:					
Information:					
3	Foreign Reference	0art2.pdf	263673 b58e9073ea2cab934ee4d67658dc7604 0aacad11	no	9
Warnings:					
Information:					
4	Foreign Reference	0art3.pdf	1282355 544bfeb5da62aa07ce28095f87b3 80dd7ccfcbc0	no	16
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5	Foreign Reference	0art4.pdf	744192 132ad0d1699b2f73eee97443c1da0a6a9da1f869e0	no	8
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7	Fee Worksheet (SB06)	fee-info.pdf	30553 8ca319c5b6754274 4393ed62f247bea79bb40191	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	3935196		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Albert W. Paladini
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

INFORMATION DISCLOSURE STATEMENT

Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

Applicants note that the two German references listed on the enclosed PTO-1449 form (Desig. ID Nos. 32 and 33) were previously cited in an Information Disclosure Statement on April 23, 2010, however only the English Abstract was referenced at that time. Applicant is now submitting machine translations of both German references.

The applicants invite the examiner to consider the position of the examiner and replies by the applicants that have been set forth in the prosecution of the following U.S. patent applications. These applications are related to the present application under Section 120 and/or contain at least some material that is similar to the material set forth in the specification of this application. The applicants assume that the examiner has direct access to these files, but will be happy to provide copies to the examiner upon request.

Application No.	Filing Date	Status
11/481,077	July 5, 2006	Issued
12/055,963	March 26, 2008	Issued
12/415,650	March 31, 2009	Issued
12/415,616	March 31, 2009	Issued
12/415,655	March 31, 2009	Issued
12/415,667	March 31, 2009	Published
12/437,641	May 9, 2009	Issued

Application No.	Filing Date	Status
12/466,065	May 14, 2009	Issued
12/553,957	September 3, 2009	Published
12/571,949	October 1, 2009	Published
12/639,958	December 16, 2009	Published
12/639,961	December 16, 2009	Published
12/639,962	December 16, 2009	Published
12/639,966	December 16, 2009	Published
12/639,967	December 16, 2009	Published
12/639,972	December 16, 2009	Published
12/646,442	December 23, 2009	Published
12/646,524	December 23, 2009	Published
12/649,635	December 30, 2009	Published
12/649,777	December 30, 2009	Published
12/649,813	December 30, 2009	Published
12/649,852	December 30, 2009	Published
12/649,904	December 30, 2009	Published
12/649,973	December 30, 2009	Published
12/688,305	January 15, 2010	Published
12/688,339	January 15, 2010	Published
12/708,850	February 19, 2010	Published
12/713,556	February 26, 2010	Published
12/717,559	March 4, 2010	Published
12/726,742	March 18, 2010	Published
12/726,913	March 18, 2010	Published
12/726,953	March 18, 2010	Published
12/732,399	March 26, 2010	Published
12/766,232	April 23, 2010	Published

Application No.	Filing Date	Status
12/784,615	May 21, 2010	Published
12/787,765	May 26, 2010	Published
12/837,675	July 16, 2010	Published
12/862,907	August 25, 2010	Published
12/868,852	August 26, 2010	Published
12/879,263	September 10, 2010	Published
12/879,395	September 10, 2010	Published
12/896,328	October 1, 2010	Published
12/896,400	October 1, 2010	Published
12/939,400	November 4, 2010	Published
12/949,504	November 18, 2010	Published
12/949,544	November 18, 2010	Published
12/949,580	November 18, 2010	Published
13/030,395	February 18, 2011	Published
13/030,400	February 18, 2011	Published
13/036,177	February 28, 2011	Published
13/040,810	March 16, 2011	Published
13/051,098	March 18, 2011	Published
13/051,153	March 18, 2011	Published
13/078,511	April 1, 2011	Published
13/102,498	May 6, 2011	Pending
13/107,293	May 20, 2011	Published
13/112,476	May 20, 2011	Published
13/116,474	May 26, 2011	Published
13/163,020	June 17, 2011	Published
13/288,308	November 3, 2011	Published
13/477,459	May 22, 2012	Pending

This statement is being filed after a first Office action on the merits, but before receipt of a final Office action or a Notice of Allowance. The fees in the amount of $180 in payment of the late submission fee of §1.17(p) are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 7/30/12



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/639,963	12/16/2009	John D. Joannopoulos	01997-0359009 / MIT 11757	7811

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FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER	
FLEMING, FRITZ M	

ART UNIT	PAPER NUMBER
2836	

NOTIFICATION DATE	DELIVERY MODE
08/31/2012	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):

PATDOCTC@fr.com

Office Action Summary	Application No.	Applicant(s)	
	12/639,963	JOANNOPOULOS ET AL.	
	Examiner	Art Unit	
	FRITZ M. FLEMING	2836	

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

Period for Reply

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

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

Status

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

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

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

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

Disposition of Claims

5)☒ Claim(s) *1-48* 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) *1-48* is/are rejected.

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

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

Application Papers

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

11)☒ The drawing(s) filed on *16 December 2009* 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).

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

Priority under 35 U.S.C. § 119

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

a)☐ All b)☐ Some * c)☐ None of:

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

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

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

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

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *7/31/2012,5/24/2012,11/23/2011*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

InductEV, Inc.
Exhibit 1025
Page 839

DETAILED ACTION

Terminal Disclaimer

1. The terminal disclaimer filed on 11/23/2011 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of U.S. Patent 7,741,734 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Response to Arguments

2. Applicant's arguments with respect to claims 1-48 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 1-48 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

5. Claims 1 and 2 recite optional coupling to the energy source and drain. "Optional" does not require an actual coupling, and if the source and drain are not present, then there can be no wireless power transfer. Also, subsequent recitation of the source and second and third resonators should include the "high-Q", so as to have consistent claim language.

Priority

6. This application repeats a substantial portion of prior Application No. 12/553957, filed 9/3/2009, and adds and claims additional disclosure not presented in the prior application. Since this application names an inventor or inventors named in the prior application, it may constitute a continuation-in-part of the prior application. Should applicant desire to obtain the benefit of the filing date of the prior application, attention is directed to 35 U.S.C. 120 and 37 CFR 1.78.

It is noted that applicants have now claimed second and third high Q resonators. These appear to only be found in the instant application claims and abstract, and not in the specification. Therefore it would appear proper that this instant application be a CIP and not a CON. Applicants' response should provide specific recitation of areas where this can be found.

Drawings

7. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the second and third resonators must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure

is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 103

8. 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.

9. The factual inquiries set forth in *Graham* v. *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

10. 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).

11. Claims 1-21,23-43,45-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chary (2005/0151511) in view of Hassler, Jr. et al. (Hassler-2005/0288741).

12. Chary teaches the basic configuration of a source of wireless power transfer (18,22) and at least two loads (24a,b) some of which are wireless phones. The devices are located at different variable distances from the source. The source is a power supply [0021] and the devices have drains (batteries are charged). What is missing is the use of "high-Q" resonators. Hassler shows the use of resonant circuits at the primary and secondary (see Figures 1-3). The primary is "high-Q" [0032] greater than 100, and the secondary is a lower Q of 10-15 [0033], but can be more [0029]. High-Q allows for a high power level at a narrow range of frequencies centered on a resonant frequency [0031].

13. Therefore it would have been obvious to one having ordinary skill in the art at the time that the invention was made to modify the system of Chary by the teachings of Hassler in order to be able allows for a high power level at a narrow range of frequencies centered on a resonant frequency. While the device Q has been described

to be lower per Hassler (under 100), it is clear from [0029] that it can be higher (and thus over 100, like the primary), if the ability to have a broader bandwidth is not desired. As the resonant frequency is discussed in Hassler, it is clear that one has to tune the resonant circuits, and thus "tunable" is clearly met. As Chary has shown the device to be movable, the transmission range is also variable, and the range being a function of the relative strength of the source and efficiency of the power transfer. As power efficiency is a desirable feature and the goal of standard design practice, the exact efficiency and wireless transfer rates to compensate for intrinsic losses are routine parameters taken into account for any type of power transfer system, and is obvious subject matter representing the application of routine and ordinary skill in the art, absent a showing of unexpected results or a unique technical feature. Hassler teaches it is known to operate at higher frequencies up to 30MHz [0012]. Likewise, an increased ratio of useful to lost power is a function of overall efficiency, and thus to design an efficient system is a routine goal. The claims do not specify a particular arrangement, only a broadly worded "configured to". Also, as noted above the ability to adjustably tune is needed in order to achieve the desired Q and resonant frequency. Finally, Hassler teaches different coil sizes [0032-33]. The above is applicable to method claims, as the system described will perform the method steps when operating.

14. Claims 22 and 44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chary and Hassler as applied to claims 1-21,23-43,45-48 above, and further in view of Young et al. (Young-5,455,467).

Claims 22 and 44 add a feedback mechanism to correct for detuning. Note that Chary does teach a feedback mechanism for the amount of power needed. In the same field of endeavor, Young teaches it is known to compensate for a "detuning" in the form of decreased power transfer due to improper alignment. See for example Figure 7. Therefore it would have been obvious to one having ordinary skill in the art at the time that the invention was made to modify the combined teachings of Chary and Hassler by the teachings of Young to be able to compensate for a "detuning" due to misalignment and to correct such by adjusting the power transferred. The type of detuning is not specified in the claims, and thus a power transfer that is not as designed is a detuning to the extent claimed.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to FRITZ M. FLEMING whose telephone number is (571)272-4145. The examiner can normally be reached on M-F, 0900-1730.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jared Fureman can be reached on 571-272-2391. 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.

FRITZ M FLEMING
Primary Examiner
Art Unit 2836

/FRITZ M FLEMING/
Primary Examiner, Art Unit 2836

Notice of References Cited	Application/Control No. 12/639,963	Applicant(s)/Patent Under Reexamination JOANNOPOULOS ET AL.	
	Examiner FRITZ M. FLEMING	Art Unit 2836	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,455,467	10-1995	Young et al.	307/104
*	B	US-2005/0151511	07-2005	Chary, Ram V.	320/127
*	C	US-2005/0288741	12-2005	Hassler et al.	607/061
	D	US-			
	E	US-			
	F	US-			
	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.

InductEV, Inc.
Exhibit 1025
Page 847

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))	Applicant John D. Joannopoulos et al.	
	Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	5,053,774	10/1/1991	Schuermann et al.			
	2	5,287,112	2/15/1994	Schuermann			
	3	5,455,467	10/3/1995	Young et al.			
	4	6,772,011	8/3/2004	Dolgin			
	5	8,076,800	12/13/2011	Joannopoulos et al.			
	6	8,076,801	12/13/2011	Karalis et al.			
	7	8,084,889	12/27/2011	Joannopoulos et al.			
	8	8,097,983	1/17/2012	Karalis et al.			
	9	2003/0124050	7/3/2003	Yadav et al.			
	10	2003/0126948	7/10/2003	Yadav et al.			
	11	2004/0100338	5/27/2004	Clark			
	12	2004/0233043	11/25/2004	Yazawa et al.			
	13	2006/0202665	9/14/2006	Hsu			
	14	2012/0068549	3/22/2012	Karalis et al.			

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	15	JP 02-097005	04/09/1990	Japan	H01F	21/06		X
	16	WO 2009/140506	11/19/2009	WIPO				
	17	WO 2010/039967	4/8/2010	WIPO				

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	18	Copy of Non-Final Office Action for U.S. Application Serial No. 12/648,604 by Examiner Justen Fauth dated December 5, 2011
	19	Copy of Non-Final Office Action for U.S. Application Serial No. 13/036,177 by Examiner Fritz M. Fleming dated May 15, 2012
	20	Copy of Non-Final Office Action for U.S. Application Serial No. 13/078,511 by Examiner Fritz M. Fleming dated May 15, 2012
	21	Copy of Non-Final Office Action for U.S. Application Serial No. 12/726,742 by Examiner Fritz M. Fleming dated May 11, 2012

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form (PTO-1449)

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

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Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	22	Copy of Non-Final Office Action for U.S. Application Serial No. 13/030,395 by Examiner Fritz M. Fleming dated May 17, 2012
	23	Copy of Non-Final Office Action for U.S. Application Serial No. 13/040,810 by Examiner Fritz M. Fleming dated May 17, 2012

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

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U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	6,664,770	12/16/2003	Bartels			
	2	7,514,818	4/7/2009	Abe et al.			
	3	8,022,576	9/20/2011	Joannopoulos et al.			
	4	2007/0021140	1/25/2007	Keyes, IV et al.			
	5	2008/0266748	10/30/2008	Lee			
	6	2009/0174263	7/9/2009	Baarman et al.			
	7	2009/0267709	10/29/2009	Joannopoulos et al.			
	8	2009/0267710	10/29/2009	Joannopoulos et al.			
	9	2009/0284083	11/19/2009	Karalis et al.			
	10	2010/0096934	4/22/2010	Joannopoulos et al.			
	11	2010/0102640	4/29/2010	Joannopoulos et al.			
	12	2010/0102641	4/29/2010	Joannopoulos et al.			
	13	2010/0123353	5/20/2010	Joannopoulos et al.			
	14	2010/0123354	5/20/2010	Joannopoulos et al.			
	15	2010/0123355	5/20/2010	Joannopoulos et al.			
	16	2010/0127573	5/27/2010	Joannopoulos et al.			
	17	2010/0127574	5/27/2010	Joannopoulos et al.			
	18	2010/0133918	6/3/2010	Joannopoulos et al.			
	19	2010/0133919	6/3/2010	Joannopoulos et al.			
	20	2010/0133920	6/3/2010	Joannopoulos et al.			
	21	2010/0148589	6/17/2010	Hamam et al.			
	22	2010/0187911	7/29/2010	Joannopoulos et al.			
	23	2010/0207458	8/19/2010	Joannopoulos et al.			
	24	2011/0043046	2/24/2011	Joannopoulos et al.			
	25	2011/0074218	3/31/2011	Karalis et al.			
	26	2011/0074347	3/31/2011	Karalis et al.			
	27	2011/0089895	4/21/2011	Karalis et al.			

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

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	Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	28	2011/0193419	8/11/2011	Karalis et al.			
	29						

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	30	2011/062827	5/26/2011	WIPO	G06F	1/26		

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	31	Andre Kurs et al., "Simultaneous mid-range power transfer to multiple devices", Applied Physics Letters, Vol. 96, No. 044102 (2010)
	32	David Schneider, "A Critical Look at Wireless Power", IEEE Spectrum, (May 2010)
	33	Marin Soljacic, "Wireless nonradiative energy transfer", Visions of Discovery New Light on Physics, Cosmology, and Consciousness, Cambridge University Press, New York, NY pp. 530-542 (2011)
	34	Joseph C. Stark III, "Wireless Power Transmission Utilizing a Phased Array of Tesla Coils", Master Thesis, Massachusetts Institute of Technology (2004)
	35	Copy of International Search Report and Written Opinion of the International Searching Authority for International Application No. PCT/US2011/027868 by Examiner Blaine R. Copenheaver dated July 5, 2011

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

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	1	2010/0102639	4/29/2010	Joannopoulos et al.			
	2	2010/0117455	5/13/2010	Joannopoulos et al.			
	3	2010/0117456	5/13/2010	Karalis et al.			
	4	2010/0171370	7/8/2010	Karalis et al.			
	5	2010/0181844	7/22/2010	Karalis et al.			
	6	2010/0201205	8/12/2010	Karalis et al.			
	7	2010/0225175	9/9/2010	Karalis et al.			
	8	2010/0231053	9/16/2010	Karalis et al.			
	9	2010/0237706	9/23/2010	Karalis et al.			
	10	2010/0237707	9/23/2010	Karalis et al.			
	11	2010/0237708	9/23/2010	Karalis et al.			
	12	2010/0253152	10/7/2010	Karalis et al.			
	13	2010/0264745	10/21/2010	Karalis et al.			
	14	2010/0277005	11/4/2010	Karalis et al.			
	15	2010/0327660	12/30/2010	Karalis et al.			
	16	2010/0327661	12/30/2010	Karalis et al.			
	17	2011/0012431	1/20/2011	Karalis et al.			
	18	2011/0018361	1/27/2011	Karalis et al.			
	19	2011/0025131	2/3/2011	Karalis et al.			
	20	2011/0049996	3/3/2011	Karalis et al.			
	21	2011/0049998	3/3/2011	Karalis et al.			
	22	2011/0140544	6/16/2011	Karalis et al.			
	23	2011/0148219	6/23/2011	Karalis et al.			
	24	2011/0162895	7/7/2011	Karalis et al.			
	25	2011/0169339	7/14/2011	Karalis et al.			
	26	2011/0181122	7/28/2011	Karalis et al.			
	27	2011/0198939	8/18/2011	Karalis et al.			

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form (PTO-1449)

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

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))	Applicant John D. Joannopoulos et al.	
	Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	28	2011/0221278	9/15/2011	Karalis et al.			
	29	2011/0227528	9/22/2011	Karalis et al.			
	30	2011/0227530	9/22/2011	Karalis et al.			
	31	2011/0241618	10/6/2011	Karalis et al.			

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	32	38 24 972	1/12/1989	Germany			Machine Translation	
	33	100 29147	12/20/2001	Germany			Machine Translation	
	34	6-341410	12/13/1994	Japan	F15B	15/18	English Abstract Only	
	35	11-188113	7/13/1999	Japan	A61N	1/378	English Abstract Only	
	36	2006/011769	2/2/2006	WIPO	H04B	7/14		

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	37	

Examiner Signature	Date Considered
/Fritz Fleming/ (08/27/2012)	

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form (PTO-1449)

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

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	12528	high adj q	USPAT	OR	OFF	2012/03/20 16:45
S2	296	S1 same wireless	USPAT	OR	OFF	2012/03/20 16:45
S3	88674	("5876425" | "20040130916" | "6345203" | "20050151511" | "5455467" | "6597076" | "6307468" | "6047214" | "5517194" | "20030014091" | "7355150" | "20030114769" | "6442434" | "20040130915" | "6364735" | "20030069051")".PN"	US-PGPUB; USPAT	OR	OFF	2012/03/20 16:48
S4	16	("5876425" | "20040130916" | "6345203" | "20050151511" | "5455467" | "6597076" | "6307468" | "6047214" | "5517194" | "20030014091" | "7355150" | "20030114769" | "6442434" | "20040130915" | "6364735" | "20030069051").PN.	US-PGPUB; USPAT	OR	OFF	2012/03/20 16:49
S5	5	S4 and q	US-PGPUB; USPAT	OR	OFF	2012/03/20 16:57
S6	2141	(307/104).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/20 16:59
S7	39	S6 and q	USPAT	OR	OFF	2012/03/20 16:59
S8	306	S6 and q	US-PGPUB; USPAT	OR	OFF	2012/03/20 16:59
S9	362	(320/108).CCLS.	USPAT; USOCR	OR	OFF	2012/03/20 17:35
S10	893	(320/108).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/20 17:36
S11	129	S10 and q	US-PGPUB; USPAT	OR	OFF	2012/03/20 17:36
S12	5432	(high adj q) same resonator	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 17:51
S13	480	(high adj q) same resonator same (contactless or (contact adj less) or inductive or inductively or wireless or wirelessly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 17:52

S14	402	("2133494" | "20030062794" | "20030199778" | "20040130916" | "20050127849" | "20060185809" | "20080197710" | "20090033564" | "20090072627" | "20090224608" | "6450946" | "6960968" | "7069064" | "7116200" | "7180248" | "7385357" | "20080067874" | "20090085408" | "20090085706" | "20090251008" | "0649621" | "7514818" | "8022576" | "1119732" | "20030214255" | "20040201361" | "20060022636" | "20080211320" | "20090127937" | "20090153273" | "4088999" | "5027709" | "5070293" | "5999308" | "6436299" | "7239110" | "7248017" | "7474058" | "7518267" | "20050288740" | "20090189458" | "20090284082" | "7191007" | "20070145830" | "20090267709" | "20100123355" | "20100207458" | "20110074218" | "20110193419" | "20030038641" | "20040000974" | "20040267501" | "20050093475" | "20050156560" | "20070178945" | "20080014897" | "20090195333" | "20090224856" | "20100038970" | "5898579" | "6597076" | "6749119" | "6798716" | "6831417" | "6917431" | "7126450" | "7375493" | "0787412" | "20090108997" | "20090284227" | "20090289595" | "7795708" | "20080266748" | "20100133918" | "20110043046" | "20020105343" | "20020118004" | "20040232845" | "20050116650" | "20060270440" | "20090058189" | "20090212636" | "20090213028" | "20090273242" | "5216402" | "5437057" | "6937130" | "7042196" | "7382636" | "7525283" | "20090096413" | "20090230777" | "20090281678" | "20090284220" | "5986895" | "7147604" | "7639514" | "7843288" | "7741734" | "20100123353" | "20040113847" | "20040150934" | "20050007067" | "20050122059" | "20070267918" | "20080191638" | "20090010028" | "20090072628" | "20090072629" | "20090224609" | "5493691" | "5118997" | "7599743" | "7825543" | "20090108679" | "0645576" | "20090284083" | "20100102641" | "20100133919" | "20100187911" | "20110089895" | "20020032471" | "20030062980" | "20060132045" | "20070276538" | "20080278264" | "20090045772" | "20090079268" | "20090102292" | "20090134712" | "20090179502" | "20090243397" | "5341083" | "6452465" | "6731071" | "6806649" | "7118240" | "7212414" | "7462951" | "20080012569" | "20080030415" | "20090146892" | "20090237194" | "20090267558" |	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 21:29

		"20090284245" | "20090286476" | "20100231163" | "20100289449" | "6664770" | "20090267710" | "20040130915" | "20050122058" | "20050127866" | "20070064406" | "20070171681" | "20070222542" | "20090015075" | "20090051224" | "20090195332" | "20090243394" | "3517350" | "5528113" | "6184651" | "6515878" | "6844702" | "6856291" | "6906495" | "6975198" | "7132918" | "7375492" | "7378817" | "7492247" | "7615936" | "20070182367" | "20080265684" | "20090067198" | "20090160261" | "20090174263" | "20090180679" | "20090271047" | "20090284369" | "20090286470" | "20070021140" | "20100123354" | "20110074347" | "20040222751" | "20050085873" | "20050104064" | "20050127850" | "20060061323" | "20060181242" | "20060205381" | "20090167449" | "20090299918" | "3535543" | "5367242" | "5550452" | "6812645" | "6825620" | "6917163" | "6973250" | "7466213" | "20050288739" | "20090271048" | "20090284218" | "20090286475" | "20100102640" | "20100133920" | "20100148589").PN.				
S15	10488	tet same q	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:31
S16	4	tet same q same implant	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:32
S17	2	trancutaneous adj energy adj transfer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:34
S18	550	transcutaneous adj energy adj transfer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:34
S19	60	S18 and q	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2012/03/20 22:34

			DERWENT; IBM_TDB			
S20	1060	("near" adj field) same wireless same power	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:49
S21	76	("near" adj field) same wireless same power same q	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:49
S22	233	("near" adj field) same (wireless adj power)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 22:52
S23	156	("near" adj field) adj inductive	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 23:01
S24	178	("near" adj field) same implant$ same power	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 23:19
S25	192	("near" adj field) same power same q	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/20 23:40
S26	2141	(307/104).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/20 23:54
S27	893	(320/108).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/20 23:54
S28	2316	S26 or S27	US-PGPUB; USPAT	OR	OFF	2012/03/20 23:54
S29	319	S28 and "near" adj field	US-PGPUB; USPAT	OR	ON	2012/03/20 23:54
S30	31	("3167168" | "4023753" | "4331225" | "4459438" | "4603640" | "4689530" | "4800328" | "4833337" | "4836344" | "4879522").PN. OR ("5519262").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 00:10
S31	4	("near" adj field) same implant$ same q	US-PGPUB; USPAT;	OR	ON	2012/03/21 00:16

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S32	186	("near" adj field) same high adj q	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/03/21 00:20
S33	34	("2401572" | "2426226" | "2805414" | "3546699" | "3713162" | "3771075" | "3786376" | "3810183" | "3914715" | "4150345" | "4157516" | "4163961" | "4233580" | "4253101" | "4258365" | "4288759" | "4358746" | "Re29296").PN. OR ("4516097").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 00:30
S34	1	("20100102639").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 11:50
S35	1	(("2010012355") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 12:29
S36	2	(("20100012355") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 12:29
S37	2	(("20100123355") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 12:30
S38	2	(("20100096934") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 12:52
S39	2	(("20100123355") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/21 20:45
S40	0	S39 and (tunable)	US-PGPUB; USPAT	OR	OFF	2012/03/21 20:45
S41	0	S39 and (tuning)	US-PGPUB; USPAT	OR	OFF	2012/03/21 20:46
S42	0	S39 and (tune)	US-PGPUB; USPAT	OR	OFF	2012/03/21 20:46
S43	1	("20100127574").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/26 06:11
S44	1	S43 and rate	US-PGPUB; USPAT	OR	OFF	2012/03/26 06:13
S45	1	S43 and "0.2"	US-PGPUB; USPAT	OR	OFF	2012/03/26 06:18
S46	1	S43 and (tunable or tuning or tuned or feedback)	US-PGPUB; USPAT	OR	ON	2012/03/26 06:20
S47	1	S43 and (tunable or tuning or tuned or feedback or detune or detuning)	US-PGPUB; USPAT	OR	ON	2012/03/26 06:21
S48	1	("20090085408").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/26 06:57

S49	1	("20110140544").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/04/09 13:11
S50	1	S49 and common	US-PGPUB; USPAT	OR	OFF	2012/04/09 13:11
S51	3	(("20110140544") or ("7825543") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/04/09 13:14
S52	3	S51 and common	US-PGPUB; USPAT	OR	OFF	2012/04/09 13:14
S53	1	S51 and (common adj inductance)	US-PGPUB; USPAT	OR	ON	2012/04/09 13:15
S54	4	(("20110140544") or ("20100117456") or ("7825543") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/04/09 13:19
S55	1	S52 and (common adj inductance)	US-PGPUB; USPAT	OR	ON	2012/04/09 13:19
S56	3	S52 and common	US-PGPUB; USPAT	OR	OFF	2012/04/09 13:20
S57	4	S54 and common	US-PGPUB; USPAT	OR	OFF	2012/04/09 13:20
S58	368	(high adj q) same resonant same (tune or tuning)	USPAT	OR	OFF	2012/04/09 13:54
S59	587	(high adj q) same resonant same (tune or tuning)	US-PGPUB; USPAT	OR	ON	2012/04/09 13:54
S60	1485	(307/104).CCLS.	USPAT; USOCR	OR	OFF	2012/05/07 04:48
S61	3	S60 and young and fleming	USPAT	OR	OFF	2012/05/07 04:48
S62	2	(("7825543") or ("7741734")).PN.	USPAT; USOCR	OR	OFF	2012/05/07 08:04
S63	5	"2006011769"	EPO; DERWENT	OR	OFF	2012/05/07 08:16
S64	4	"2004072581"	EPO; DERWENT	OR	OFF	2012/05/07 08:17
S65	2179	(307/104).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/05/07 12:02
S66	921	(320/108).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/05/07 12:02
S67	1199	S65 or S66	USPAT	OR	OFF	2012/05/07 12:02
S68	2381	S65 or S66	US-PGPUB; USPAT	OR	OFF	2012/05/07 12:02
S69	100	S68 and (nano or nanoscale)	US-PGPUB; USPAT	OR	ON	2012/05/07 12:02
S70	409	capacitor same inductor same(nano or nanoscale)	US-PGPUB; USPAT	OR	ON	2012/05/07 12:07
S71	5	capacitor same inductor same(nano or nanoscale) same transponder	US-PGPUB; USPAT	OR	ON	2012/05/07 12:13
S72	365	capacitor same inductor same powder	US-PGPUB; USPAT	OR	ON	2012/05/07 12:19
S73	87	q same (inductor or inductance) same (air adj core) same frequency	US-PGPUB; USPAT	OR	ON	2012/05/07 13:09

S74	5	q same (inductor or inductance) same (air adj core) same adjustable	US-PGPUB; USPAT	OR	ON	2012/05/07 13:13
S75	24	(inductor or inductance) same (air adj core) same adjustable	US-PGPUB; USPAT	OR	ON	2012/05/07 13:14
S76	79	(inductor or inductance) same (air adj core) same variable	US-PGPUB; USPAT	OR	ON	2012/05/07 13:15
S77	166	S68 and (air adj core)	US-PGPUB; USPAT	OR	ON	2012/05/07 13:24
S78	21	(inductor or inductance) same (air adj core) same variable	EPO; JPO; DERWENT	OR	ON	2012/05/07 13:38
S79	98	S68 and (variable or adjustable) near2 (inductor or inductance)	US-PGPUB; USPAT	OR	ON	2012/05/07 13:43
S80	53	("20020082059" | "20030006880" | "20030090239" | "3689885" | "3938018" | "3949268" | "4800328" | "4818855" | "5229652" | "5341280" | "5428659" | "5455466" | "5455467" | "5550452" | "5600225" | "5701657" | "5734254" | "5814900" | "5831348" | "5982764" | "6057668" | "6127799" | "6252380" | "6265791" | "6301128" | "6323775" | "6424124" | "6429622" | "6462432" | "6597076" | "6683438" | "6703920" | "6821670" | "6844702" | "6977479").PN. OR ("7518267").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/05/07 13:51
S81	1	("6436299").PN.	USPAT; USOCR	OR	OFF	2012/05/07 13:59
S82	2222	(307/104).OCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/18 05:48
S83	962	(320/108).OCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/18 05:48
S84	2222	(307/104).OCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/18 05:49
S85	962	(320/108).OCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/18 05:49
S86	2458	S84 or S85	US-PGPUB; USPAT	OR	OFF	2012/06/18 05:49
S87	511	(high adj q) same resonator same (contactless or (contact adj less) or inductive or inductively or wireless or wirelessly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/18 05:50
S88	264	("near" adj field) same (wireless adj power)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/18 05:50
S89	163	("near" adj field) adj inductive	US-PGPUB; USPAT; USOCR;	OR	ON	2012/06/18 05:50

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S90	2458	S84 or S85	US-PGPUB; USPAT	OR	OFF	2012/06/18 05:51
S91	350	S90 and "near" adj field	US-PGPUB; USPAT	OR	ON	2012/06/18 05:51
S92	11	("20040100338" | "20040233043" | "20060202665" | "20120068549" | "5053774" | "5287112" | "6772011" | "8076800" | "8076801" | "8084889" | "8097983").PN.	US-PGPUB; USPAT	OR	ON	2012/06/18 07:40
S93	4	("20030124050" | "20030126948" | "5455467" | "6772011").PN.	US-PGPUB; USPAT	OR	ON	2012/06/18 07:40
S94	2	(("7825543") or ("7741734")).PN.	USPAT; USOCR	OR	OFF	2012/06/18 08:05
S95	2	S94 and characteristic	USPAT	OR	OFF	2012/06/18 08:05
S96	1	("20030210106").PN.	US-PGPUB; USPAT	OR	OFF	2012/07/03 10:37
S97	1	("5959433").PN.	US-PGPUB; USPAT	OR	OFF	2012/07/03 10:39
S98	447	evanescent adj tail	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/07/03 10:40
S99	50	S98 and inductive	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/07/03 10:41
S100	97	S98 same power	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/07/03 10:42
S101	50	S98 same wireless$	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/07/03 10:43
S102	60	S98 and wireless$	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/07/03 10:44
S103	37316	computer same (wireless$ or inductive$)	US-PGPUB;	OR	ON	2012/07/03

		same power	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			11:05
S104	4230	computer same (wireless$ or inductive$) same power same (coupling or transfer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/07/03 11:05
S105	56	("2967267" | "3549990" | "4038625" | "4654573" | "4697183" | "4755783" | "4914561" | "4924171" | "4996638" | "5122729" | "5157319" | "5166965").PN. OR ("5455467").URPN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/03 11:06
S106	1358	computer same (wireless$ or inductive$) same power same (charging)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/07/03 11:09
S107	2	("2005/0151511").URPN.	USPAT	OR	OFF	2012/07/03 11:19
S108	971	(320/108).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/03 11:20
S109	130	S108 and computer	USPAT	OR	OFF	2012/07/03 11:20
S110	364	S108 and computer	US-PGPUB; USPAT	OR	OFF	2012/07/03 11:21
S111	1	("20100277005").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/03 11:28
S112	2	(("20100277005") or ("20110049996")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/03 11:29
S113	0	S112 and base	USPAT	OR	OFF	2012/07/03 11:30
S114	0	S112 and hold	USPAT	OR	OFF	2012/07/03 11:30
S115	0	S112 and portable	USPAT	OR	OFF	2012/07/03 11:31
S116	2	S112 and portable	US-PGPUB; USPAT	OR	OFF	2012/07/03 11:31
S117	2	S112 and base	US-PGPUB; USPAT	OR	OFF	2012/07/03 11:31
S118	135	S108 and contacts	USPAT	OR	OFF	2012/07/03 11:44
S119	1	("5367242").PN.	USPAT; USOCR	OR	OFF	2012/07/03 12:01
S120	0	S119 and phone	USPAT	OR	OFF	2012/07/03 12:01
S121	244	S108 and ferrite	US-PGPUB;	OR	OFF	2012/07/03

			USPAT			12:19
S122	1	S112 and desktop	US-PGPUB; USPAT	OR	OFF	2012/07/03 13:38
S123	2	S112 and "near"	US-PGPUB; USPAT	OR	OFF	2012/07/03 13:48
S124	2	S112 and evanescent	US-PGPUB; USPAT	OR	OFF	2012/07/03 14:44
S125	2	S112 and radiative	US-PGPUB; USPAT	OR	OFF	2012/07/03 14:46
S126	2	(("7825543") or ("7741734")).PN.	USPAT; USOCR	OR	OFF	2012/07/03 14:50
S127	1	("20100207458").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/13 02:46
S128	1	S127 and characteristic	US-PGPUB; USPAT	OR	OFF	2012/08/13 02:46
S129	1	("20100127575").PN.	US-PGPUB; USPAT	OR	OFF	2012/08/27 06:11
S130	1	S129 and second and third	US-PGPUB; USPAT	OR	OFF	2012/08/27 06:14
S131	0	("7687939").PN.	USPAT; USOCR	OR	OFF	2012/08/27 06:15
S132	0	("7687939").PN.	US-PGPUB; USPAT	OR	OFF	2012/08/27 06:16
S133	0	("7687939").PN.	US-PGPUB; USPAT	OR	OFF	2012/08/27 06:16
S134	1	("7741734").PN.	US-PGPUB; USPAT	OR	OFF	2012/08/27 06:21
S135	0	S134 and second and third	USPAT	OR	OFF	2012/08/27 06:22

EAST Search History (Interference)

<This search history is empty>

8/27/2012 7:58:09 AM
C:\Users\ffleming\Documents\EAST\Workspaces\2836\FY2012\mit wireless power.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12639963	JOANNOPOULOS ET AL.
	Examiner	Art Unit
	Fritz M. Fleming	2836

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/23/2011	08/27/2012							
	1	✓	✓							
	2	✓	✓							
	3		✓							
	4		✓							
	5		✓							
	6		✓							
	7		✓							
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	9		✓							
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	11		✓							
	12		✓							
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	30		✓							
	31		✓							
	32		✓							
	33		✓							
	34		✓							
	35		✓							
	36		✓							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12639963	JOANNOPOULOS ET AL.
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✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
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☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/23/2011	08/27/2012							
	37		✓							
	38		✓							
	39		✓							
	40		✓							
	41		✓							
	42		✓							
	43		✓							
	44		✓							
	45		✓							
	46		✓							
	47		✓							
	48		✓							

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12639963	JOANNOPOULOS ET AL.
	Examiner	Art Unit
	Fritz M. Fleming	2836

SEARCHED			
Class	Subclass	Date	Examiner
307	104	9/23/11	awp
333	195	9/23/11	awp

SEARCH NOTES		
Search Notes	Date	Examiner
EAST	9/23/11	awp
Updated Search	8/27/2012	FMF

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

	/FRITZ M FLEMING/ Primary Examiner.Art Unit 2836

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Albert W. Paladini
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

INFORMATION DISCLOSURE STATEMENT

Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

Applicants note that the two German references listed on the enclosed PTO-1449 form (Desig. ID Nos. 32 and 33) were previously cited in an Information Disclosure Statement on April 23, 2010, however only the English Abstract was referenced at that time. Applicant is now submitting machine translations of both German references.

The applicants invite the examiner to consider the position of the examiner and replies by the applicants that have been set forth in the prosecution of the following U.S. patent applications. These applications are related to the present application under Section 120 and/or contain at least some material that is similar to the material set forth in the specification of this application. The applicants assume that the examiner has direct access to these files, but will be happy to provide copies to the examiner upon request.

Application No.	Filing Date	Status
11/481,077	July 5, 2006	Issued
12/055,963	March 26, 2008	Issued
12/415,650	March 31, 2009	Issued
12/415,616	March 31, 2009	Issued
12/415,655	March 31, 2009	Issued
12/415,667	March 31, 2009	Published
12/437,641	May 9, 2009	Issued

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

Application No.	Filing Date	Status
12/466,065	May 14, 2009	Issued
12/553,957	September 3, 2009	Published
12/571,949	October 1, 2009	Published
12/639,958	December 16, 2009	Published
12/639,961	December 16, 2009	Published
12/639,962	December 16, 2009	Published
12/639,966	December 16, 2009	Published
12/639,967	December 16, 2009	Published
12/639,972	December 16, 2009	Published
12/646,442	December 23, 2009	Published
12/646,524	December 23, 2009	Published
12/649,635	December 30, 2009	Published
12/649,777	December 30, 2009	Published
12/649,813	December 30, 2009	Published
12/649,852	December 30, 2009	Published
12/649,904	December 30, 2009	Published
12/649,973	December 30, 2009	Published
12/688,305	January 15, 2010	Published
12/688,339	January 15, 2010	Published
12/708,850	February 19, 2010	Published
12/713,556	February 26, 2010	Published
12/717,559	March 4, 2010	Published
12/726,742	March 18, 2010	Published
12/726,913	March 18, 2010	Published
12/726,953	March 18, 2010	Published
12/732,399	March 26, 2010	Published
12/766,232	April 23, 2010	Published

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

Application No.	Filing Date	Status
12/784,615	May 21, 2010	Published
12/787,765	May 26, 2010	Published
12/837,675	July 16, 2010	Published
12/862,907	August 25, 2010	Published
12/868,852	August 26, 2010	Published
12/879,263	September 10, 2010	Published
12/879,395	September 10, 2010	Published
12/896,328	October 1, 2010	Published
12/896,400	October 1, 2010	Published
12/939,400	November 4, 2010	Published
12/949,504	November 18, 2010	Published
12/949,544	November 18, 2010	Published
12/949,580	November 18, 2010	Published
13/030,395	February 18, 2011	Published
13/030,400	February 18, 2011	Published
13/036,177	February 28, 2011	Published
13/040,810	March 16, 2011	Published
13/051,098	March 18, 2011	Published
13/051,153	March 18, 2011	Published
13/078,511	April 1, 2011	Published
13/102,498	May 6, 2011	Pending
13/107,293	May 20, 2011	Published
13/112,476	May 20, 2011	Published
13/116,474	May 26, 2011	Published
13/163,020	June 17, 2011	Published
13/288,308	November 3, 2011	Published
13/477,459	May 22, 2012	Pending

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

This statement is being filed after a first Office action on the merits, but before receipt of a final Office action or a Notice of Allowance. The fees in the amount of $180 in payment of the late submission fee of §1.17(p) are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 7/30/12

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/Fritz Fleming/ (08/27/2012)

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Fritz Fleming
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

AMENDMENT IN REPLY TO ACTION OF AUGUST 31, 2012

Please amend the above-identified application as follows:

Amendments to the Specification:

Please add the following new paragraphs after the paragraph ending at page 5, paragraph number [0032]:

--FIG. 7 is a schematic diagram of a feedback mechanism to correct the resonators exchanging wireless energy for detuning because of the effect of an extraneous object.--

--FIG. 8 is a schematic diagram of an exemplary system in which a high-Q source resonator 810 is receiving power from a power supply 820 and wirelessly transfers non-radiative electromagnetic energy to multiple high-Q device resonators 830 and 840, each of which is coupled to an energy drain 850 and 860, respectively.--

Please replace paragraph [0034] with the following amended paragraph:

[0034] The omnidirectional by stationary (non-lossy) nature of the near field makes this mechanism suitable for mobile wireless receivers. It could therefore have a variety of possible applications including for example, placing a source connected to a wired electricity network on the ceiling of a factory room, while devices, such as robots, vehicles, computers, or similar are roaming freely within the room. Other possible applications include electric-engine buses, RFIDs, and perhaps even nano-robots. Similarly, in some embodiments multiple sources can transfer energy to one or more device objects. For example, as explained at in the paragraph bridging pages 4-5 of U.S. Provisional Application No. 60/698,442 to which the present application claims benefit and which is incorporated by reference above, for certain applications having uneven power transfer to the device object as the distance between the device and the source changes, multiple sources can be strategically placed to alleviate the problem, and/or the peak amplitude of the source can be dynamically adjusted.

Please replace the paragraph beginning at page 12, paragraph number [0051] with the following amended paragraph:

--Namely, the effect of the extraneous object is just a perturbation on the resonance of the resonant object and it is twofold: First, it shifts its resonant frequency through the real part of κ_{11} thus detuning it from other resonant objects. As shown in FIG. 7, this ~~This~~ is a problem that can be fixed rather easily by applying a feedback mechanism 710 to every device (e.g., device resonators 720 and 730) that corrects its frequency, such as through small changes in geometry, and matches it to that of the source resonator 740. Second, it forces the resonant object to lose modal energy due to scattering into radiation from the extraneous object through the induced polarization or currents in it, and due to material absorption in the extraneous object through the imaginary part of κ_{11}. This reduction in Q can be a detrimental effect to the functionality of the energy-transfer scheme, because it cannot be remedied, so its magnitude must be quantified.--

Please replace the paragraph beginning at page 16, paragraph number [0063] with the following amended paragraph:

--[0063] The invention provides a resonance-based scheme for mid-range wireless non-radiative energy transfer. Analyses of very simple implementation geometries provide encouraging performance characteristics for the potential applicability of the proposed mechanism. For example, in the macroscopic world, this scheme could be used to deliver power to robots and/or computers in a factory room, or electric buses on a highway (source-cavity would in this case be a "pipe" running above the highway). In the microscopic world, where much smaller wavelengths would be used and smaller powers are needed, one could use it to implement optical inter-connects for CMOS electronics or else to transfer energy to autonomous nano-objects, without worrying much about the relative alignment between the sources and the devices; energy-transfer distance could be even longer compared to the objects' size, since $Im\{\varepsilon(\omega)\}$ of dielectric materials can be much lower at the required optical frequencies than it is at microwave frequencies. Accordingly, FIG. 8 is a schematic drawing showing an exemplary system in which a high-Q source resonator 810 is receiving power from a power supply 820 and wirelessly transfers non-radiative electromagnetic energy to multiple high-Q device resonators 830 and 840, each of which is coupled to an energy drain 850 and 860, respectively. --

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. (Currently Amended) A system, comprising:

a source ~~high-Q~~ resonator having a resonant frequency ω_1, an intrinsic loss rate Γ_1, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$, ~~optionally~~ the source resonator configured to be coupled to an energy source;

a second ~~high-Q~~ resonator having a resonant frequency ω_2, an intrinsic loss rate Γ_2, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_2 = \omega_2 / (2\Gamma_2)$, ~~optionally coupled to an energy drain,~~ the second resonator located a distance from the source resonator; and

a third ~~high-Q~~ resonator having a resonant frequency ω_3, an intrinsic loss rate Γ_3, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_3 = \omega_3 / (2\Gamma_3)$, ~~optionally coupled to an energy drain,~~ the third resonator located a distance from the source resonator,

wherein the source resonator and at least one of the second resonator and third resonator are configured to be coupled to wirelessly transfer electromagnetic energy from said source resonator to said at least one of the second resonator and third resonator when the source resonator is coupled to the energy source.

2. (Currently Amended) A method, comprising:

providing a source ~~high-Q~~ resonator having a resonant frequency ω_1, an intrinsic loss rate Γ_1, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$, ~~optionally~~ the source resonator configured to be coupled to an energy source;

providing a second ~~high-Q~~ resonator having a resonant frequency ω_2, an intrinsic loss rate Γ_2, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_2 = \omega_2 / (2\Gamma_2)$, ~~optionally coupled to an energy drain,~~ the second resonator located a distance from the source resonator; and

providing a third ~~high-Q~~ resonator having a resonant frequency ω_3, an intrinsic loss rate Γ_3, and capable of storing electromagnetic energy with a high intrinsic quality factor $Q_3 = \omega_3 / (2\Gamma_3)$, ~~optionally coupled to an energy drain,~~ the third resonator located a distance from the source resonator,

wherein the source resonator and at least one of the second resonator and third resonator are configured to be coupled to wirelessly transfer electromagnetic energy from said source resonator to said at least one of the second resonator and third resonator when the source resonator is coupled to the energy source.

3. (Previously Presented) The system of claim 1, further comprising the energy source coupled to the source resonator.

4. (Currently Amended) The system of claim 1, further comprising ~~the first-mentioned~~ an energy drain configured to be coupled to the second resonator and ~~the second-mentioned~~ an energy drain configured to be coupled to the third resonator.

5. (Previously Presented) The system of claim 4, wherein at least one of the energy drains comprises a robot, vehicle, computer, cell phone, or a portable electronic device.

6. (Currently Amended) The system of claim 1, wherein $Q_1 > 100$ ~~at least one of the high-Q resonators has a Q-factor $Q_i > 100$~~.

7. (Currently Amended) The system of claim 6, wherein $Q_1 > 100$ and $Q_2 > 100$ ~~another one of the high-Q resonators has a Q-factor $Q_3 > 100$~~.

8. (Previously Presented) The system of claim 1, wherein the source resonator is electromagnetically coupled to each of the second and third resonators.

9. (Previously Presented) The system of claim 8, wherein the source resonator is configured to wirelessly transfer electromagnetic energy from the source resonator to each of the second and third resonators.

10. (Currently Amended) The system of claim 1, wherein $Q_1 > 100$ ~~at least one of the high-Q resonators has a Q-factor $Q_1 > 100$~~.

11. (Currently Amended) The system of claim 10, wherein $Q_1 > 100$ and $Q_2 > 100$ ~~another one of the high-Q resonators has a Q-factor $Q_3 > 100$~~.

12. (Previously Presented) The system of claim 1, wherein at least one of the resonators is tunable.

13. (Previously Presented) The system of claim 1, wherein the resonators are movable relative to one another and wherein the wireless energy transfer occurs over a range of distances.

14. (Previously Presented) The system of claim 13, wherein the range of distances includes 5 cm.

15. (Previously Presented) The system of claim 13, wherein the range of distances includes 10 cm.

16. (Previously Presented) The system of claim 13, wherein the range of distances includes 30 cm.

17. (Previously Presented) The system of claim 13, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 0.2$ over the range of distances, wherein κ is the wireless energy transfer rate, Γ_1 is the intrinsic loss rate of the source resonator, and Γ_2 is the intrinsic loss rate of said at least one of the second resonator and the third resonator.

18. (Previously Presented) The system of claim 17, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 0.5$ over the range of distances.

19. (Previously Presented) The system of claim 17, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 1$ over the range of distances.

20. (Previously Presented) The system of claim 13, wherein the efficiency of the wireless energy transfer is at least 20% over the range of distances.

21. (Currently Amended) The system of claim 1, wherein ~~the resonant~~ frequencies $f_1 = \omega_1/2\pi$, $f_2 = \omega_2/2\pi$, and $f_3 = \omega_3/2\pi$ of the resonators are each at least 5 MHz.

22. (Currently Amended) The system of claim 1, further comprising a feedback mechanism coupled to at least one of the resonators to correct for detuning to correct for detuning of the resonant frequencies.

23. (Currently Amended) The system of claim 1, wherein the energy source is coupled to the source resonator, [[the]] an energy drain is coupled to the second resonator, and the source

resonator is electromagnetically coupled to the second resonator, and wherein the energy source and energy drain are configured to be driven to increase the ratio of useful-to-lost power for varying wireless energy transfer rates κ between the source resonator and the second resonator.

24. (Previously Presented) The system of claim 1, wherein the source resonator is electromagnetically coupled to the second resonator, and wherein the source resonator and second resonator are configured to be adjustably tuned to increase the ratio of useful-to-lost power for varying wireless energy transfer rates κ between the source resonator and the second resonator.

25. (Previously Presented) The method of claim 2, wherein the energy source is coupled to the source resonator.

26. (Currently Amended) The method of claim 2, wherein ~~the first-mentioned~~ an energy drain is coupled to the second resonator and ~~the second-mentioned~~ an energy drain is coupled to the third resonator.

27. (Previously Presented) The method of claim 26, wherein at least one of the energy drains comprises a robot, vehicle, computer, cell phone, or a portable electronic device.

28. (Currently Amended) The method of claim 2, wherein ~~at least one of the high-Q resonators has a Q-factor $Q_i > 100$~~ $Q_1 > 100$.

29. (Currently Amended) The method of claim 28, wherein ~~another one of the high-Q resonators has a Q-factor $Q_j > 100$~~ $Q_1 > 100$ and $Q_2 > 100$.

30. (Currently Amended) The method of claim 2, wherein the source resonator is electromagnetically coupled to each of the second and third resonators.

31. (Previously Presented) The method of claim 30, wherein the source resonator is configured to wirelessly transfer electromagnetic energy from the source resonator to each of the second and third resonators.

32. (Currently Amended) The method of claim 30, wherein ~~at least one of the high-Q resonators has a Q-factor $Q_i > 100$~~ $Q_1 > 100$.

33. (Currently Amended) The method of claim 32, wherein ~~another one of the high-Q resonators has a Q-factor $Q_j > 100$~~ $Q_1 > 100$ and $Q_2 > 100$.

34. (Previously Presented) The method of claim 2, wherein at least one of the resonators is tunable.

35. (Previously Presented) The method of claim 2, wherein the resonators are movable relative to one another and wherein the wireless energy transfer occurs over a range of distances.

36. (Previously Presented) The method of claim 35, wherein the range of distances includes 5 cm.

37. (Previously Presented) The method of claim 35, wherein the range of distances includes 10 cm.

38. (Previously Presented) The method of claim 35, wherein the range of distances includes 30 cm.

39. (Previously Presented) The method of claim 35, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 0.2$ over the range of distances, wherein κ is the wireless energy transfer rate, Γ_1 is the intrinsic loss rate of

the source resonator, and Γ_2 is the intrinsic loss rate of said at least one of the second resonator and the third resonator.

40. (Previously Presented) The method of claim 39, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 0.5$ over the range of distances.

41. (Previously Presented) The method of claim 39, wherein $\kappa/\sqrt{\Gamma_1\Gamma_2} > 1$ over the range of distances.

42. (Previously Presented) The method of claim 35, wherein the efficiency of the wireless energy transfer is at least 20% over the range of distances.

43. (Currently Amended) The method of claim 2, wherein ~~the resonant~~ frequencies $f_1 = \omega_1/2\pi$, $f_2 = \omega_2/2\pi$, and $f_3 = \omega_3/2\pi$ of the resonators are each at least 5 MHz.

44. (Currently Amended) The method of claim 2, wherein a feedback mechanism is coupled to at least one of the resonators to correct for detuning to correct for detuning of the resonant frequencies.

45. (Currently Amended) The method of claim 2, wherein the energy source is coupled to the source resonator, [[the]] an energy drain is coupled to the second resonator, and the source resonator is electromagnetically coupled to the second resonator, and wherein the energy source and energy drain is driven to increase the ratio of useful-to-lost power for varying wireless energy transfer rates κ between the source resonator and the second resonator.

46. (Previously Presented) The method of claim 2, wherein the source resonator is electromagnetically coupled to the second resonator, and wherein the source resonator and

second resonator are adjustably tuned to increase the ratio of useful-to-lost power for varying wireless energy transfer rates κ between the source resonator and the second resonator.

47. (Previously Presented) The system of claim 1, wherein the source resonator and the second resonator have different characteristic sizes.

48. (Previously Presented) The method of claim 2, wherein the source resonator and the second resonator have different characteristic sizes.

49. (New) The system of claim 1, wherein $f_1 = \omega_1 / (2\pi)$, $f_2 = \omega_2 / (2\pi)$, and $f_3 = \omega_3 / (2\pi)$, and each of f_1, f_2, and f_3 is between about 5 MHz and 380 MHz.

50. (New) The method of claim 2, wherein $f_1 = \omega_1 / (2\pi)$, $f_2 = \omega_2 / (2\pi)$, and $f_3 = \omega_3 / (2\pi)$, and each of f_1, f_2, and f_3 is between about 5 MHz and 380 MHz.

Amendments to the Drawings:

The attached new sheets of drawings include a new Fig. 7 to show the feedback mechanism described in original paragraph [0052] and a new Fig. 8 to show a source resonator wirelessly transferring energy to multiple device resonators as described in original paragraphs [0034] – [0036] and [0063].

Attachments following last page of this Amendment:
New Sheets (2 pages)

REMARKS

Claim Status

Claims 1-50 are pending. Claims 1 and 2 are independent claims. Claims 49-50 are new.

Section 112 Rejections

Without conceding the merits of the rejections, we have amended the claims to address the concerns raised in the action. For example, independent claims 1 and 2 now each recite "the source resonator configured to be coupled to an energy source" and "wherein the source resonator and at least one of the second resonator and third resonator are configured to be coupled to wirelessly transfer electromagnetic energy from said source resonator to said at least one of the second resonator and third resonator when the source resonator is coupled to the energy source."

Priority

As stated in paragraph [0001] of the specification as filed, the present application is a continuation application of U.S. patent application no. 12/553,957, which is a continuation of U.S. patent application no. 11/481,077 (now issued as U.S. Patent No. 7,741,734), which in turn claims priority to provisional application no. 60/698,442. The present application is not a continuation-in-part application. No new matter has been added.

With respect to the "second and third high Q resonators" referenced in the Office Action, we submit that this is disclosed in the original specification at least as follows. For example, original paragraph [0034] expressly describes how the presently disclosed wireless energy transfer scheme can be used to deliver power from *a source* to *multiple* devices: "It could therefore have a variety of possible applications including for example, placing a source connected to the wired electricity network on the ceiling of a factory room, while devices, such as robots, vehicles, computers, or similar, are roaming freely within the room." Furthermore, for example, this concept of delivering powering wirelessly to multiple devices is reiterated in original paragraph [0063]: "For example, in the macroscopic world, this scheme could be used

to deliver power to robots and/or computers in a factory room, or electric buses on a highway (source-cavity would in this case be a "pipe" running above the highway)." The detailed portion of the original specification goes on to describe the basic embodiment of invention involving only a single source resonator coupled to a power supply and a single device resonator coupled to an energy drain. See, e.g., paragraphs [0035]-[0039] and FIG. 1. However, a person of skill in the art would have understood the specification as disclosing that this can be generalized to multiple devices based on the express guidance in paragraphs [0034] and [0063] as described above. Finally, the original specification repeatedly emphasizes the importance of using high-Q resonators to facilitate the wireless energy transfer. See, e.g., paragraph [0036] which states: "Therefore, the invention requires resonant modes of high $Q=\omega/(2\Gamma)$ for low intrinsic-loss rates $\Gamma_{1,2}$..."

Drawings

The specification has been amended and new drawings submitted to address the drawing objection. Specifically, new FIG. 8 shows the second and third high-Q resonators claimed. In addition, new FIG. 7 shows the feedback mechanism referred to in dependent claims 22 and 44. The feedback mechanism is described in at least original paragraph [0052] and the source resonator wirelessly transferring energy to multiple device resonators is described in at least original paragraphs [0034] – [0036] and [0063].

Section 103 Rejections

The action rejects claims 1-21, 23-43, and 45-48 as allegedly obvious over U.S. Patent Publication No. 2005/0151511 ("Chary") in view of U.S. Patent Publication No. 2005/0288741 ("Hassler"). Specifically, the action states:

> 12. Chary teaches the basic configuration of a source of wireless power transfer (18,22) and at least two loads (24a,b) some of which are wireless phones. The devices are located at different variable distances from the source. The source is a power supply [0021] and the devices have drains (batteries are charged). What is missing is the use of "high-Q" resonators. Hassler shows the use of resonant

circuits at the primary and secondary (see Figures 1-3). The primary is "high-Q" [0032] greater than 100, and the secondary is a lower Q of 10-15 [0033], but can be more [0029]. High-Q allows for a high power level at a narrow range of frequencies centered on a resonant frequency [0031].

13. Therefore it would have been obvious to one having ordinary skill in the art at the time that the invention was made to modify the system of Chary by the teachings of Hassler in order to be able allows for a high power level at a narrow range of frequencies centered on a resonant frequency. While the device Q has been described to be lower per Hassler (under 100), it is clear from [0029] that it can be higher (and thus over 100, like the primary), if the ability to have a broader bandwidth is not desired. As the resonant frequency is discussed in Hassler, it is clear that one has to tune the resonant circuits, and thus "tunable" is clearly met. As Chary has shown the device to be movable, the transmission range is also variable, and the range being a function of the relative strength of the source and efficiency of the power transfer. As power efficiency is a desirable feature and the goal of standard design practice, the exact efficiency and wireless transfer rates to compensate for intrinsic losses are routine parameters taken into account for any type of power transfer system, and is obvious subject matter representing the application of routine and ordinary skill in the art, absent a showing of unexpected results or a unique technical feature. Hassler teaches it is known to operate at higher frequencies up to 30MHz [0012]. Likewise, an increased ratio of useful to lost power is a function of overall efficiency, and thus to design an efficient system is a routine goal. The claims do not specify a particular arrangement, only a broadly worded "configured to". Also, as noted above the ability to adjustably tune is needed in order to achieve the desired Q and resonant frequency. Finally, Hassler teaches different coil sizes [0032-33]. The above is applicable to method claims, as the system described will perform the method steps when operating.

We traverse.

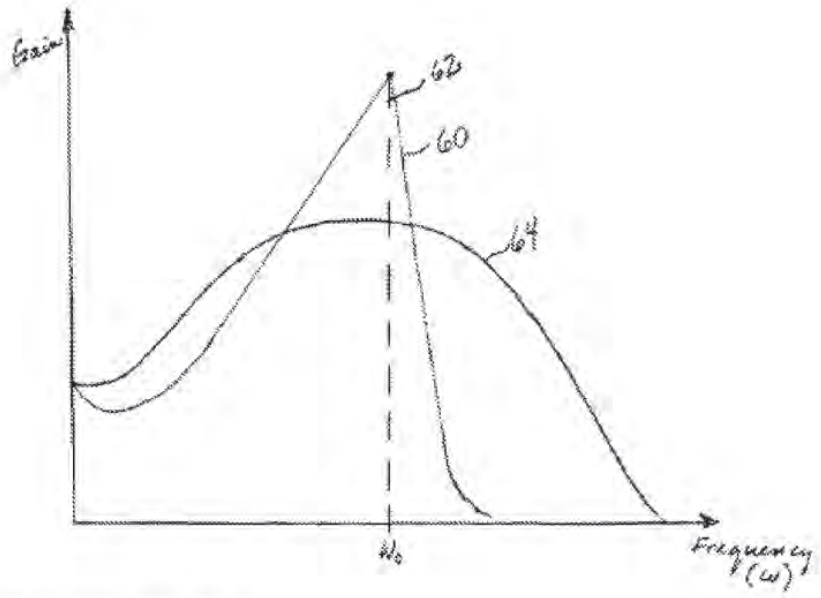
First, the Action is wrong when it says that Hassler teaches primary and secondary resonant circuits that are each high-Q. The prior art combination proposed in the Action, even if permissible, does not disclose multiple resonators, each of which is "capable of storing electromagnetic energy with a high intrinsic quality factor," as claimed in amended independent claims 1 and 2. Indeed, an important aspect the present invention is the recognition that wireless energy transfer is possible over a range of distances, even for resonators that are moving freely relative to one another, when each resonator satisfies this limitation. (See, e.g., paragraphs [0034]-[0036] from the original specification.)

Hassler expressly teaches away from this requirement by emphasizing a *low-Q* secondary resonant circuit. For example, Hassler states:

> "*Secondary resonant circuit 34 is tuned to have a lower Q* ..." (Hassler at [0029], emphasis added.)
>
> "Conversely, secondary resonant circuit 34 *has a significantly lower Q* than primary resonant circuit 30 ...." (Hassler at [0031], emphasis added.)
>
> "The parallel secondary coils were connected in series with a capacitance of 1.1 microFarads to create a series tuned tank circuit having *a significantly lower Q* than the primary resonant circuit. In the experimental circuit, *the secondary circuit had a Q in the range of approximately ten (10) to fifteen (15)*." (Hassler at [0033], emphasis added.)

Hassler touts the importance of this low-Q constraint for the secondary resonant circuit because it creates a broad bandwidth for the secondary resonant circuit and thereby minimizes or eliminates tuning issues. For example Hassler explains this in connection with broadband curve 64 for the secondary resonant circuit in Fig. 4 (reproduced further below):

> "FIG. 4 provides a graphical representation of the gain verses frequency response of primary resonant circuit 30 and secondary resonant circuit 34. As shown in FIG. 4, primary resonant circuit 30 is very frequency selective, as indicated by the steep curve 60, thereby producing a high Q and power level at a narrow range of frequencies centered on the resonant frequency 62. Conversely, *secondary resonant circuit 34 has a significantly lower Q than primary resonant circuit 30 and is less frequency selective as indicated by the more rounded curve 64. The broader bandwidth of secondary resonant circuit 34 desensitizes the circuit to shifts in the resonant frequency of the primary circuit 30, thus enabling the secondary resonant circuit 34 to couple with one or more different primary circuits without having to be specifically tuned to the primary circuit resonant frequency 62*." (Hassler at [0031], emphasis added)



(Figure 4 from Hassler.)

It is true that Hassler makes a single passing remark at the end of paragraph [0029] that "… a higher Q may be used." But when read in context, it does not disclose what is claimed. The full sentence from paragraph [0029] in Hassler states:

> Secondary resonant circuit 34 *is tuned to have a lower Q* and broader bandwidth than primary resonant circuit 30 *in order to couple with a broader range of resonant frequencies, and eliminate the need to individually tune the secondary resonant circuit to a particular primary resonant circuit*, although it should be appreciated that a higher Q may be used. (Hassler at [0029], emphasis added).

Thus, this sentence, like the others cited above from Hassler, again emphasizes that the secondary resonant circuit should have a *low Q*, not a high-Q. The single, passing remark at the end of this passage cannot be fairly interpreted to disclose a Q of over 100 for both the primary and secondary resonant circuits as suggested in the Action. Such an interpretation is contrary to the repeated emphasis in both Hassler that the Q of the secondary resonant circuit is low to thereby couple with a broader range of resonant frequencies.

Moreover, this passing remark simply says a "higher Q", it does not say a Q greater than 100. To the contrary, the only fair interpretation here is that the word "higher" in this statement is relative to the Q otherwise set forth for the secondary resonant circuit in Hassler A, which is "in the range of approximately ten (10) to fifteen (15)", as cited above. Thus, the Q for the secondary circuit might be higher than approximately 10 to 15, but it should still nonetheless be "low", and certainly not as high as 100 or more, for example, as expressly recited in dependent claims 7, 11, 29, and 33. Indeed, this is the only interpretation that is consistent with the repeated emphasis in Hassler to have a broad bandwidth for the secondary resonant circuit.

Finally, even if one were to interpret this single passing statement as disclosing a high Q for the secondary resonant circuit, there is nothing in this passage the teaches *simultaneously* maintaining a high-Q for the primary resonant circuit, so that *both* circuits are high-Q. To the contrary, what would be fairly taught under this interpretation is that the Q of the secondary resonant circuit could be made high, but only if the Q of the primary resonant circuit is made low. This is the only way to maintain the broad resonance condition repeatedly emphasized in Hassler.

In sum, Hassler does not teach or suggest *both* resonant circuits being high-Q, nor does it teach or suggest the more specific numerical limits for the high Qs set forth in dependent claims 7, 11, 29, and 33.

Second, even if, for the sake of argument only, one were to interpret this passing remark in Hassler as disclosing both resonant circuits being high-Q, which we dispute, the abundant additional disclosure in Hassler discussed above emphasizing a broad bandwidth (and therefore a low-Q) for the secondary resonant circuit plainly teaches away from modifying Chary to include high-Q resonators as proposed in the Action. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." In re Gurley, 27 F.3d 551, 553 (Fed.Cir.1994). See also, KSR Int'l Co. v. Teleflex, Inc., 127 S.Ct. 1727, 1739-40 (2007) (explaining that when the prior art teaches away from a combination, that combination is more likely to be nonobvious).

Moreover, there is no recognition in Hassler (or Chary) of the unexpected benefits that accrue from the use of multiple high-Q resonators for wireless energy transfer over a range of distances, such as enabling highly efficient wireless energy transfer to multiple devices over a range of distances, without constraining the position and/or orientations of the resonators. This is yet another reason why the obviousness rejection should be withdrawn. See KSR, 127 S.Ct. at 1740 (explaining that elements working together in an unexpected and fruitful manner support the conclusion of nonobviousness). Indeed, as explained further below, the non-obviousness of this recognition is confirmed by the abundant acclaim the inventors have received for this invention in both the academic and popular press.

Finally, not only is Chary "missing … the use of '*high-Q*' resonators," but Chary is missing the use of multiple resonators all together. *Each* of the three resonators claimed in independent claims 1 and 2 has a resonant frequency, an intrinsic loss rate, and is capable of storing electromagnetic energy. Chary does not disclose this. To the contrary, Chary simply describes conventional inductive coupling with coils:

> [0024] Turning now to FIGS. 4 and 5, it can be seen that the charge transfer interface may be implemented in a number of different ways. For example, one approach is to equip a computer system 26' with an inductive coupling charge transmitter 23 in order to transfer power to receiving devices 27 (27a-27d). The inductive coupling charge transmitter 23 can therefore be readily substituted for the charge transfer interface 22 (FIG. 2) already discussed. While the illustrated charge transmitter 23 is shown as being coupled to a lid of the computer system 26', other physical arrangements can be used without parting from the spirit and scope of the embodiments of the invention. *Inductive coupling battery charging, which is a well understood technique, uses a coil located in the source device as a first winding of a transformer and a coil located in the receiving device as a second winding of the transformer. The result is a contactless transfer of power between the two devices when they are brought in proximity to one another and a current is applied to one of the windings*. (Chary at [0024], emphasis added).

While Hassler discloses primary and secondary resonant circuits, there is nothing in the Action to explain why it would have been obvious to modify each of the source coil and two load coils in Chary to be a resonant circuit as in Hassler, let alone a high-Q resonant circuit. "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements;

instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness". KSR, 127 S.Ct. at 1741, citing In re Kahn, 441 F.3d 977, 988 (Fed. Cir. 2006).

To the contrary, the applications in Chary and Hassler are quite different from one another and motivate away from any such substitution. For example, Chary is directed to providing power to multiple consumer electronic devices, such as a computer 12a, personal digital assistant (PDA) 12b, wireless phone 12c, and wireless headset 12d, all of which are not generally constrained relative to one another. On the other hand, Hassler is directed to a transcutaneous energy transfer system in which a single load is rigidly secured internal to a patient's body and receives energy from a primary circuit located immediately external the patient's body. (See, e.g., Hassler at [0008]-[0010]).

Accordingly, for at least the above reasons, we ask the Examiner to withdraw the obviousness rejection of independent claims 1 and 2.

Dependent claims

We submit that each dependent claim distinguishes the cited prior art for at least the same reasons as those set forth above with respect to the independent claims from which the dependent claims depend. Nonetheless, we provide further reasons below as to why certain dependent claims distinguish the cited prior art.

Dependent claims 7, 11, 29, and 33 recite specific lower limits for the values of the high intrinsic quality factors Q_1 and Q_2 for the source resonator and the second resonator. As explained above, Hassler does not disclose *both* resonant circuits being high-Q, let alone that $Q_1 > 100$ and $Q_2 > 100$, as required by these claims.

Claims 12 and 34 each recite "wherein at least one of the resonators is tunable." The Action states that: "As the resonant frequency is discussed in Hassler, it is clear that one has to tune the resonant circuits, and thus 'tunable' is clearly met." We disagree.

The fact that a resonant circuit has a resonant frequency does not mean that the resonant circuit is tunable. To the contrary, the resonant frequency of the resonant circuit is generally

fixed by the structure of the circuit. What is claimed in dependent claims 12 and 34 requires at least one the resonators to be tunable, i.e., have a resonant frequency that can be adjusted. For example, the specification at paragraph [0063] explains how a feedback mechanism can make "small changes in [the] geometry" of the device resonator to adjust its resonate frequency. The Action points to nothing in Hassler to describe such a tunable resonator.

Claims 21, 43, 49, and 50 each set a lower limit of 5 MHz for the absolute value of the resonant frequencies for the source resonator and the second resonator, $f_1 = \omega_1 / (2\pi)$ and $f_2 = \omega_2 / (2\pi)$, respectively. In rejecting dependent claims 21 and 43, the action states that: "Hassler teaches it is known to operate at higher frequencies up to 30 MHz." But this is plainly insufficient, as Hassler expressly teaches away from operating at such frequencies, and so it would not have been obvious to modify the specific resonant circuits in Hassler to operate above 5 MHz and to further implement them in Chary.

For example, Hassler states:

> "In order to transfer sufficient power to the secondary coil of the TET system to operate an implant, TET systems have typically operated at frequencies from 100 kHz to upwards of 30 MHz. At these higher frequency levels, the alternating electromagnetic field that the primary coil generates couples not only to the secondary coil, but also to any metallic objects near it, including a metallic implant case. This parasitic coupling produces eddy currents in the implant case. *These eddy currents reduce the amount of effective power transferred to the secondary coil, thereby increasing the amount of power required from the primary coil to drive the implant. In addition, the eddy currents can cause heating of the metallic case.* Heating a metallic implant case by more than 2° Celsius above normal body temperature can have derogatory effects on the implant recipient." (Hassler A at [0012], emphasis added)

> "The invention overcomes the above-noted and other deficiencies of the prior art *by providing a transcutaneous energy transfer (TET) system that advantageously transmits between 1 to 100 kHz*, thereby achieving an electromagnetic pattern that may more efficiently penetrate a physical boundary such as a metallic case of an implant or human tissue, without excessive power loss due to eddy currents, thereby avoiding heating." (Hassler A at [0016], emphasis added)

Moreover, it is improper for the Action to combine the high-frequency limitation from the background of Hassler with the other, contradictory aspects of Hassler's TET system that

allegedly use high-Q resonant circuits in order to supply what is certainly missing from Chary. *Net MoneyIN, Inc. v. Verisign, Inc.,* 545 F.3d 1359, 1369 (Fed. Cir. 2008), *citing Connell v. Sears Roebuck & Co.,* 722 F.2d 1542, 1548 (Fed. Cir. 1983)("[T]he prior art reference – in order to anticipate under 35 U.S.C. § 102 – must not only disclose all elements of the claim within the four corners of the document, but must also disclosed those elements 'arranged as in the claims'").

Dependent claims 22 and 44 have been amended to more specifically recite that "a feedback mechanism is coupled to at least one of the resonators to correct for detuning of the resonant frequencies." The action rejected these claims allegedly obvious over the combination of Chary and Hassler, further in view of US 5,455,467 ("Young") as follows:

> "Claims 22 and 44 add a feedback mechanism to correct for detuning. Note that Chary does teach a feedback mechanism for the amount of power needed. In the same field of endeavor, Young teaches it is known to compensate for a "detuning" in the form of decreased power transfer due to improper alignment. See for example Figure 7. Therefore it would have been obvious to one having ordinary skill in the art at the time that the invention was made to modify the combined teachings of Chary and Hassler by the teachings of Young to be able to compensate for a "detuning" due to misalignment and to correct such by adjusting the power transferred. The type of detuning is not specified in the claims, and thus a power transfer that is not as designed is a detuning to the extent claimed." (Action at p. 7).

We traverse for several reasons.

First, as presently amended, the dependent claims are specifically directed to "detuning of the resonant frequencies." Therefore, even if the Examiner were correct to construe the claims as broadly as was done in the section of the Action cited above, the present amendment should moot the rejection.

Second, even if Young were to disclose the feedback mechanism claimed, Hassler would teach away from any modification of the resonant circuits in the Hassler TET system because Hassler specifically touts a broad bandwidth for the second resonator to *avoid* tuning. For example, as explained above, Hassler states:

> "The broader bandwidth of secondary resonant circuit 34 desensitizes the circuit to shifts in the resonant frequency of the primary circuit 30, thus enabling the

secondary resonant circuit 34 to couple with one or more different primary circuits *without having to be specifically tuned to the primary circuit resonant frequency 62*." (Hassler at [0031], emphasis added.)

For at least the above reasons, we ask the Examiner to withdraw the obviousness rejection based on Chary, Hassler, and Young.

Secondary Considerations

As noted above, Applicants' invention has received abundant acclaim in both academic and popular press. We respectively submit that such documents are evidence of the non-obviousness of the claimed invention. A list of these documents is provided below, including in which Information Disclosure Statement ("IDS") they were submitted.

Andre Kurs et al., "Wireless Power Transfer via Strongly Coupled Magnetic Resonances", Science Vol. 317, pp. 83-86 (July 6, 2007) **(Desig. ID No. 201 – IDS filed on 4/23/10)**

"Physics Promises Wireless Power" by Jonathan Fildes, Science and Technology Reporter, BBC News, (November 15, 2006) **(Desig. ID No. 241 – IDS filed on 4/23/10)**

"Intel CTO Says Gap between Humans, Machines Will Close by 2050", Intel News Release, (See intel.com/.../20080821comp.htm?iid=S...) (Printed 11/6/2009) **(Desig. ID No. 195 – IDS filed on 4/23/10)**

"Intel Moves to Free Gadgets of Their Recharging Cords", By John Markoff, The New York Times - nytimes.com, August 21, 2008 **(Desig. ID No. 267 – IDS filed on 4/23/10)**

"Man tries wirelessly boosting batteries", by Seth Borenstein, AP Science Writer, Boston.com, (See http://www.boston.com/business/technology/articles/2006/11/15/man_tries_wirelessly_b...) (November 15, 2006) **(Desig. ID No. 245 – IDS filed on 4/23/10)**

"MIT Scientists Pave the Way For Wireless Battery Charging", by William M. Bulkeley, The Wall Street Journal, (See http://online.wsj.com/article/SB118123955549228045.html?mod=googlenews_wsj) (June 8, 2007) **(Desig. ID No. 265 – IDS filed on 4/23/10)**

"Automatic Recharging, From a Distance" by Anne Eisenberg, The New York Times, (see www.nytimes.com/2012/03/11/business/built-in-wireless-chargeing-for-electronic-devices.html?_r=0) (published on March 10, 2012) **(To be filed in an IDS with the present response)**

"How Wireless Charging Will Make Life Simpler (And Greener)" by David Ferris, Forbes (See forbes.com/sites/davidferris/2012/07/24/how-wireless-charging-will-make-life-simpler-and-greener/print/) (dated 7/24/2012) **(To be filed in an IDS with the present response)**

"Wireless charging – the future for electric cars?" by Katia Moskvitch, BBC News Technology (See www.bbc.co.uk/news/technology-14183409) (dated July 21, 2011) **(To be filed in an IDS with the present response)**

"Next Little Thing 2010 Electricity without wires", CNN Money (See money.cnn.com/galleries/2009/smallbusiness/0911/gallery.next_little_thing_2010.smb/) (dated November 30, 2009) **(To be filed in an IDS with the present response)**

Conclusion

In view of the above, we ask that the application be allowed.

Canceled claims, if any, have been canceled without prejudice or disclaimer. Any circumstance in which we have: (a) addressed certain comments in the Action does not mean that we concede other comments in the Action; (b) made arguments for the patentability of some claims does not mean that there are not other good reasons for patentability of those claims and other claims; or (c) amended or canceled a claim does not mean that we concede any of the Action's positions with respect to that claim or other claims

The fees in the amount of $124.00 for excess claim fees and the fees in the amount of $1290.00 for the Petition for Extension of Time fee are being paid concurrently herewith on the Electronic Filing System (EFS) by way of Deposit Account authorization. Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: February 28, 2013

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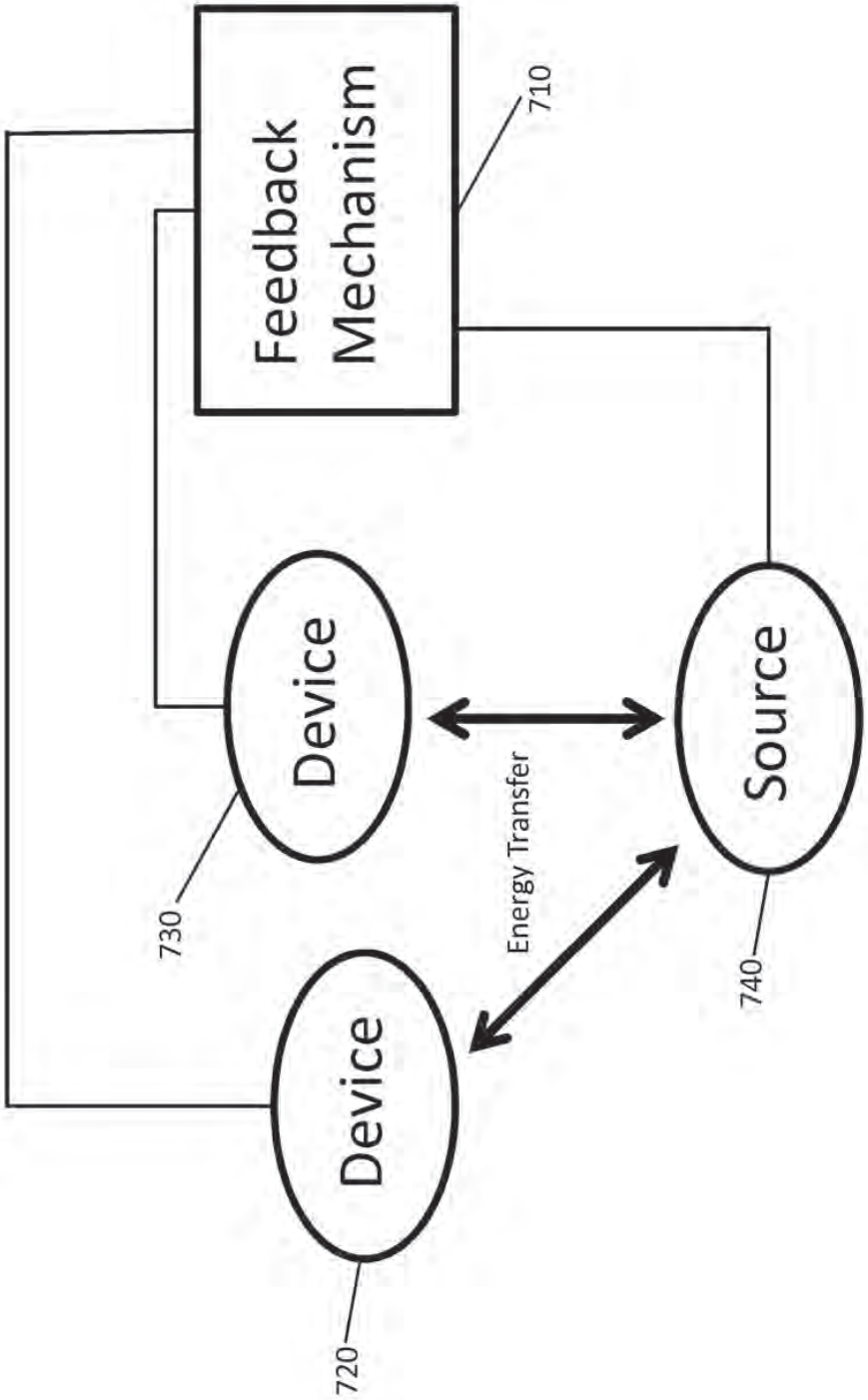

Feedback Mechanism
710
Device
730
Energy Transfer
Source
740
Device
720

FIG. 7

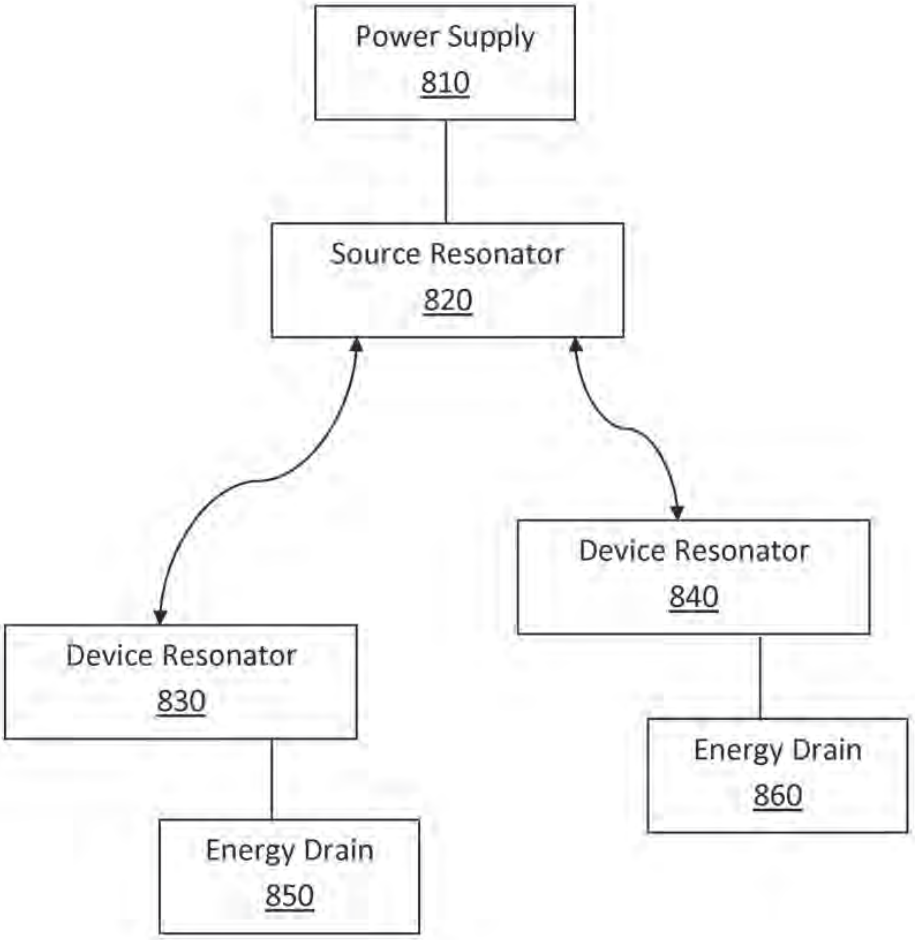

Power Supply
810
Source Resonator
820
Device Resonator
840
Device Resonator
830
Energy Drain
860
Energy Drain
850

FIG. 8

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Fritz Fleming
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

INFORMATION DISCLOSURE STATEMENT

Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

This statement is being filed after a first Office action on the merits, but before receipt of a final Office action or a Notice of Allowance. The fees in the amount of $180 in payment of the late submission fee of §1.17(p) are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 2/28/13

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22929769.doc

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	2006/0090956	5/4/2006	Peshkovskiy et al.			

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	2	102 21 484	11/27/2003	Germany	G06F	1/26	X	
	3	200 16 655	2/14/2002	Germany	H02J	17/00	X	
	4	2006-074848	3/16/2006	Japan	H02J	17/00	X	
	5	10-2007-0017804	2/13/2007	Korea	H02J	17/00	X	

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	6	"Automatic Recharging, From a Distance" by Anne Eisenberg, The New York Times, (see www.nytimes.com/2012/03/11/business/built-in-wireless-chargeing-for-electronic-devices.html?_r=0) (published on March 10, 2012)
	7	"How Wireless Charging Will Make Life Simpler (And Greener)" by David Ferris, Forbes (See forbes.com/sites/davidferris/2012/07/24/how-wireless-charging-will-make-life-simpler-and-greener/print/) (dated 7/24/2012)
	8	"Wireless charging – the future for electric cars?" by Katia Moskvitch, BBC News Technology (See www.bbc.co.uk/news/technology-14183409) (dated July 21, 2011)
	9	"Next Little Thing 2010 Electricity without wires", CNN Money (See money.cnn.com/galleries/2009/smallbusiness/0911/gallery.next_little_thing_2010.smb/) (dated November 30, 2009)
	10	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/949,544 by Examiner Fritz M. Fleming dated September 5, 2012 (41 pages)
	11	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/646,524 by Examiner Fritz M. Fleming dated October 1, 2012 (11 pages)
	12	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/415,667 by Examiner Fritz M. Fleming dated October 5, 2012 (20 pages)
	13	Copy of Final Office Action with regard to U.S. Application Serial No. 12/639,967 by Examiner Fritz M. Fleming dated October 5, 2012 (21 pages)
	14	Copy of Final Office Action with regard to U.S. Application Serial No. 12/639,966 by Examiner Fritz M. Fleming dated October 9, 2012 (20 pages)
	15	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/868,852 by Examiner Fritz M. Fleming dated October 10, 2012 (26 pages)
	16	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/649,635 by Examiner Fritz M. Fleming dated December 21, 2012 (41 pages)
	17	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/649,777 by Examiner Fritz M. Fleming dated December 24, 2012 (43 pages)

Examiner Signature	Date Considered

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form (PTO-1449)

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))	Applicant John D. Joannopoulos et al.	
	Filing Date December 16, 2009	Group Art Unit 2836

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	18	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/649,813 by Examiner Fritz M. Fleming dated December 21, 2012 (40 pages)
	19	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/649,852 by Examiner Fritz M. Fleming dated December 21, 2012 (41 pages)
	20	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/649,904 by Examiner Fritz M. Fleming dated December 28, 2012 (43 pages)

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

DERWENT-ACC-NO: 2004-036374

DERWENT-WEEK: 200404

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TITLE: Inductive coils are used to provide electrical energy for inductive coupling used to transmit data from identification tag on animal to processing unit

INVENTOR: HOLM H; LAUE H

PATENT-ASSIGNEE: HOLM H[HOLMI] , LAUE H[LAUEI]

PRIORITY-DATA: 2002DE-1021484 (May 15, 2002)

PATENT-FAMILY:

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DE 10221484 A1	November 27, 2003	DE

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
DE 10221484A1	N/A	2002DE-1021484	May 15, 2002

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TYPE	IPC DATE
CIPS	A01K11/00 20060101

ABSTRACTED-PUB-NO: DE 10221484 A1

BASIC-ABSTRACT:

NOVELTY - The stall has a watering station (18) that is used by such as a milk cow. The animal has a data memory element implanted that is read by coils (28) set into the sides of the stall. These are supplied by an ac generator (32). A sensor (34) is used to detect the presence of the cow.

USE - Monitoring of animal condition.

ADVANTAGE - Simple means of supplying energy.

DESCRIPTION OF DRAWING(S) - The figure shows a schematic of the system.

Stall (10)

Watering station (18)

Coils (28)

Generator (32)

Sensor (34)

CHOSEN-DRAWING: Dwg.1/2

TITLE-TERMS: INDUCTIVE COIL ELECTRIC ENERGY COUPLE TRANSMIT DATA IDENTIFY TAG ANIMAL PROCESS UNIT

DERWENT-CLASS: P14 T01 V02 W02 W06 X25

EPI-CODES: T01-J07A; V02-G01D; W02-G05A; W02-G05B; W06-A04B5A; X25-N02A;

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This text has been taken over by the DPMA from original sources. It contains no drawings. The representation of tables and formulas can be unsatisfactory.

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[DE] An apparatus for supplying power to a data acquisition and
Data transfer unit as well as data acquisition and transmission unit

[EN] Inductive coils are used to Ooops electrical energy for inductive coupling used to transmit data from one animal identification tag to processing unit

[DE] An apparatus for supplying power to a data acquisition and data transmission unit, the physiological data of a via sensors Farm-animal is detected and the detected data, sends a station for the livestock, the two side walls and a feeding trough, a drinking bowl or the like, each with a ring-shaped coil in each of the side walls which are aligned with each other, and with a AC voltage generator, which is connected to the coils.

[EN] The stall has a watering station (18) that is used by search as a milk cow. The animal has a data memory element implanted that is read by coils (28) set into the sides of the stall. These are supplied by an ac generator (32). A sensor (34) is used to detect the presence of the cow.

[0001] The invention relates to a device for supplying power to a data acquisition and data transmission unit. Also relates to the Invention itself, a data acquisition and transmission unit

[0002] DE 199 01 124, the applicant is a device for the controlled supply of farm animals known. A probe in the stomach / intestines the domestic animal detected physiological data of the animal, and sends the corresponding results to a supply device, for example for Concentrated feed, or they are used to control rutting and / or for general health monitoring.

[0003] WO 98/47351 is known to animals with an electronic identification device. The electronic identification device may, in addition to the measured values of an identification characteristic physiological condition of the animal to receive a recipient. The Identification means is provided as a passive component without its own energy supply. For this purpose, a transponder is in the unit provided which is excited by an electromagnetic radiation to and emits a corresponding resonant frequency identification.

[0004] In addition to the above mentioned passive devices, devices with an active power supply are known in which a quality battery's energy supply is ensured. An advantage of the active power supply is that for example, a Can take place between storage of data. It proves to be a disadvantage, however, that a battery has a limited service life and must be replaced.

[0005] The invention has the object of providing an apparatus for supplying power to a data acquisition and data transmission unit as a data collection and data transmission unit itself provide the energy supply at low cost with simple means allow.

[0006] According to the invention is achieved by a device according to claim 1 and by a data collection and data transmission unit achieved according to claim 7. The dependent claims form advantageous

embodiments of the invention.

[0007] The inventive device for power supply provides for data acquisition and data transfer unit, the electrical Energize. For data collection, the physiological data of the farm animal is detected and subsequently the acquired data are a Receiving station sent. The inventive device has a station for the livestock, the two side walls and a feed trough one, Water Bowl or the like. In each of the side walls each having an annular coil is provided, the coils on each other aligned and connected to an alternating voltage generator. Of the alternating voltage generator applies an AC voltage to the coil on, generating a first time-varying magnetic field in the space between the coils. In this manner, electromagnetic energy in the Area between the coils provided, which can serve to supply a data collection and data transmission unit. Particularly advantage of the inventive device, is that the power supply takes place during the food or water consumption of the farm animal.

[0008] In a preferred embodiment, the station is provided with a stay sensor detecting one animal in the station, and Initiates charging signal for controlling the charging process. During charging, the generator produces the AC voltage and the Coil pair radiates from the time varying magnetic field.

[0009] To the charging only then to carry out when it is required, the sensor can be configured in such a stay that detects is that animal is located in the station. The control of the charging process will then check how long the last load operation for the detected Utilization lags and solves one of charging only when the last charging place more than a predetermined time period.

[0010] In a preferred embodiment, the coils have the same diameter of preferably about 1 m, wherein the coils one Distance of about 0.8 m have. The distance corresponds to the distance of the walls in the station. The coils are coplanar, wherein the center has the same distance from the bottom of the station. The pair of coils produced in his space an approximately homogeneous Magnetic field, similar to a helmet wooden spools pair.

[0011] According to the invention, the object is also achieved by a data collection and data transmission unit, the sensors detecting physiological data of the domestic animal, and send the detected data. The data acquisition and data transfer unit is connected to a provided or a plurality of coils, a rectifier and a storage device for electrical energy, wherein the memory means all or partially providing the energy required for the sensors and the transmission means. The coil (s) is (are) electrically connected to the rectifier conductively connected to an AC induced voltage is rectified forwarded to the memory means. Can as a storage device for example, a capacitor or a rechargeable battery can be provided.

[0012] In order to ensure a good position in any energy consumption, are a plurality of coils around a cuboid or cube-shaped base body wound. Preferred as the main body, a cube made of ferrite material is

provided.

[0013] The invention is explained in more detail by way of example. It shows:

[0014] Figure 1 is a charging station and

[0015] FIG. 2 a bolus in a schematic view

[0016] Figure 1 below refers to a drinking water for dairy cows. In a so playpen, the cows kept free running and enter daily recurring a water drinker. Automatic water trough is known from the publication DE 100 57 989 known. As an alternative to the automatic water drinking device of the invention may also be in a polling station for concentrates, a Parlor or another visited periodically place the livestock be provided.

[0017] The water station 10 consists of a tubular construction with plastic sheets 12, 14, 16, which close the water station on three sides. Head side in the feeding station a drinking bowl with an inlet 20 and an outlet 22 is provided. For a better overview in Figure 1 is an imaginary opening 26 shown by the wall 12.

[0018] In the side walls 12 and 14, respectively, a coil 28 is provided and 30. The coils 28 and 30 are fed by a generator 32. A presence sensor 34 detects whether the cow has entered the potions.

[0019] data acquisition and transmission units can be designed for farm animals in different ways. It is, for example, possible to use this set as an implant under the skin or placed on a so-called bolus in the gastrointestinal tract. It is particularly preferred in Ruminants to place these in the rumen, where they can remain without problems for the animal for many years. This so-called rumen bolus
the animal is entered through the throat, and since it is not digested in the contrast to the feed, it will remain in the front part of the rumen. Shall such a rumen bolus operated with a high-quality battery, so it works only for a few months, at most a few years guaranteed. Since cows but certainly over 10 years' standing in milk "may be the power supply of a rumen bolus through a battery insufficient.

[0020] Figure 2 shows the schematic structure of a rumen bolus in a block diagram. The rumen bolus receives its power via three Coils 34 to 38, wherein the coil 34 is arranged in an XY plane, coil 36 in a YZ-plane and the coil 38 in the XZ plane. With this relative orientation of the three coils to each other it is ensured that, regardless of the spatial orientation of the rumen bolus relative to the pair of coils 28 and 30 through the coil, a magnetic flux is present. In the coil induces the time-varying magnetic field AC voltage, which is converted via a rectifier to a DC voltage. The thus obtained direct current is to an accumulator 42 and / or capacitors as storage unit for the electrical energy to. The accumulator 42 feeds the sensors shown schematically 44 to 48, which measure, for example, pressure, temperature, electrical conductivity, and pH. The measured data to a Microprocessor 50 transmitted from which the corresponding measured data are forwarded to a reclaimed transmission device 52.

First

Apparatus for supplying power to a data acquisition and data transmission unit, the physiological data of a via sensors Domestic animal is detected and the detected data sent with, - a station (10) for livestock, the two side walls (12, 14) and a feed trough one, Drinking bowl (18) or the like, - in each case an annular coil (28, 30) in each of the side walls, the aligned, and - an AC generator (32) which is connected to the coils.

Second

Apparatus according to claim 1, characterized in that, in the sensor station, a stay (34) is provided which detects a farm animal in the station and a load signal for a control of the Charging triggers.

Third

Apparatus according to claim 2, characterized in that the sensor detects stay which animal in the Station is located, and the controller checks the charging process, as long as the last load operation for the detected animal is returned and a Charging triggers when the last load operation dates back more than a predetermined period.

4th

Device according to one of claims 1 to 3, characterized in that the coils have the same diameter of preferably about 1 m.

5th

Apparatus according to claim 4, characterized in that the coils are at a distance of about 0.8 m.

6th

Device according to one of claims 1 to 5, characterized in that the coils are arranged co-planar and their centers have the same distance from the ground.

7th

Data acquisition and Data transmission unit, which sensors detects physiological data of the livestock animal and transmits the detected data with, - one or more Coils, a rectifier and a storage device for electrical energy, the whole or part of the energy necessary for the sensors and the transmitting means provides, - wherein the coil (s) is (34, 36, 38) connected to a rectifier (40) is electrically conductive / are a induced alternating voltage is rectified to be applied to the storage device (42).

8th

Data acquisition and data transfer unit according To claim 7, characterized in that a plurality of coils are wound around a cuboid or cube-shaped base body.

9th

Data acquisition and Data transmission unit according to claim 8, characterized in that the base body is formed as a cube, and three pairs of vertically each stationary coils.

10th

Data acquisition and data transfer unit according to claim 8 or 9, characterized in that the basic body consists of a ferrite material.

11th

Data acquisition and data transfer unit according to any one of claims 7 to 10, characterized in that it is formed as a bolus, in particular a ruminal bolus

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Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Vorrichtung zur Energieversorgung einer Datenerfassungs- und Datenübertragungseinheit sowie Datenerfassungs- und Übertragungseinheit

(57) Vorrichtung zur Energieversorgung einer Datenerfassungs- und Datenübertragungseinheit, die über Sensoren physiologische Daten eines Nutztiers erfaßt und die erfaßten Daten sendet, mit einer Station für das Nutztier, die zwei Seitenwände und einen Futtertrog, ein Tränkebecken oder dergleichen aufweist, mit jeweils einer ringförmigen Spule in jeder der Seitenwände, die aufeinander ausgerichtet sind, und mit einem Wechselspannungsgenerator, der an die Spulen angeschlossen ist.

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Beschreibung

[0001] Die Erfindung betrifft eine Vorrichtung zur Energieversorgung einer Datenerfassungs- und Datenübertragungseinheit. Ebenfalls betrifft die Erfindung eine Datenerfassungs- und Datenübertragungseinheit selbst.

[0002] Aus DE 199 01 124 der Anmelder ist eine Vorrichtung zur gesteuerten Versorgung von Nutztieren bekannt. Eine Sonde im Magen-/Darmkanal des Nutztieres erfaßt physiologische Daten des Tieres und sendet entsprechende Ergebnisse an eine Versorgungseinrichtung, beispielsweise für Kraftfutter, oder diese werden zur Brunftkontrolle und/oder zur allgemeinen Gesundheitsüberwachung eingesetzt.

[0003] Aus WO 98/47351 ist bekannt, Nutztiere mit einem elektronischen Identifikationsgerät zu versehen. Das elektronische Identifikationsgerät kann neben einem Identifikationsmerkmal Meßgrößen zum physiologischen Zustand des Tieres an einen Empfänger senden. Die Identifikationseinrichtung ist als ein passives Bauelement ohne eigene Energieversorgung ausgestattet. Hierzu ist ein Transponder in dem Gerät vorgesehen, der durch eine elektromagnetische Strahlung zur Resonanz angeregt wird und mit einer entsprechenden Identifikationsfrequenz abstrahlt.

[0004] Neben den oben genannten passiven Geräten sind auch Geräte mit einer aktiven Energieversorgung bekannt, bei denen über eine hochwertige Batterie die Energieversorgung sichergestellt wird. Vorteilhaft an der aktiven Energieversorgung ist, daß beispielsweise eine Zwischenspeicherung von Daten erfolgen kann. Als nachteilig erweist es sich jedoch, daß eine Batterie nur eine begrenzte Lebensdauer hat und ausgetauscht werden muß.

[0005] Der Erfindung liegt die Aufgabe zugrunde, eine Vorrichtung zur Energieversorgung einer Datenerfassungs- und Datenübertragungseinheit wie eine Datenerfassungs- und Datenübertragungseinheit selbst bereitzustellen, die bei geringem Aufwand mit einfachen Mitteln eine Energieversorgung ermöglichen.

[0006] Erfindungsgemäß wird die Aufgabe durch eine Vorrichtung nach Anspruch 1 und durch eine Datenerfassungs- und Datenübertragungseinheit nach Anspruch 7 gelöst. Die Unteransprüche bilden vorteilhafte Ausgestaltungen der Erfindung.

[0007] Die erfindungsgemäße Vorrichtung zur Energieversorgung stellt für eine Datenerfassungs- und Datenübertragungseinheit die elektrische Energie bereit. Bei der Datenerfassung werden die physiologischen Daten des Nutztieres erfaßt und nachfolgend werden die erfaßten Daten an eine Empfangsstation gesendet. Die erfindungsgemäße Vorrichtung besitzt eine Station für das Nutztier, die zwei Seitenwände und einen Futtertrog, ein Tränkebecken oder dergleichen aufweist. In jeder der Seitenwände ist jeweils eine ringförmige Spule vorgesehen, wobei die Spulen aufeinander ausgerichtet und mit einem Wechselspannungsgenerator verbunden sind. Der Wechselspannungsgenerator legt eine Wechselspannung an die Spulen an, die ein sich zeitlich änderndes Magnetfeld im Raum zwischen den Spulen erzeugen. Auf diese Weise wird elektromagnetische Energie in dem Bereich zwischen den Spulen bereitgestellt, die zur Versorgung einer Datenerfassungs- und Datenübertragungseinheit dienen kann. Als besonders vorteilhaft an der erfindungsgemäßen Vorrichtung ist, daß die Energieversorgung während der Futter- oder Wasseraufnahme des Nutztieres stattfindet.

[0008] In einer bevorzugten Ausgestaltung ist die Station mit einem Aufenthaltssensor versehen, der ein Nutztier in der Station erfaßt und ein Ladesignal für eine Steuerung des Ladevorgangs auslöst. Während des Ladevorgangs erzeugt der Generator die Wechselspannung und das Spulenpaar

strahlt das zeitlich veränderliche Magnetfeld ab.

[0009] Um den Ladevorgang lediglich dann durchzuführen, wenn dieser erforderlich ist, kann der Aufenthaltssensor so ausgestaltet sein, daß erfaßt wird, welches Nutztier sich in der Station befindet. Die Steuerung des Ladevorgangs überprüft dann, wie lange der letzte Ladevorgang für das erfaßte Nutztier zurückliegt und löst einen Ladevorgang nur dann aus, wenn der letzte Ladevorgang mehr als eine vorbestimmte Zeitdauer zurückliegt.

[0010] In einer bevorzugten Ausgestaltung besitzen die Spulen den gleichen Durchmesser von vorzugsweise ungefähr 1 m, wobei die Spulen einen Abstand von ungefähr 0,8 m besitzen. Der Abstand entspricht dem Abstand der Wände in der Station. Die Spulen sind koplanar angeordnet, wobei der Mittelpunkt den gleichen Abstand vom Boden der Station aufweist. Das Spulenpaar erzeugt in seinem Zwischenraum ein annähernd homogenes Magnetfeld, ähnlich dem eines Helmholzspulenpaars.

[0011] Erfindungsgemäß wird die Aufgabe ebenfalls durch eine Datenerfassungs- und Datenübertragungseinheit gelöst, die über Sensoren physiologische Daten des Nutztieres erfassen und die erfaßten Daten senden. Die Datenerfassungs- und Datenübertragungseinheit ist mit einer oder mehreren Spulen, einem Gleichrichter und einer Speichereinrichtung für elektrische Energie versehen, wobei die Speichereinrichtung ganz oder teilweise die notwendige Energie für die Sensoren und die Sendeeinrichtung bereitstellt. Die Spule(n) ist (sind) mit dem Gleichrichter elektrisch leitend verbunden, um eine induzierte Wechselspannung gleichgerichtet an die Speichereinrichtung weiterzuleiten. Als Speichereinrichtung kann beispielsweise ein Kondensator oder ein Akkumulator vorgesehen sein.

[0012] Um in jeder Position eine gute Energieaufnahme sicherzustellen, sind mehrere Spulen um einen quader- oder würfelförmigen Grundkörper gewickelt. Bevorzugt ist als Grundkörper ein Kubus aus Ferritmaterial vorgesehen.

[0013] Die Erfindung wird nachfolgend anhand eines Ausführungsbeispiels näher erläutert. Es zeigt:

[0014] **Fig.** 1 eine Ladestation und

[0015] **Fig.** 2 einen Bolus in einer schematischen Ansicht.

[0016] **Fig.** 1 bezieht sich nachfolgend auf eine Wassertränke für Milchkühe. In einem sogenannten Laufstall werden die Kühe freilaufend gehalten und betreten täglich wiederkehrend eine Wassertränke. Eine automatische Wassertränke ist beispielsweise aus der Offenlegungsschrift DE 100 57 989 bekannt. Alternativ zu der automatischen Wassertränke könnte die erfindungsgemäße Vorrichtung auch in einer Abrufstation für Kraftfutter, einem Melkstand oder einem anderen in regelmäßigen Abständen besuchten Ort für das Nutztier vorgesehen sein.

[0017] Die Wasserstation **10** besteht aus einer Rohrkonstruktion mit Kunststoffplatten **12**, **14**, **16**, die die Wasserstation dreiseitig abschließen. Kopfseitig in der Tränkestation ist ein Tränkebecken mit einer Zuleitung **20** und einer Ableitung **22** vorgesehen. Zur besseren Übersicht ist in **Fig.** 1 ein gedachter Durchbruch **26** durch die Wand **12** dargestellt.

[0018] In den Seitenwänden **12** und **14** ist jeweils eine Spule **28** und **30** vorgesehen. Die Spulen **28** und **30** werden von einem Generator **32** gespeist. Ein Anwesenheitssensor **34** erkennt, ob die Milchkuh die Tränke betreten hat.

[0019] Datenerfassungs- und -übertragungseinheiten können für Nutztiere in unterschiedlicher Form ausgebildet sein. So ist es beispielsweise möglich, diese als Implantat unter die Haut zu setzen oder als sogenannter Bolus im Magen-/Darmtrakt zu plazieren. Besonders bevorzugt ist es bei Wiederkäuern, diese im Pansen zu plazieren, wo sie ohne Probleme für das Tier über viele Jahre verbleiben kann. Dieser sogenannte Pansenbolus wird dem Tier über den

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Schlund eingegeben und da er im Gegensatz zum Futter nicht verdaut wird, bleibt er im vorderen Teil des Pansens. Wird ein solcher Pansenbolus mit einer hochwertigen Batterie betrieben, so ist seine Funktionsweise lediglich für einige Monate, allenfalls wenige Jahre gewährleistet. Da Kühe jedoch durchaus über 10 Jahre "in Milch stehen" können, ist die Stromversorgung eines Pansenbolus über eine Batterie unzureichend.

[0020] **Fig.** 2 zeigt den schematischen Aufbau eines Pansenbolus in einer Blockdarstellung. Der Pansenbolus empfängt seine Energie über drei Spulen **34** bis **38**, wobei die Spule **34** in einer XY-Ebene, Spule **36** in einer YZ-Ebene und Spule **38** in der XZ-Ebene angeordnet ist. Mit dieser relativen Ausrichtung der drei Spulen zueinander wird sichergestellt, daß unabhängig von der räumlichen Orientierung des Pansenbolus relativ zu dem Spulenpaar **28** und **30** durch die Spulen ein magnetischer Fluß vorhanden ist. In den Spulen induziert das zeitlich veränderliche Magnetfeld einen Wechselspannung, die über einen Gleichrichter in eine Gleichspannung umgesetzt wird. Der so gewonnene Gleichstrom liegt an einem Akkumulator **42** und/oder Kondensatoren als Speichereinheit für die elektrische Energie an. Der Akkumulator **42** speist die schematisch dargestellten Sensoren **44** bis **48**, die beispielsweise Druck, Temperatur, elektrische Leitfähigkeit und einen pH-Wert messen. Die gemessenen Daten werden an einen Mikroprozessor **50** weitergeleitet, von dem die entsprechend aufgearbeiteten Meßdaten an eine Sendeeinrichtung **52** weitergeleitet werden.

Patentansprüche

1. Vorrichtung zur Energieversorgung einer Datenerfassungs- und Datenübertragungseinheit, die über Sensoren physiologische Daten eines Nutztieres erfaßt und die erfaßten Daten sendet, mit
   - einer Station (**10**) für das Nutztier, die zwei Seitenwände (**12, 14**) und einen Futtertrog, ein Tränkebecken (**18**) oder dergleichen aufweist,
   - jeweils einer ringförmigen Spule (**28, 30**) in jeder der Seitenwände, die aufeinander ausgerichtet sind, und
   - einem Wechselspannungsgenerator (**32**), der an die Spulen angeschlossen ist.

2. Vorrichtung nach Anspruch **1**, dadurch gekennzeichnet, daß in der Station ein Aufenthaltssensor (**34**) vorgesehen ist, der ein Nutztier in der Station erfaßt und ein Ladesignal für eine Steuerung des Ladevorgangs auslöst.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß der Aufenthaltssensor erfaßt, welches Nutztier sich in der Station befindet, und die Steuerung des Ladevorgangs überprüft, wie lange der letzte Ladevorgang für das erfaßte Nutztier zurückliegt und einen Ladevorgang auslöst, wenn der letzte Ladevorgang mehr als eine vorbestimmte Dauer zurückliegt.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Spulen einen gleichen Durchmesser von vorzugsweise ungefähr 1 m besitzen.

5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Spulen einen Abstand von ungefähr 0,8 m aufweisen.

6. Vorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Spulen koplanar angeordnet sind und deren Mittelpunkte den gleichen Abstand vom Boden aufweisen.

7. Datenerfassungs- und Datenübertragungseinheit, die über Sensoren physiologische Daten des Nutztiers erfaßt und die erfaßten Daten sendet, mit
   - einer oder mehreren Spulen, einem Gleichrichter und einer Speichereinrichtung für elektrische Energie, die ganz oder teilweise die notwendige Energie für die Sensoren und die Sendeeinrichtung bereitstellt,
   - wobei die Spule(n) (**34, 36, 38**) mit einem Gleichrichter (**40**) elektrisch leitend verbunden ist/sind, um eine induzierte Wechselspannung gleichgerichtet an die Speichereinrichtung (**42**) anzulegen.

8. Datenerfassungs- und Datenübertragungseinheit nach Anspruch 7, dadurch gekennzeichnet, daß mehreren Spulen um einen quader- oder würfelförmigen Grundkörper gewickelt sind.

9. Datenerfassungs- und Datenübertragungseinheit nach Anspruch 8, dadurch gekennzeichnet, daß der Grundkörper als Kubus ausgebildet ist und drei paarweise senkrecht zueinander stehende Spulen aufweist.

10. Datenerfassungs- und Datenübertragungseinheit nach Anspruch 8 oder 9, dadurch gekennzeichnet, daß der Grundkörper aus einem Ferritmaterial besteht.

11. Datenerfassungs- und Datenübertragungseinheit nach einem der Ansprüche 7 bis 10, dadurch gekennzeichnet, daß diese als ein Bolus, insbesondere als ein Pansen-Bolus ausgebildet ist.

Hierzu 2 Seite(n) Zeichnungen

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Offenlegungstag: 27. November 2003

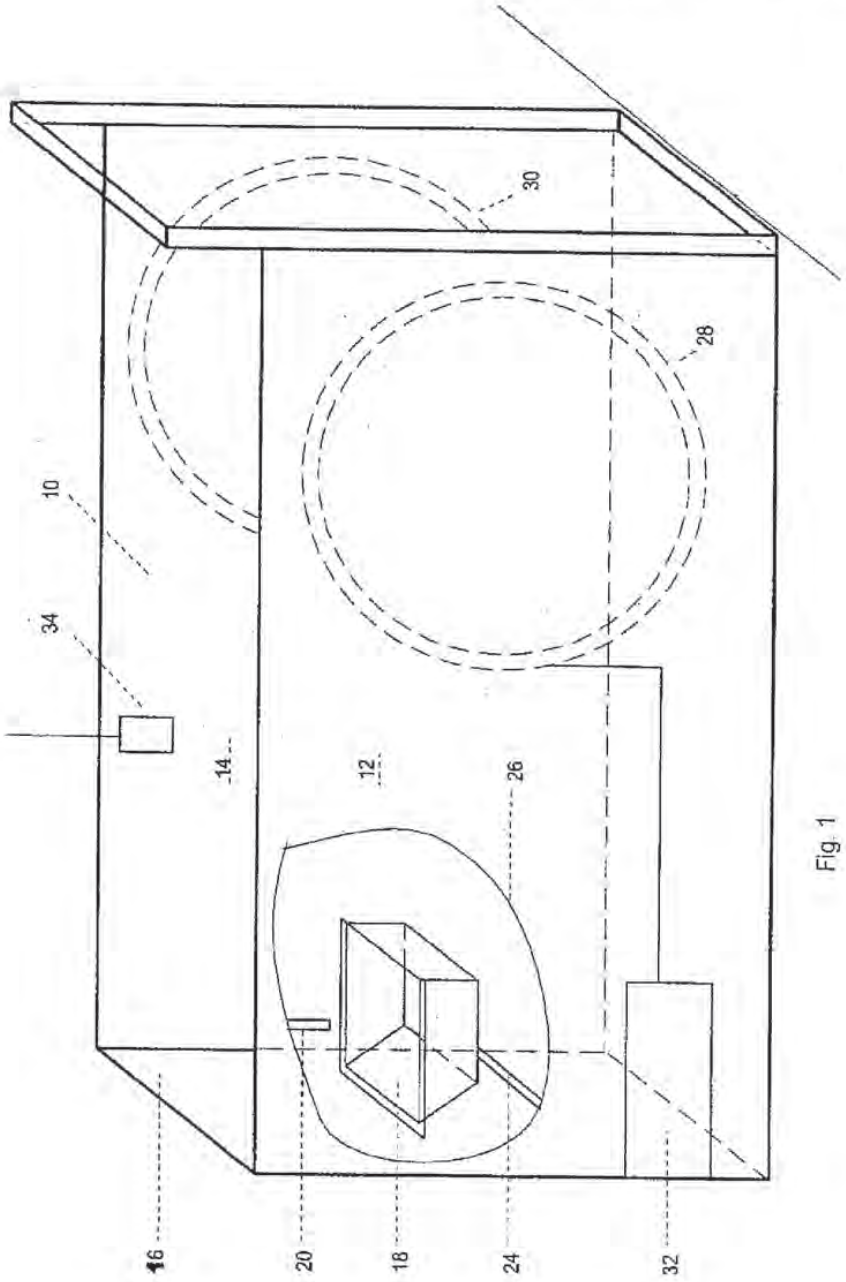


Fig. 1

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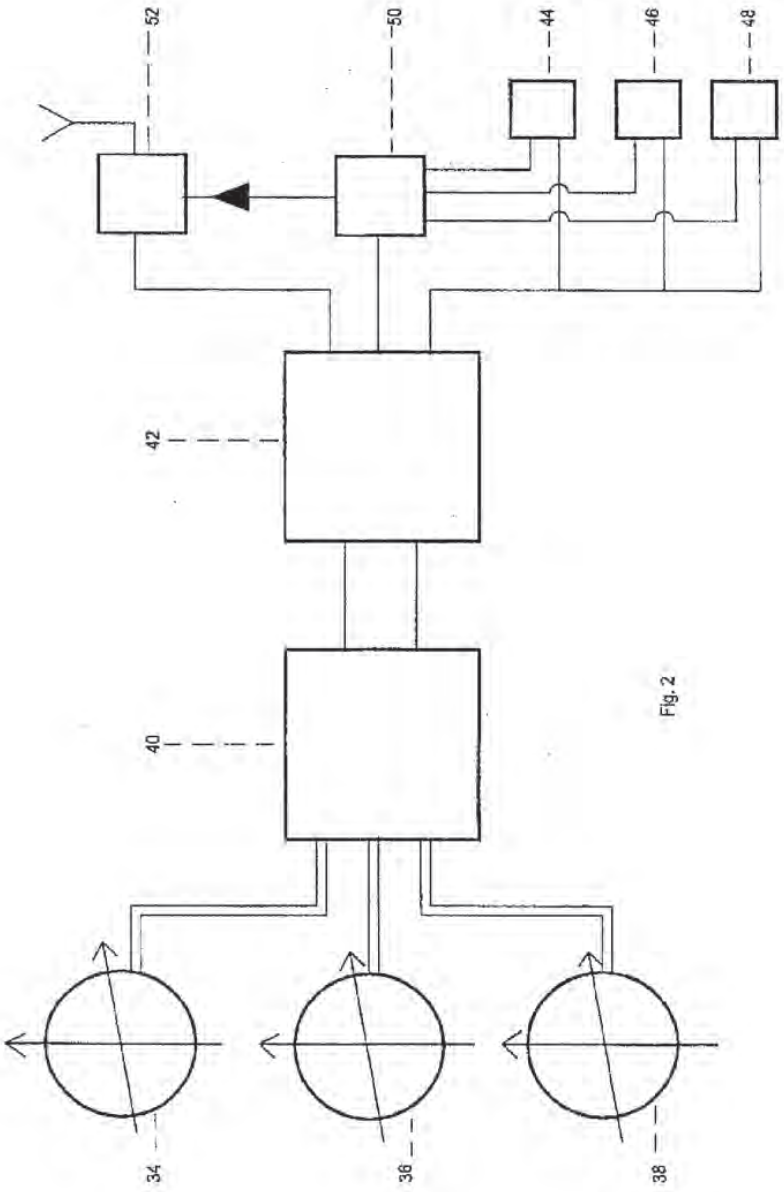


Fig. 2

103 480/413

DERWENT-ACC-NO: 2003-560319

DERWENT-WEEK: 200353

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TITLE: System for wireless energy and data transmission has detector of received energy level, regulator producing control signal for sending transmitter/receiver depending on detector signal

PATENT-ASSIGNEE: IC HAUS GMBH[ICHAN]

PRIORITY-DATA: 2000DE-2016655 (September 25, 2000)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE
DE 20016655 U1	February 14, 2002	DE

INT-CL-CURRENT:

TYPE	IPC DATE
CIPS	G08C17/02 20060101
CIPS	H02J7/02 20060101

ABSTRACTED-PUB-NO: DE 20016655 U1

BASIC-ABSTRACT:

NOVELTY - The system has a first transmitter/receiver with a regulated supply for supplying a second transmitter/receiver and a wireless data and energy transmitter with a transmitted energy receiver, a rectifier, a device for storing transmitted energy, an energy level detector, a regulator producing a control signal for the first transmitter/receiver and a transmitter for sending the signal to the first transmitter/receiver

DESCRIPTION - The system has a first transmitter/receiver (10) with a regulated supply device for supplying a second transmitter/receiver (20) and a transmitter for wireless data and energy transmission. The second transmitter/receiver has a receiver (30) for the transmitted energy, a rectifier (22), a device (24) for at least partly storing the transmitted energy, a detector (40) of the energy level, a regulator (50) for producing a control signal for the first transmitter/receiver and a transmitter (60) for sending the signal to the first transmitter/receiver. AN INDEPENDENT

CLAIM is also included for the following: a transmitter/receiver, especially an implantable transponder for use in an inventive system.

USE - For wireless energy and data transmission.

ADVANTAGE - Enables a transmitter/receiver with no batteries to be supplied with energy in a certain manner, preferably regulated as required for operation of the transmitter/receiver.

DESCRIPTION OF DRAWING(S) - The drawing shows a schematic representation of an inventive system

first transmitter/receiver (10)

second transmitter/receiver (20)

receiver (30)

rectifier (22)

device (24)

detector (40)

regulator (50)

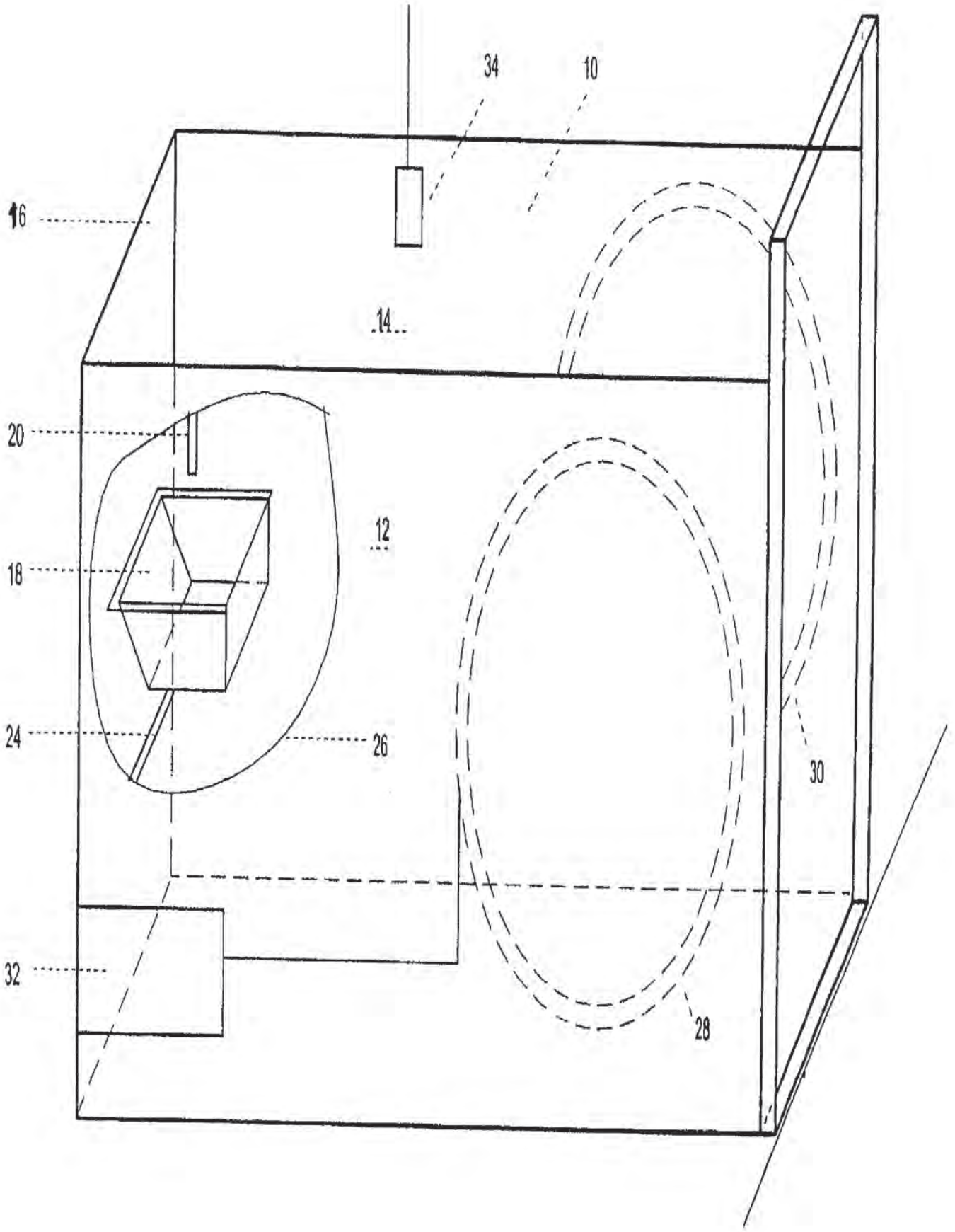
transmitter (60)

CHOSEN-DRAWING: Dwg.1/1

TITLE-TERMS: SYSTEM WIRELESS ENERGY DATA TRANSMISSION DETECT RECEIVE LEVEL REGULATE PRODUCE CONTROL SIGNAL SEND TRANSMIT DEPEND

DERWENT-CLASS: U24 W02 W05

EPI-CODES: U24-E02; W02-G05A; W05-D06A1A; W05-D07G;


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Description DE20016655

<Desc/Clms Page number 1>
EMI 1.1

EMI 1.2
Energy and data transmission, and a transmitting / receiving device for use in such a system.

Numerous transponder systems are known that consist essentially of an interrogator and an implantable, for example in a human or animal body transponder.
Known transponder can consist of multiple actuators and sensors, run the commands and identify specific data.
The collected data are then transmitted from the transponder to the interrogator and evaluated there.
Such a transponder system is described for example in DE 195 382 13th

The power supply of a transponder can be performed using a separate battery, or in case of a battery-free transponder via an externally coupled supply energy.
Such a battery-free transponder for example disclosed in EP 0 442 390th

It describes batteryless transponder has a resonant circuit which is tuned to the frequency of the transmission signal of the interrogator.
Furthermore, an energy storage is provided which is charged by the light coming from the interrogator transmitter signal rectified.
The energy storage device provides in the charged state, the supply voltage for the transponder.
Further comprising a voltage-limiting means for limiting the voltage across the energy storage device is provided at a predetermined value.
With the known device and the query batteryless transponders it is not possible to
EMI 1.3

<Desc/Clms Page number 2>

to regulate from the interrogator provided for the transponder as a function of energy supply in the transponder determined and evaluated data.

The invention is therefore based on the object, a system for wireless power and data transmission as well as
EMI 2.1
to provide a supply of energy, which is regulated to a certain value, preferably for the operation of the battery-less transceiver required energy.

The gist of the invention is the fact that in the self-powered transceiver a manipulated variable is determined, which is used to a controllable
EMI 2.2
Receiving means to settle such that the wireless transceiver to the battery-less energy transferred substantially to the information required by the battery-free transmission / reception device energy quantity.

The above-mentioned technical problem is solved by the invention for one of the features of claim 1

For this purpose a system for wireless power and data transmission is provided, which preferably has a first and a second transceiver.
The first transceiver has a variable power supply means for providing a
EMI 2.3
and power transmission means for transmitting via a wireless data and.
The second, advantageously powered wireless transceiver comprises a receiving means for receiving from the first transmitting / receiving means wirelessly transmitted energy supply.
For rectifying the transmitted via an RF carrier signal energy of the receiving device is a rectifier, preferably associated with a bridge rectifier.
An energy storage device is used to the wirelessly transmitted and rectified supply energy

<Desc/Clms Page number 3>

EMI3.1
Amount of energy provided border energy quantity.
A regulating device is used to generate, in response to the output signal of the detection means a control signal for controlling the power supply means of the first transmitting / receiving device, wherein the control signal via a transmitting means is wireless to the first transmitting / receiving means transferable.

Advantageous developments are the subject of the dependent claims.

The detection device has, according to a first alternative embodiment of a series circuit comprising a voltage stabilizing means, and a current meter.
The detection means and the control means are able to compare the current flowing through the voltage-stabilizing device current with a predetermined current value.
The predetermined current value is preferably from the first transceiver to operate the required supply energy.

That is, the excess energy is preferably kept small.

According to a further embodiment, the detecting means to one of a load associated voltmeter.
The falling of the load voltage in turn can be compared by means of the detection device or the control device with a predetermined voltage value, which in turn reflects the time required by the second transmitting / receiving device energy.

By the special design of the detection device according to the above-described alternatives, it is possible to regulate the power supply device of the first transmitter / receiver device such that the transmitted output power substantially corresponds to the energy that is required by the second battery-free transceiver.
In this way it is possible to
EMI3.2

<Desc/Clms Page number 4>

Heat keeping in the second transceiver to a minimum.
In addition, during battery operation of the first transceiver can therefore its battery life can be extended, also, the transmission field strength can be reduced to the necessary degree.

Advantageously, the energy transfer takes place inductively, in which case the receiving means of the second transceiver for receiving said energy comprises a resonant circuit with a fixed resonant frequency.

The two transceivers used in the near field, a carrier frequency for the respective transmission means and a resonant frequency for the resonant circuit can be selected, which lie at around 130 kHz.

The second batteryless transceiver used for example as in a body implantable transponders, it is useful to measure with an implantable temperature sensor measures the temperature in the vicinity of the transponder, in order to avoid a critical heating of the environment.
For this purpose the control device is designed such that it can generate a control signal in dependence of the output signal of the detection device and the temperature sensor.
In this way it is possible, the transmit power to reduce by means of the variable power supply means in the first transmitting / receiving device, even when although the transmitted energy is not required by the second transmitting / receiving device of energy is exceeded, but the temperature in the vicinity of transponder reaches a critical value.

As mentioned, it may, at the second transmitting / receiving device, be an implantable transponder, and then the first transceiver advantageously acts as interrogator.

At this point it should be mentioned that the second transmitting / receiving device according to the various application

<Desc/Clms Page number 5>

May have actuators and sensors, with the exception of the integration of the temperature sensor are not the subject of the invention.

The above object is also achieved by a transmitting / receiving device, which can for example be designed as an implantable, batteryless transponder.
The essential features of the batteryless
EMI5.1
that the characteristics are not repeated at this point.

The invention will now be described by way of example in more detail in conjunction with FIG.

In the present example as the first transmitting / receiving means comprises a retrieval means 10 is used, which communicates for example with a battery-less transponder 20 via a known inductive coupling. Wherein said implantable batteryless transponder 20 may be a transponder to be used in medical inkorporalen nerve stimulation.

The interrogation device comprises in addition to a known transmission means 12, and receiving device 14 includes a variable power supply means 16, which provides the supply energy for the transponder 20.
The wireless power and data transmission between the interrogator 10 and the transponder 20 via a carrier signal having a frequency of 130kHz for example.
The data can be transmitted, for example as a frequency-modulated signals via the transmitting means 12 for transponder 20.
For this purpose, the transponder 20 corresponding decoding and demodulation, which are not shown.

The transmitted RF signals are coupled via a resonant frequency circuit 30, which is constructed by a parallel circuit of a coil 32 and a capacitor 34.
The resonant frequency of the resonant circuit 30 is
EMI5.2

<Desc/Clms Page number 6>

EMI6.1
this example, 130 kHz. The injected HFSpannungen be rectified by a bridge rectifier 22, and then at least partially loading a charging capacitor 24.
The charging capacitor 24 is used as an energy storage in the power supply of the transponder 20th
A voltage-stabilizing or voltage limiting element 42, the voltage drop across the charging capacitor 24 voltage is stabilized and limited.
The voltage stabilizing element 42 may be realized for example as a Zener diode 42.
The Zener diode 42 in the present example is part of a detection device 40, further comprising a capacitor connected in series with the Zener diode 42 current blade 44.
The ammeter 44 of the detection device has the task to measure the effluent through the Zener diode 42 current.
The measured current is a measure of whether the transponder 20 is placed too much or too little power supply energy from the interrogation device 10 are available.
In a control device 50 of the measured current with a predetermined current value is compared to the required mapping of the transponder 20 supply energy.
In the control means 50 or alternatively, in the detection device 40 of the measured current from the current sensor 44 with the predetermined current value is compared.

From the comparison value, the control device 50 determines a control signal which is transmitted via a transmission device 60 to the interrogation device 10.
Increases as a function of the actuating signal, or lowers the controllable power supply device, the transmission power of the interrogation device 10
In other words, the transmission power of the interrogator 10 is increased, when the current flowing through the Zener diode 42 current falls below the predetermined current value, while the transmission power is lowered when the measured current exceeds the predetermined current value.

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Alternatively, the detection means comprise a voltage meter and a load, wherein the voltage drop is measured at the load from the voltage meter.
The measured voltage value is then compared with a predetermined voltage value, which in turn corresponds to the required by the transponder 20 supply energy.

This embodiment is not shown in the figure.

For example, the body temperature in the vicinity of the receiving means 30 and the transmitting means 60 of the transponder 20 can measure a temperature sensor 80 is provided.
To avoid that the skin is heated in a critical way, the measured temperature value is also supplied to the control means 50 which produces now both the measured temperature as well as from the current flowing through the Zener diode 42 power a control signal, which power supply means, the controllable 16 of the interrogator prompted to change the transmit power is such that on the one hand, the environment can not be heated in a critical manner and also ensure sufficient energy supply for the transponder.
The signal generated by the control means 50 in the extreme case the control signal can turn the interrogator in order to avoid damage to the body in the vicinity of the transponder.

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

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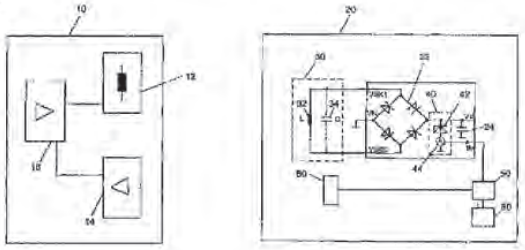
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(54) System zur drahtlosen Energie- und Datenübertragung

(57) System zur drahtlosen Energie- und Datenübertragung mit einer ersten Sende-/Empfangseinrichtung (10), die eine regelbare Energieversorgungseinrichtung (16) zur Bereitstellung einer Versorgungsenergie für eine zweite Sende-/Empfangseinrichtung (20) und eine Sendeeinrichtung (12) zur drahtlosen Daten- und Energieübertragung aufweist, wobei die zweite Sende-/Empfangseinrichtung (20) folgende Merkmale aufweist:
eine Empfangseinrichtung (30, 32, 34) zum Empfangen der von der ersten Sende-/Empfangseinrichtung (10) drahtlos übertragenen Versorgungsenergie,
einen der Empfangseinrichtung (30, 32, 34) zugeordneten Gleichrichter (22), einen Energiespeicher (24) zum wenigstens teilweisen Speichern der drahtlos übertragenen und gleichgerichteten Versorgungsenergie,
eine Detektionseinrichtung (40) zum Erfassen einer eine vorbestimmte Energiemenge überschreitende Energiemenge,
eine Regeleinrichtung (50), die in Abhängigkeit von dem Ausgangssignal der Detektionseinrichtung (40) eine Stellgröße zur Regelung der Energieversorgungseinrichtung (16) der ersten Sende-/Empfangseinrichtung (10) erzeugt und
eine Sendeeinrichtung (60) zum drahtlosen Übertragen der Stellgröße zur ersten Sende-/Empfangseinrichtung (10).



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26.09.00

iC-Haus GmbH

System zur drahtlosen Energie- und Datenübertragung

Die Erfindung betrifft ein System zur drahtlosen Energie- und Datenübertragung sowie eine Sende-/Empfangseinrichtung zum Einsatz in einem solchen System.

Zahlreiche Transpondersysteme sind bekannt, die im Wesentlichen aus einer Abfrageeinrichtung und einem beispielsweise in einen menschlichen oder tierischen Körper implantierbaren Transponder bestehen. Bekannte Transponder können aus mehreren Aktoren und Sensoren bestehen, die Befehle ausführen bzw. bestimmte Daten ermitteln. Die ermittelten Daten werden dann vom Transponder zur Abfrageeinrichtung übertragen und dort ausgewertet. Ein solches Transpondersystem ist beispielsweise in der DE 195 382 13 beschrieben.

Die Energieversorgung eines Transponders kann mittels einer eigenen Batterie oder im Falle eines batterielosen Transponders über eine extern eingekoppelte Versorgungsenergie erfolgen. Ein solcher batterieloser Transponder ist beispielsweise Gegenstand der EP 0442 390. Der darin beschriebene batterielose Transponder weist einen Resonanzschwingkreis auf, der auf die Frequenz des Sendesignals der Abfrageeinrichtung abgestimmt ist. Ferner ist ein Energiespeicher vorgesehen, der durch das von der Abfrageeinrichtung kommende gleichgerichtete Sendesignal aufgeladen wird. Der Energiespeicher liefert im geladenen Zustand die Versorgungsspannung für den Transponder. Ferner ist eine Spannungs-begrenzende Einrichtung zum Begrenzen der Spannung an dem Energiespeicher auf einen vorbestimmten Wert vorgesehen. Mit der bekannten Abfrageeinrichtung und dem batterielosen Transponder ist es jedoch nicht möglich, die

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von der Abfrageeinrichtung für den Transponder bereitgestellte Versorgungsenergie in Abhängigkeit von im Transponder ermittelten und ausgewerteten Daten zu regeln.

Der Erfindung liegt daher die Aufgabe zugrunde, ein System zur drahtlosen Energie- und Datenübertragung sowie eine Sende-/Empfangseinrichtung zu schaffen, mit denen es möglich ist, eine batterielose Sende-/Empfangseinrichtung mit einer Versorgungsenergie zu versorgen, die auf einen bestimmten Wert, vorzugsweise auf die zum Betrieb der batterielosen Sende-/Empfangseinrichtung benötigte Energie geregelt wird.

Der Kerngedanke der Erfindung ist darin zu sehen, dass in der batterielosen Sende-/Empfangseinrichtung eine Stellgröße ermittelt wird, die dazu dient, eine regelbare Versorgungsenergie in der externen Sende-/Empfangseinrichtung derart zu regeln, dass die drahtlos zur batterielosen Sende-/Empfangseinrichtung übertragene Energie im Wesentlichen der von der batterielosen Sende-/Empfangseinrichtung benötigten Energiemenge entspricht.

Das oben genannte technische Problem löst die Erfindung zum einen mit den Merkmalen des Anspruchs 1.

Hierzu ist ein System zur drahtlosen Energie- und Datenübertragung vorgesehen, welches vorzugsweise eine erste und eine zweite Sende-/Empfangseinrichtung aufweist. Die erste Sende-/Empfangseinrichtung verfügt über eine regelbare Energieversorgungseinrichtung zur Bereitstellung einer Versorgungsenergie für die zweite Sende-/Empfangseinrichtung und über eine Sendeeinrichtung zur drahtlosen Daten- und Energieübertragung. Die zweite, zweckmäßigerweise batterielose Sende-/Empfangseinrichtung weist eine Empfangseinrichtung zum Empfangen der von der ersten Sende-/Empfangseinrichtung drahtlos übertragenen Versorgungsenergie auf. Zur Gleichrichtung der über ein HF-Trägersignal übertragenen Energie ist der Empfangseinrichtung ein Gleichrichter, vorzugsweise ein Brückengleichrichter zugeordnet. Ein Energiespeicher dient dazu, die drahtlos übertragene und gleichgerichtete Versorgungsenergie

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wenigstens teilweise zu speichern. Ferner ist eine Detektionseinrichtung zum Erfassen einer eine vorbestimmte Energiemenge überschreitende Energiemenge vorgesehen. Eine Regeleinrichtung dient dazu, in Abhängigkeit von dem Ausgangssignal der Detektionseinrichtung ein Stellsignal zur Regelung der Energieversorgungseinrichtung der ersten Sende-/Empfangseinrichtung zu erzeugen, wobei das Stellsignal über eine Sendeeinrichtung drahtlos zur ersten Sende-/ Empfangseinrichtung übertragbar ist.

Vorteilhafte Weiterbildungen sind Gegenstand der Unteransprüche.

Die Detektionseinrichtung weist gemäß einer ersten alternativen Ausführungsform eine Serienschaltung aus einer Spannungs-stabilisierenden Einrichtung und einem Strommessgerät auf. Die Detektionseinrichtung oder die Regeleinrichtung sind in der Lage, den durch die Spannung-stabilisierende Einrichtung fließenden Strom mit einem vorbestimmten Stromwert zu vergleichen. Der vorbestimmte Stromwert bildet vorzugsweise die zum Betrieb der ersten Sende-/ Empfangseinrichtung benötigte Versorgungsenergie ab. Das heißt, die überschüssige Energie wird vorzugsweise klein gehalten.

Gemäß einer weiteren Ausführungsform weist die Detektionseinrichtung einen einer Last zugeordneten Spannungsmesser auf. Die an der Last abfallende Spannung kann wiederum mittels der Detektionseinrichtung oder der Regeleinrichtung mit einem vorbestimmten Spannungswert verglichen werden, der wiederum die von der zweiten Sende-/ Empfangseinrichtung benötigte Energie abbildet.

Durch die spezielle Ausgestaltung der Detektionseinrichtung gemäß den oben beschriebenen Alternativen ist es möglich, die Energieversorgungseinrichtung der ersten Sende-/Empfangseinrichtung derart zu regeln, dass die übermittelte Sendeleistung im Wesentlichen der Energie entspricht, die von der zweiten, batterielosen Sende-/ Empfangseinrichtung benötigt wird. Auf diese Weise ist es möglich, die

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Wärmeentwicklung in der zweiten Sende-/ Empfangseinrichtung möglichst klein zu halten. Darüber hinaus kann bei Batteriebetrieb der ersten Sende-/ Empfangseinrichtung demzufolge deren Batterielebensdauer verlängert werden. Ferner kann die Sendefeldstärke auf das notwendige Maß reduziert werden.

Zweckmäßigerweise erfolgt die Energieübertragung induktiv, wobei dann die Empfangseinrichtung der zweiten Sende-/Empfangseinrichtung zum Empfang der Energie einen Schwingkreis mit einer fest vorgegebenen Resonanzfrequenz aufweist.

Werden die beiden Sende-/Empfangseinrichtungen im Nahfeld benutzt, kann eine Trägerfrequenz für die jeweiligen Sendeeinrichtungen und eine Resonanzfrequenz für den Schwingkreis gewählt werden, die etwa bei 130 kHz liegen. Wird die zweite batterielose Sende-/Empfangseinrichtung beispielsweise als in einem Körper implantierbarer Transponder verwendet, ist es sinnvoll, mit einem implantierbaren Temperatursensor die Temperatur in der Umgebung des Transponders zu messen, um eine kritische Erwärmung der Umgebung zu vermeiden. Hierzu ist die Regeleinrichtung derart ausgebildet, dass sie ein Stellsignal in Abhängigkeit des Ausgangssignals der Detektionseinrichtung und des Temperatursensors erzeugen kann. Auf diese Weise ist es möglich, die Sendeleistung mittels der regelbaren Energieversorgungseinrichtung in der ersten Sende-/ Empfangseinrichtung auch dann zu reduzieren, wenn zwar die übertragene Energie die von der zweiten Sende-/ Empfangseinrichtung benötigte Energie nicht überschritten, aber die Temperatur in der Umgebung des Transponders einen kritischen Wert erreicht hat.

Wie erwähnt, kann es sich bei der zweiten Sende-/ Empfangseinrichtung um einen implantierbaren Transponder handeln, wobei dann die erste Sende-/Empfangseinrichtung zweckmäßigerweise als Abfrageeinrichtung fungiert.

An dieser Stelle sei erwähnt, dass die zweite Sende-/ Empfangseinrichtung je nach Anwendungsfall verschiedene

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Aktoren und Sensoren aufweisen kann, die mit Ausnahme der Einbindung des Temperatursensors nicht Gegenstand der Erfindung sind.

Die oben genannte Aufgabe wird ferner durch eine Sende-/Empfangseinrichtung gelöst, die beispielsweise als implantierbarer, batterieloser Transponder ausgebildet sein kann. Die wesentlichen Merkmale der batterielosen Sende-/Empfangseinrichtung wurden obenstehend in Bezug auf die zweite Sende-/Empfangseinrichtung näher ausgeführt, so dass die Merkmale an dieser Stelle nicht mehr wiederholt werden.

Die Erfindung wird nachstehend anhand eines Ausführungsbeispiels in Verbindung mit einer Figur näher erläutert.

In dem vorliegenden Beispiel wird als erste Sende-/Empfangseinrichtung eine Abfrageeinrichtung 10 verwendet, die beispielsweise mit einem batterielosen Transponder 20 über eine an sich bekannte induktive Kopplung kommuniziert. Bei dem implantierbaren batterielosen Transponder 20 kann es sich um einen in der Medizintechnik einsetzbaren Transponder zur inkorporalen Nervenstimulation handeln.

Die Abfrageeinrichtung weist neben einer an sich bekannten Sendeeinrichtung 12 und Empfangseinrichtung 14 eine regelbare Energieversorgungseinrichtung 16 auf, die die Versorgungsenergie für den Transponder 20 liefert. Die drahtlose Energie- und Datenübertragung zwischen der Abfrageeinrichtung 10 und dem Transponder 20 erfolgt über ein Trägersignal, welches beispielsweise eine Frequenz von 130kHz aufweist. Die Daten können beispielsweise als frequenzmodulierte Signale über die Sendeeinrichtung 12 zum Transponder 20 übertragen werden. Hierzu weist der Transponder 20 entsprechende Decodier- und Demodulationseinrichtungen auf, die nicht dargestellt sind. Die übertragenen HF-Signale werden über einen Resonanzfrequenzkreis 30 eingekoppelt, der durch eine Parallelschaltung aus einer Spule 32 und einem Kondensator 34 aufgebaut ist. Die Resonanzfrequenz des Schwingkreises 30 ist

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auf die Trägerfrequenz des Sendesignals der Abfrageeinrichtung abgestimmt und beträgt daher in dem vorliegenden Beispiel 130 kHz. Die eingekoppelten HF-Spannungen werden über einen Brückengleichrichter 22 gleichgerichtet und laden anschließend zumindest teilweise einen Ladekondensator 24 auf. Der Ladekondensator 24 dient als Energiespeicher bei der Energieversorgung des Transponders 20. Über ein Spannungs-stabilisierendes oder Spannungs-begrenzendes Element 42 wird die über den Ladekondensator 24 abfallende Spannung stabilisiert und begrenzt. Das Spannungs-stabilisierende Element 42 kann beispielsweise als Zener-Diode 42 realisiert werden. Die Zener-Diode 42 ist im vorliegenden Beispiel Bestandteil einer Detektionseinrichtung 40, die ferner einen in Reihe zur Zener-Diode 42 geschalteten Strommesser 44 aufweist. Der Strommesser 44 der Detektionseinrichtung hat die Aufgabe, den über die Zener-Diode 42 abfließenden Strom zu messen. Der gemessene Strom ist ein Maß dafür, ob dem Transponder 20 zu viel oder zu wenig Versorgungsenergie von der Abfrageeinrichtung 10 zur Verfügung gestellt wird. In einer Regeleinrichtung 50 wird der gemessene Strom mit einem vorbestimmten Stromwert verglichen, der die von dem Transponder 20 benötigte Versorgungsenergie abbildet. In der Regeleinrichtung 50 oder alternativ auch in der Detektionseinrichtung 40 wird der vom Strommesser 44 gemessene Strom mit dem vorbestimmten Stromwert verglichen. Aus dem Vergleichswert ermittelt die Regeleinrichtung 50 ein Stellsignal, welches über eine Sendeeinrichtung 60 zur Abfrageeinrichtung 10 übertragen wird. In Abhängigkeit des Stellsignals erhöht oder erniedrigt die regelbare Energieversorgungseinrichtung die Sendeleistung der Abfrageeinrichtung 10. Mit anderen Worten wird die Sendeleistung der Abfrageeinrichtung 10 erhöht, wenn der durch die Zener-Diode 42 fließende Strom den vorbestimmten Stromwert unterschreitet, während die Sendeleistung erniedrigt wird, wenn der gemessene Strom den vorbestimmten Stromwert überschreitet.

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Alternativ kann die Detektionseinrichtung einen Spannungsmesser und eine Last aufweisen, wobei der Spannungsabfall an der Last vom Spannungsmesser gemessen wird. Der gemessene Spannungswert wird dann mit einem vorbestimmten Spannungswert verglichen, der wiederum der von dem Transponder 20 benötigten Versorgungsenergie entspricht. Dieses Ausführungsbeispiel ist jedoch nicht in der Figur dargestellt.

Um beispielsweise die Körpertemperatur in der Nähe der Empfangseinrichtung 30 und der Sendeeinrichtung 60 des Transponders 20 messen zu können, ist ein Temperatursensor 80 vorgesehen. Um zu vermeiden, dass die Haut sich in kritischer Weise erwärmt, wird der gemessene Temperaturwert ebenfalls der Regeleinrichtung 50 zugeführt, die nunmehr sowohl aus der gemessenen Temperatur als auch aus dem durch die Zener-Diode 42 fließenden Strom ein Stellsignal erzeugt, welches die regelbare Energieversorgungseinrichtung 16 der Abfrageeinrichtung veranlasst, die Sendeleistung derart zu ändern, dass zum einen die Umgebung sich nicht in kritischer Weise erwärmt und andererseits eine ausreichende Energieversorgung für den Transponder gewährleistet ist. Das von der Regeleinrichtung 50 erzeugte Stellsignal kann im Extremfall die Abfrageeinrichtung deaktivieren, um Schädigungen des Körpers in der Nähe des Transponders zu vermeiden.

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Schutzansprüche

1. System zur drahtlosen Energie- und Datenübertragung mit einer ersten Sende-/Empfangseinrichtung (10), die eine regelbare Energieversorgungseinrichtung (16) zur Bereitstellung einer Versorgungsenergie für eine zweite Sende-/Empfangseinrichtung (20) und eine Sendeeinrichtung (12) zur drahtlosen Daten- und Energieübertragung aufweist, wobei
die zweite Sende-/Empfangseinrichtung (20) folgende Merkmale aufweist:
eine Empfangseinrichtung (30, 32, 34) zum Empfangen der von der ersten Sende-/Empfangseinrichtung (10) drahtlos übertragenen Versorgungsenergie,
einen der Empfangseinrichtung (30, 32, 34) zugeordneten Gleichrichter (22), einen Energiespeicher (24) zum wenigstens teilweisen Speichern der drahtlos übertragenen und gleichgerichteten Versorgungsenergie,
eine Detektionseinrichtung (40) zum Erfassen einer eine vorbestimmte Energiemenge überschreitende Energiemenge,
eine Regeleinrichtung (50), die in Abhängigkeit von dem Ausgangssignal der Detektionseinrichtung (40) eine Stellgröße zur Regelung der Energieversorgungseinrichtung (16) der ersten Sende-/Empfangseinrichtung (10) erzeugt und
eine Sendeeinrichtung (60) zum drahtlosen Übertragen der Stellgröße zur ersten Sende-/Empfangseinrichtung (10).

2. System zur drahtlosen Energie- und Datenübertragung nach Anspruch 1,
dadurch gekennzeichnet, dass
die Detektionseinrichtung (40) eine Serienschaltung aus

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einer Spannungs-stabilisierenden Einrichtung (42) und einem Strommessgerät (44) umfasst und den durch die Spannungs-stabilisierende Einrichtung (42) fließenden Strom mit einem vorbestimmten Stromwert vergleichen kann.

3. System zur drahtlosen Energie- und Datenübertragung nach Anspruch 1, dadurch gekennzeichnet, dass die Detektionseinrichtung einen einer Last zugeordneten Spannungsmesser aufweist und die an der Last abfallende Spannung mit einem vorbestimmten Spannungswert vergleichen kann.

4. System zur drahtlosen Energie- und Datenübertragung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, dass die Energieübertragung induktiv erfolgt und die Empfangseinrichtung der zweiten Sende-/Empfangseinrichtung (30) ein Schwingkreis (32, 34) mit einer fest vorgegebenen Resonanzfrequenz ist.

5. System zur drahtlosen Energie- und Datenübertragung nach Anspruch 4, dadurch gekennzeichnet, dass die Trägerfrequenz der jeweiligen Sendeeinrichtungen (12, 60) und die Resonanzfrequenz des Schwingkreises (32, 34) bei etwa 130 kHz liegt.

6. System zur drahtlosen Energie- und Datenübertragung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass die zweite Sende-/Empfangseinrichtung (20) einen Temperatursensor (80) aufweist, wobei die

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Regeleinrichtung (50) eine Stellgröße in Abhängigkeit des Ausgangssignals der Detektionseinrichtung (40) und des Temperatursensor (80) erzeugt.

7. System zur drahtlosen Energie- und Datenübertragung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass die erste Sende-/Empfangseinrichtung (10) eine Abfrageeinrichtung und die zweite Sende-/Empfangseinrichtung (20) ein implantierbarer Transponder ist.

8. Sende-/Empfangseinrichtung, insbesondere ein implantierbarer Transponder zum Einsatz in einem System zur drahtlosen Energie- und Datenübertragung nach einem der Ansprüche 1 bis 7, umfassend
eine Empfangseinrichtung (30) zum Empfangen der von einer entfernten Sende-/Empfangseinrichtung (10) drahtlos übertragenen Versorgungsenergie,
einen der Empfangseinrichtung (30) zugeordneten Gleichrichter (22), einen Energiespeicher (24) zum wenigstens teilweise Speichern der drahtlos übertragenen und gleichgerichteten Versorgungsenergie,
eine Detektionseinrichtung (40) zum Erfassen einer eine vorbestimmte Energiemenge überschreitende Energiemenge,
eine Regeleinrichtung (50), die in Abhängigkeit von dem Ausgangssignal der Detektionseinrichtung (40) eine Stellgröße zur Regelung einer Energieversorgungseinrichtung (16) der entfernten Sende-/Empfangseinrichtung (10) erzeugt und
eine Sendeeinrichtung (60) zum drahtlosen Übertragen der Stellgröße zur entfernten Sende-/Empfangseinrichtung.

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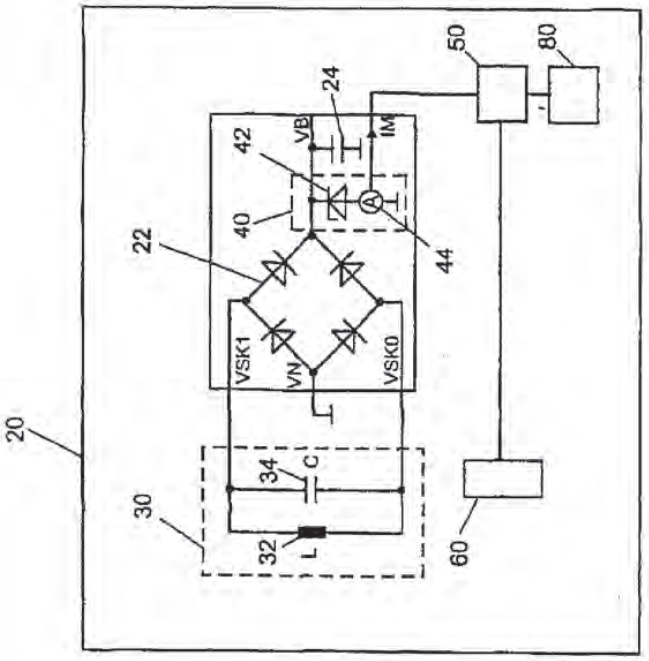
9. Sende-/Empfangseinrichtung nach Anspruch 8
dadurch gekennzeichnet, dass
die Detektionseinrichtung (40) eine Serienschaltung aus einer Spannungs-stabilisierenden Einrichtung (42) und einem Strommessgerät (44) umfasst und den durch die Spannungs-stabilisierende Einrichtung (42) fließenden Strom mit einem vorbestimmten Stromwert vergleichen kann.

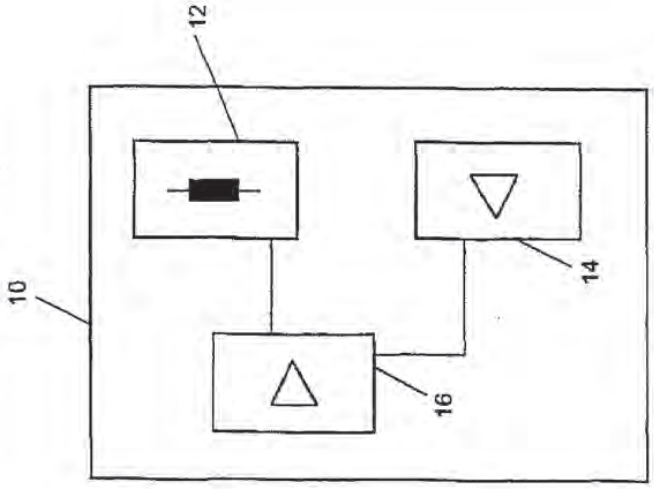
10. Sende-/Empfangseinrichtung nach Anspruch 8,
dadurch gekennzeichnet, dass
die Detektionseinrichtung einen einer Last zugeordneten Spannungsmesser aufweist und die an der Last abfallende Spannung mit einem vorbestimmten Spannungswert vergleichen kann.

11. Sende-/Empfangseinrichtung nach Anspruch 8 oder 9,
dadurch gekennzeichnet, dass
die Energieübertragung induktiv erfolgt und die Empfangseinrichtung (30) der zweiten Sende-/Empfangseinrichtung (20) ein Schwingkreis (32, 34) mit einer fest vorgegebenen Resonanzfrequenz ist.

12. Sende-/und Empfangseinrichtung nach einem der Ansprüche 8 bis 11,
dadurch gekennzeichnet, dass
die zweite Sende-/Empfangseinrichtung (20) einen Temperatursensor (80) aufweist, wobei die Regeleinrichtung (50) eine Stellgröße in Abhängigkeit des Ausgangssignals der Detektionseinrichtung (40) und des Temperatursensor (80) erzeugt.

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[Brief Translation]

JAPANESE PATENT OFFICE
PATENT APPLICATION PUBLICATION (A)

Application No.: 2004-251768 Publication No.: JP 2006-074848 A
Applicant: HOKUSHIN DENKI KK,

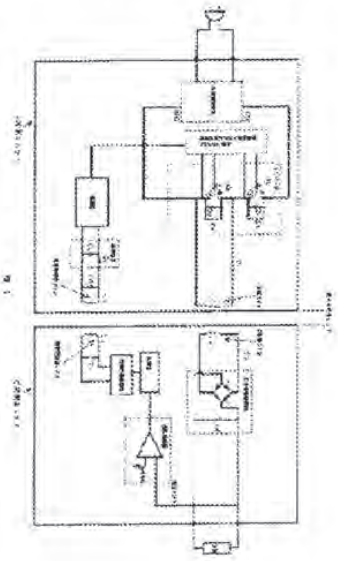
TITLE:

NON-CONTACT POWER TRANSMISSION SYSTEM

ABSTRACT:

PROBLEM TO BE SOLVED: To conduct the efficient stabilization control of a secondary output voltage and a current in a noncontact power transmission system.

SOLUTION: This non-contact power transmissions system can perform secondary stabilization control at high efficiency, in a small size, and at low cost, by transmitting a signal related to a secondary voltage and a current to a primary unit using a noncontact electromagnetic coupling coil, receiving a signal transmitted from the secondary side, and varying the drive frequency of a primary inverter. This reduces ineffective power consumption on the primary side by providing it with a means which controls the secondary output voltage and the current by shifting the drive frequency to a higher side at a light load or no-load and reducing the current of the primary coil of a coupling transformer thereby controlling the stabilization of the secondary output voltage and the current.



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審査請求 未請求　請求項の数 2　OL　（全 9 頁）

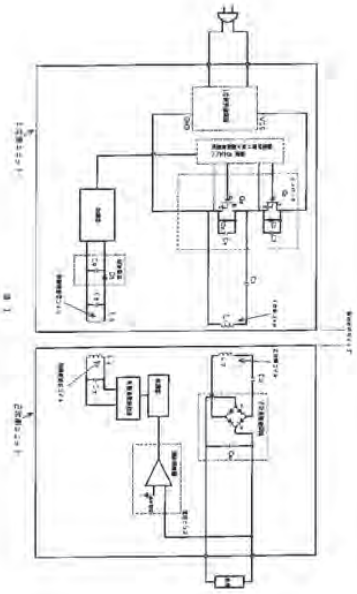
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(54)【発明の名称】非接触電力伝送装置

(57)【要約】　（修正有）
【課題】非接触電力伝送装置における２次側出力電圧、電流の安定化制御を高効率で実現する。
【解決手段】本発明の非接触電力伝送装置では、２次側における電圧および電流に関する信号を１次側ユニットへ非接触の電磁結合コイルを用いて１次側に送信し、１次側ユニットでは２次側から送られてきた信号を受信して、１次側のインバータの駆動周波数を可変させることにより高効率、小型、低コストで２次側の安定化制御を行う事が出来る。軽負荷時や無負荷時において駆動周波数を高い方に移動させ、結合トランスの１次側コイルの電流を減少させる事により２次側の出力電圧及び電流を安定化制御する手段を設ける事により、１次側の無効な消費電力が減少させる。
【選択図】　図１



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【特許請求の範囲】
【請求項１】
結合トランスの１次側と２次側を個別に収容して、相互に分離可能に構成してなる１次側ユニットと２次側ユニットを具備し、前記１次側ユニットから２次側ユニットへ電磁誘導作用を利用して非接触で電力を供給する非接触電力伝送装置において、前記２次側ユニットは、前記結合トランスの２次側における電圧および電流に関する信号を前記２次側ユニットから前記１次側ユニットへ制御用送信コイルを用いて送信する送信手段を備え、前記１次側ユニットは、前記制御用送信コイルと電磁結合された制御用受信コイルをもちいて２次側における電圧および電流に関する信号を受信して、結合トランスの１次側コイルの高周波電流を可変し２次側の出力電圧及び電流を安定化制御する手段を具備して構成したことを特徴とする非接触電力伝送装置。
【請求項２】
結合トランスの１次側と２次側を個別に収容して、相互に分離可能に構成してなる１次側ユニットと２次側ユニットを具備した非接触電力伝送装置であって１次側直列共振回路の共振周波数と駆動周波数を離調させて設定し、前記１次側直列共振回路の共振周波数と駆動周波数の離調の程度により１次側直列共振回路の電流を制限すること及び２次側直列共振回路の共振周波数を１次側駆動周波数にほぼ等しくする様に１次と２次の直列共振回路の共振周波数を設定した状態において、１次側の駆動周波数を可変することにより２次側出力電圧又は電流を可変する事を特徴とする非接触電力伝送装置。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は非接触電力伝送装置において２次側における電圧および電流を１次側にフィードバックし、２次側出力電圧、電流を安定化制御する非接触電力伝送装置に関する。
【背景技術】
【０００２】
非接触電力伝送装置において、２次側の安定化を計る場合、２次側に独立した安定化回路を設ける方法がある。（例えば、特許文献１、２，３参照。）。
【特許文献１】特許公開２００２－３５４７１１号　公報
【特許文献２】特許公開２００４－１２０９１５号　公報
【特許文献３】特許出願２００２－２５２５１１号　公報
【０００３】
２つ目の方法として、２次側共振回路の共振用コンデンサーの値を変える事により、共振周波数を変えて、２次側で受電出来る電力を可変する方法を用い安定化する方法がある。（例えば、特許文献４参照。）。
【特許文献４】特許公開２００４－７２８３２号　公報
【発明の開示】
【発明が解決しようとする課題】
【０００４】
従来方式の課題として以下のものがあげられる。すなわち２次側に独立した安定化回路を設ける方法は２次側の安定化回路の損失が有り、全体の効率を下げてしまう。
２次側が軽負荷の場合においても、結合トランスの１次側コイルの電流は少なくならず１次側コイルの消費電力が低減しない。
【０００５】
２次側の共振回路の共振周波数を変える方法は、２次側が軽負荷の場合においても、結合トランスの１次コイルの電流は小さくならず１次側コイルの消費電力が低減しない。
【０００６】
以上に述べた従来の非接触電力伝送装置における２次側出力電圧、電流を安定化制御する方法では、全体の効率が悪い。また２次側負荷が軽負荷の場合における消費電力を低減出来ない。

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【０００７】
本発明は非接触電力伝送装置における２次側出力電圧、電流の安定化制御を高効率で実現することを目的とするものである。
【課題を解決するための手段】
【０００８】
上記目的を達成するため、本発明の非接触電力伝送装置は、２次側における電圧および電流に関する信号を１次側ユニットへ非接触の電磁結合コイルを用いて１次側に送信し、１次側ユニットでは２次側から送られてきた信号を受信して、１次側ユニットのインバータの駆動周波数を可変し２次側の出力電圧及び電流を安定化制御する手段を設けたものである。
【発明の効果】
【０００９】
本発明の非接触電力伝送装置によれば、非接触で２次側の電圧電流情報を１次側に伝送しインバータの駆動周波数を変え出力電圧、電流を制御出来るため、閉磁路コアを用いたスイッチング電源と同じ安定化電源を実現出来る事にある。
このため２次側ユニットに独立した安定化のためのチョッパ回路やシリーズレギュレータが不要であり、２次側の安定化回路の為の損失が無いので、高効率の非接触電力伝送装置が実現出来る。２次側ユニットに独立した安定化回路が不要なのでこの回路の実装面積も不要となり小型化が可能に成りコストも低減する。
【００１０】
２次側負荷が軽負荷もしくは無負荷時において、インバータの駆動周波数を上げる制御を行う事により、駆動される結合トランスの１次側直列共振回路の共振周波数から離調するため１次側コイルの高周波電流も減る事になり、２次側負荷が軽負荷もしくは無負荷時において交流電源の消費電力を低減できる効果がある。
【発明を実施するための最良の形態】
【００１１】
図１は非接触電源装置に応用した回路図である。
以下本発明の実施の形態を図１から図６に基づいて説明する。
【００１２】
図１において１次側ユニットのインバータは１次側整流回路の直流出力を電源とする。前記インバータはハーフブリッジ接続され発振周波数可変２相発振器により駆動される。結合トランスの１次側コアに巻き線を巻き回し、１次側コイルを作る。この１次側コイルをＬ１とする。Ｌ１と直列に共振コンデンサＣ1を接続する。
一方、２次側ユニットでは、２次側コアに巻き線を巻き回し、２次側コイルを得る。この２次側コイルをＬ２とする。前記Ｌ２を用いてＬ１の磁力線から高周波電力を取り出す。Ｌ２にＣ２を直列に接続して２次側直列共振回路を得る。Ｃ２の後のブリッジ整流回路とＣ６から構成する２次側整流回路により整流した後、負荷に電力を供給する。
【００１３】
図１のインバータは電界効果トランジスタQ1のドレインＤを１次側整流回路のVCC側に接続し、Q1のソースＳとＱ２のドレインＤを直列に接続し、Ｑ２のソースＳを１次側整流回路のGND側に接続する。
Q1のソースＳとＱ２のドレインＤの接続点に、１次側直列共振回路のＣ１側を接続する。Ｌ１側をＱ２のソースに接続する。
Ｑ１のドレインＤとソースＳに並列にＣ３を、Ｑ２のドレインＤとソースＳに並列にＣ４を接続する。
Ｄ１、Ｄ２は電界効果トランジスタで有るＱ１、Ｑ２のボディダイオードである。
【００１４】
図１の発振周波数可変２相発振器は、Ｑ１の　Ｇ－Ｓ　間　及び　Ｑ２の　Ｇ－Ｓ　間にデットタイムを設けて交互に電圧駆動する発振周波数可変の発振器で有る。
【００１５】

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図５のタイミングチャートにおいてＱ１の　Ｇ－Ｓ　間を駆動する電圧をＱ１　ＶＧＳと表し、Ｑ2の　Ｇ－Ｓ　間を駆動する電圧をＱ２　ＶＧＳ　と表して有る。
同様に図５のタイミングチャートにおいてＱＩ　ＶＧＳとＱ2　ＶＧＳ　間のデットタイムをＤｔと表して有る。

【００１６】

図４－Ａは結合トランスの１次側直列共振回路の共振周波数と２次側直列共振回路の共振周波数対２次側負荷出力電圧の関係をグラフで表したもので有る。
縦軸は２次側負荷出力電圧を示し、横軸はインバータの駆動周波数を示す。
１次側直列共振回路の共振周波数をｆｐに設定し、２次側直列直列共振回路の共振周波数をｆｓに設定して有る。
ｆｐ　＜　ｆｓ　の関係に設定する。
駆動周波数の使用範囲は図４－Ａの　ｆｓからｆ１までとする。

【００１７】

図４－Ｂは駆動周波数対、１次側直列共振回路の共振周波数特性と２次側直列共振回路の共振周波数特性を合成した２次側整流電圧のカーブで有る。

【００１８】

図４－Ｂのグラフにおいて、ｆｓの点を使用範囲の最大出力電圧の点なるよう１次、２次の共振回路の共振周波数を設定しインバータの最低駆動周波数をｆｓに設定する。
ＡＣ入力電圧の変動や負荷の変動に応じて駆動周波数の変化範囲をｆ０からｆ１の範囲に設定する。
負荷に最大出力電圧を供給できる駆動周波数はｆｓの点になる。
定格負荷時は周波数をｆ０に設定し、ＡＣ入力電圧が低下した場合や、負荷が重たくなった場合など、周波数fsに設定する。ＡＣ入力電圧が高くなった場合や軽負荷時は、周波数をｆ1設定する。
ｆｐ、ｆｓ、ｆ０、ｆｌ　の各周波数の１例を下記に示す。
ｆｐ　≒６０ＫＨｚ、　ｆｓ　≒７４ＫＨｚ　、ｆ０　≒７７ＫＨｚ、ｆ１　≒１００ＫＨｚ

【００１９】

図４－Ｂのグラフからは、インバータの駆動周波数を変化させることで出力電圧を可変出来ることが判る。２次側出力電圧が設定より下回った場合その情報を、信号制御用送信コイルを用いて非接触で１次側ユニットに送り、１次側ユニットのインバータの駆動周波数を下げる方向でフィードバック制御を行う。また、軽負荷時等において、出力電圧が設定より上回った場合は、その情報を、制御用送信コイルを用いて非接触で１次側ユニットに送り、１次側ユニットのインバータの駆動周波数を上げる方向でフィードバック制御を行う。

【００２０】

図１において２次側整流回路の出力電圧を誤差増幅器に接続し、この電圧と基準電圧を比較する。
誤差増幅器の出力を変調器に接続し変調器の出力を制御用発振回路に接続する。
制御用発振器はＬ４とＣ７の並列共振周波数で自励発振を行う。

【００２１】

図１においてＬ３とＣ８の並列共振回路を検波回路に接続し、検波回路の出力を復調器に接続する。
復調回路の出力を発振周波数可変２相発振器に接続する。

【００２２】

図３は誤差増幅器、変調器、制御用発振器、復調器、発振周波数可変２相発振器の具体例で有る。
出力電圧をＲ２０１とＲ２０２で分割しＵ２０２のオペアンプのインバータ端子（－端子）に接続する。
Ｕ２０２のオペアンプのノンインバータ端子（＋端子）には基準電圧を印可しておく。
Ｕ２０２の出力を、Ｕ２０１のコンパレータのインバータ端子（－端子）に接続する。

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三角波発振器の出力をＵ２０１のノンインバータ端子（＋端子）に接続する。
三角波発振器の発信周波数を１０ＫＨｚ程度で有る。
制御用発振器はＬ４，Ｃ７の並列共振回路を用いたＬＣ発振器で有り、８ＭＨｚ程度の発振周波数である。Ｌ４は制御用送信コイルである。
Ｕ２０１の出力を制御用発振器に接続し、制御用発振器の発振を断続させる。
【００２３】
一方１次側ユニットにおいて、Ｌ３はＬ４と電磁結合された制御用受信コイルで有る。Ｌ３，Ｃ８の並列共振回路は制御用発振器の発振周波数に同調させる値とする。
Ｌ３，Ｃ８の並列共振回路をＤ３、Ｃ９で構成された検波回路に接続する。
検波回路の出力をＵ１０１のコンパレータのノンインバータ端子（＋端子）に接続する。
Ｕ１０１のコンパレータのインバータ端子（－端子）には、＋１２ＶをＲ１０３とＲ１０４で分割した電圧を印可する。
検波回路の出力をＲ１０３とＲ１０４で分割した電圧と比較しＵ１０１の出力とする。Ｕ１０１の出力をＮＰＮトランジスタＱ１０３のベースへ抵抗を介して接続する。
Ｑ１０３のコレクタをＰＮＰトランジスタＱ１０２のベースへ抵抗を介して接続する。Ｑ１０２のエミッタを＋１２Ｖ電源に接続する。
Ｑ１０２のエミッタにＤ１０１，Ｌ１０１，Ｃ１０２から構成するパルス幅－電圧変換回路に接続する。
パルス幅－電圧変換回路の出力をＮＰＮトランジスタＱ１０1のベースへ抵抗を介して接続する。
Ｑ１０1のエミッタにＲ１０２を接続し回路のＧＮＤに接続する。
２相発振回路はＣ１０１とＲ１０１のＣＲ発振器を構成して有る。
Ｑ１０1のコレクタをＲ１０１に接続する。Ｒ１０１はＲ１０１とＱ１０1のコレクターエミッタを通して並列接続されている。
２相発振回路の出力はＡ相とＢ相の２出力を持ち、それぞれ逆相で出力される。
２相発振回路の出力をデットタイム生成回路に接続し、Ａ相とＢ相間に僅かなデッドタイムを設ける。
デットタイム生成回路の出力をハーフブリッジドライバーに接続する。
ハーフブリッジドライバーに接続されているＤ１０１とＣ１０２はハイサイドスイッチのＱ１の駆動電源を作る目的でブーストアップ回路を構成してある。
ハーフブリッジドライバーの出力はＱ１のゲート、ソース間とＱ２のゲート、ソース間に接続する。
Ｑ１とＱ２のゲートソース間電圧波形は図５のＱ１ＶGSとＱ２ＶGSになる。
【００２４】
図２にＵ字型コアを用いた結合トランスの一例をしめす。
１次側ユニットに設けたＵ字型コアの胴部に１次巻き線　Ｌ１を巻き回する。
２次側ユニットに設けたＵ字型コアの胴部に２次巻き線　Ｌ2を巻き回する。
結合トランスの１次２次間は、１次側ユニットの樹脂製外郭と２次側ユニットの樹脂製外郭で隔てられている。
結合トランスの１次側Ｕ字型コアの脚部の先端と２次側Ｕ字型コアの脚部の先端とは、数㎜の間隔を隔てて対向している。
１次側Ｕ字コアの両脚の中央と１次側ユニットの樹脂製外郭の内側の境界面にＬ３を配置し、２次側Ｕ字コアの両脚の中央と２次側ユニットの樹脂製外郭の内側の境界面にＬ４を配置する。
Ｌ３、Ｌ４は空芯コイルを用いる。
【００２５】
フィードバック制御の説明を図３、図４、図６を用いて説明する。
１次側ユニットから２次側ユニットへ非接触で電力を伝送している状態において２次側ユニットの出力電圧が設定値より高い場合、（図６の左側部分）オペアンプＵ２０２のインバータ端子（－端子）の電圧である、Ｒ２０１とＲ２０２で出力電圧を分割した電圧とノ

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ンインバータ端子（＋端子）に接続してある基準電圧の比較でインバータ端子（－端子）の方が高いため、Ｕ２０２の出力電圧は低い方へ変化する。
Ｕ２０２の出力電圧はコンパレータのＵ２０１のインバータ端子（－端子）に接続してあり、Ｕ２０１のノンインバータ端子（＋端子）には三角波を印加してある為、三角波の振幅が、Ｕ２０１のインバータ端子より高い期間、Ｈｉレベル出力電圧になる。三角波は固定周波数で有るためその周期も固定である。一定周期の期間においてＵ２０１の出力がＵ２０１のインバータ端子の電圧に応じてＵ２０１のパルス幅が変化する為、パルス幅変調の動作といえる。
２次側ユニットの出力電圧が設定値より高い場合、Ｕ２０１のＯＮ幅が広がる結果になる。

【００２６】
Ｕ２０１の出力で制御用発振器の発振を断続する制御を行う。
Ｕ２０１の出力がＨｉレベルの状態で制御用発振器が発振し、Ｕ２０１の出力がＬｏｗレベルの状態で制御用発振器の発振が停止する。
Ｕ２０１の出力がＯＮの期間制御用発振器が発振し、出力がＯＦＦの期間制御用発振器が発振を停止する。
２次側ユニットの出力電圧が設定値より高い場合、制御用発振器が発振している期間が長くなる。

【００２７】
１次側ユニットに設けられたＬ３は２次側ユニットのＬ４と電磁結合しているためＬ３、Ｃ８の並列共振回路の高周波誘導電圧は、制御用発振器の発振の断続に応じて断続する。

【００２８】
Ｌ３、Ｃ８に接続された検波回路の出力はＵ２０１の出力がＯＮの時ＯＮ、Ｕ２０１の出力がＯＦＦの時、ＯＦＦとなり、検波回路のＯＮ幅は、Ｕ２０１の出力のＯＮ幅に同期する。

【００２９】
復調器のＵ１０１は検波回路電圧を増幅する目的のコンパレータで有る。
検波回路の出力電圧をＵ１０１のノンインバータ端子（＋端子）に接続して有るためＲ１０３とＲ１０４で生成した基準電圧よりＵ１０１のインバータ端子（－端子）の電圧が高いと、Ｕ１０１の出力はＯＮ、ＮＰＮタイプのＱ１０３がＯＮ、ＰＮＰタイプのＱ１０２がＯＮとなる。
Ｑ１０２のＯＮ幅はＵ２０１のＯＮ幅と同じになる。

【００３０】
Ｌ２０１、Ｄ１０１、Ｃ１０２を用いたパルス幅－電圧変換回路はフィードフォワードタイプのスイッチング電源回路の２次側整流回路に用いられるものと同じ構成である。
従ってＱ１０２のＯＮ幅に比例した出力電圧が得られる。
結果Ｕ２０１のＯＮ幅に比例した出力電圧が得られる。
以上から２次側ユニットの出力電圧が設定値より高い場合、パルス幅－電圧変換回路の出力電圧も高くなる。

【００３１】
パルス幅－電圧変換回路の出力を、抵抗を介してＮＰＮのＱ１０１のベースに接続して有るため、パルス幅－電圧変換回路の出力電圧が高くなるとＱ１０１のコレクタ電流が増える。
Ｑ１０１のコレクタ電流が増える事は、等価的にＲ１０１の抵抗値が減る事になる。

【００３２】
２相発振器はＣＲ発振器で構成されているため、Ｒ１０１の抵抗値が減ると２相発振器の発振周波数は高くなる。２相発振器の発振周波数が高くなるとインバータの駆動周波数が高くなる。図４－Ｂから駆動周波数が高くなると２次側ユニットの出力電圧が低くなる事が判る。

【００３３】

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２次側ユニットの出力電圧が設定値より低くい場合は図６の右側に示すとおりＵ２０１のコンパレータのＯＮ幅が狭まり、制御用発振器の発振幅が狭まりＬ４の高周波電流の発振幅が狭まる。

【００３４】

制御用発振器の発振幅が狭まりＬ４の高周波電流の発振幅が狭まると、検波回路の出力のＯＮ幅が狭まり、パルス幅－電圧変換回路の出力電圧が低くなり、Ｑ１０１のコレクタ電流が減る。Ｑ１０１のコレクタ電流が減ると等価的にＲ１０１の抵抗値に近づく事になる。

【００３５】

２相発振器はＣＲ発振器で構成されているため、２相発振器の発振周波数は低くなる。２相発振器の発振周波数が低くなるとインバータの駆動周波数が低くなる。

図４－Ｂから駆動周波数が低くなると２次側ユニットの出力電圧が高くなる事が判る。

【００３６】

以上の様に２次側電圧情報が１次側にフィードバックされ、インバータの駆動周波数を変え、２次側の出力電圧を安定化する。

【００３７】

同様な手法を用いて２次側の電流情報を１次側にフィードバックされ、インバータの駆動周波数を変え、２次側の出力電流を安定化することが出来る。

【図面の簡単な説明】

【００３８】

【図１】本発明の実施形態を示す、概略回路図である。

【図２】結合トランスの構造図。

【図３】フィードバック制御の為の詳細回路図。

【図４】駆動周波数対、１次側直列共振回路の共振周波数特性と２次側直列共振回路の共振周波数特性と２次側整流電圧の関係を表した説明図。

【図５】インバータ回路と結合トランスの動作を説明するタイムチャート。

【図６】フィードバック制御の動作を説明するタイムチャート。

【符号の説明】

【００３９】

Ｌ１：結合トランスの１次側巻き線インダクタンス。

Ｌ２：結合トランスの２次側巻き線インダクタンス。

Ｃ１：１次側直列共振用コンデンサ。

Ｃ２：２次側直列共振用コンデンサ。

Ｌ３：制御用受信コイル。

Ｌ４：制御用送信コイル。

Ｃ７：Ｌ４の並列共振用コンデンサー。

Ｃ８：Ｌ３の並列共振用コンデンサー。

ｆｐ：１次側直列共振回路の共振周波数。

ｆｓ：２次側共振回路の共振周波数。

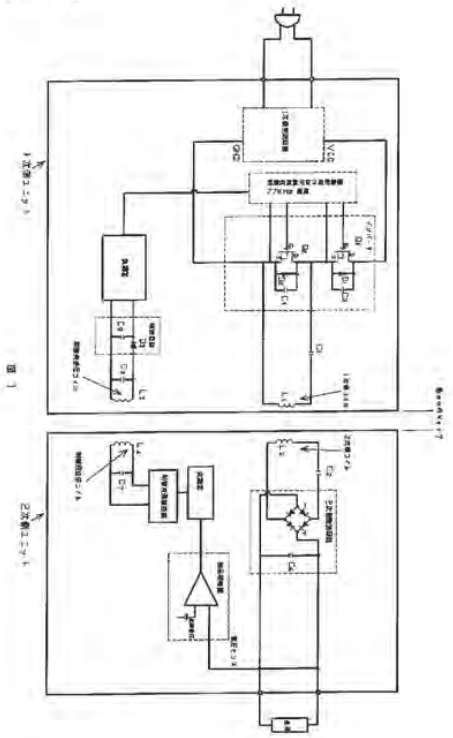
ｆ１：定格負荷時のインバータ駆動周波数。

ｆ０：重負荷時のインバータ駆動周波数。

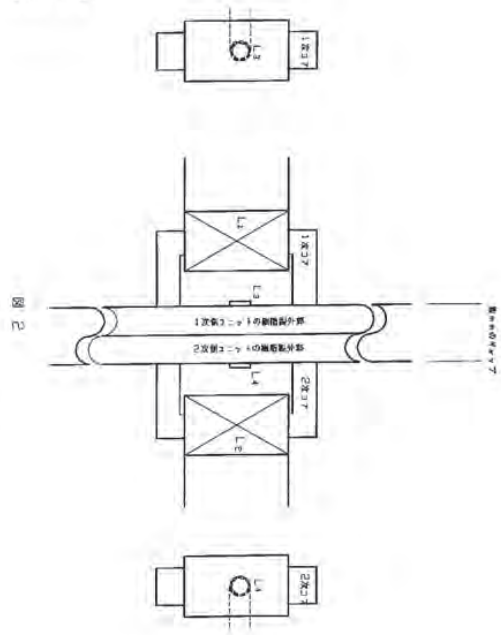
ｆ２：軽負荷時のインバータ駆動周波数。

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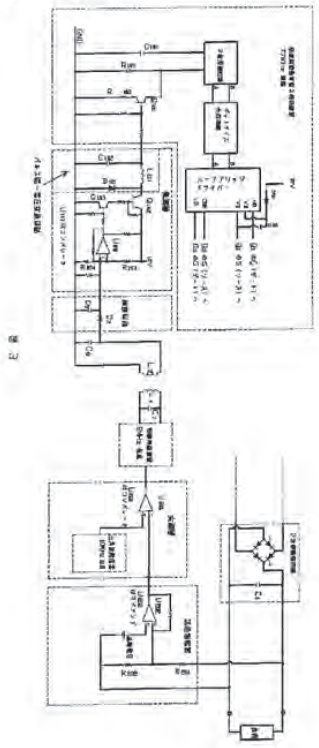
【図１】



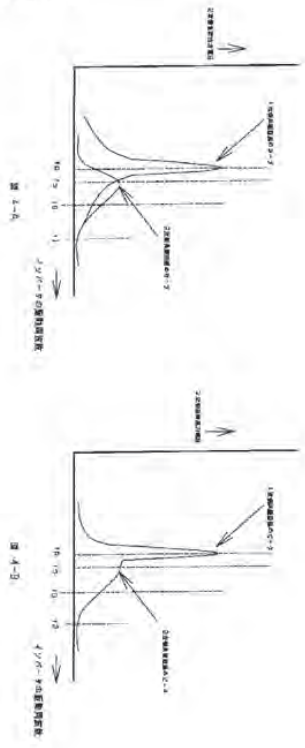
【図２】



【図３】



【図４】



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【図５】

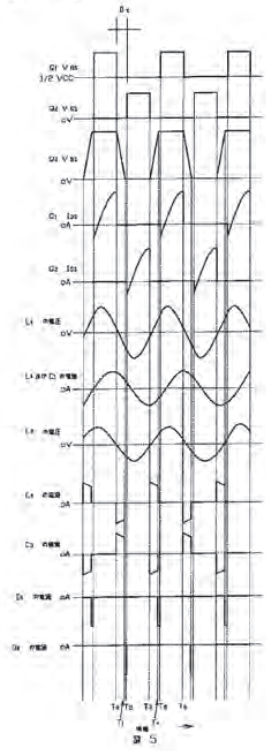


図５

【図６】

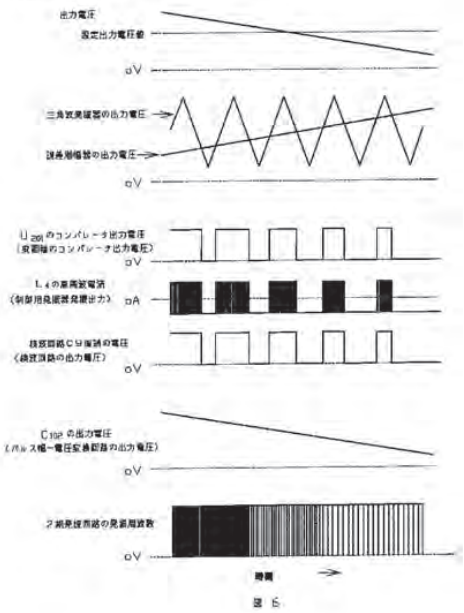


図６

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS
[Claim(s)]
[Claim 1]
Accommodate a secondary individually a primary coupling transformer side, and a primary side unit and a secondary unit which are constituted disengageable mutually are provided, In non-contact transfer-of-power equipment which supplies electric power to a secondary unit by non-contact from the aforementioned primary side unit using an electromagnetic induction action, the aforementioned secondary unit, It has a transmitting means which transmits a signal about voltage and current in a secondary of the aforementioned coupling transformer to the aforementioned primary side unit using a transmission coil for control from the aforementioned secondary unit, The aforementioned primary side unit is with a receiver coil for control by which inductive coupling was carried out to the aforementioned transmission coil for control, and a signal about voltage and current in a secondary is received, Non-contact transfer-of-power equipment providing and constituting a means which changes high frequency current of a primary side coil of a coupling transformer, and carries out stabilization control of output voltage and current of a secondary.
[Claim 2]
Accommodate a secondary individually a primary coupling transformer side, and are non-contact transfer-of-power equipment possessing a primary side unit constituted disengageable and a secondary unit, and make resonance frequency and drive frequency of a primary side series resonant circuit detune mutually, and it sets to it, In the state where resonance frequency of the primary series resonant circuit [secondary] was set up so that resonance frequency of restricting current of a primary side series resonant circuit by a degree of detuning of resonance frequency and drive frequency of the aforementioned primary side series resonant circuit and a secondary series resonant circuit might be made substantially equal to primary side drive frequency, Non-contact transfer-of-power equipment changing secondary side output voltage or current by changing drive frequency by the side of primary.

DETAILED DESCRIPTION
[Detailed Description of the Invention]
[Field of the Invention]
[0001]

The present invention feeds back the voltage and current in a secondary to a primary side in non-contact transfer-of-power equipment, and relates to the non-contact transfer-of-power equipment which carries out stabilization control of secondary side output voltage and the current.
[Background of the Invention]
[0002]
In non-contact transfer-of-power equipment, when measuring stabilization of a secondary, there is the method of providing the stabilization circuit independent to the secondary. (For example, a Patent document 1, 2, three references.).
[Patent document 1] Patent public presentation No. 354711 [2002 to] Gazette
[Patent document 2] Patent public presentation No. 120915 [2004 to] Gazette
[Patent document 3] Patent application No. 252511 [2002 to] Gazette
[0003]
By changing the value of the capacitor for resonance of a secondary resonant circuit, resonance frequency is changed and the 2nd method includes a method stable using the method of changing the electric power which can receive transmitted electricity by a secondary. (For example, see Patent Document 4.).
[Patent document 4] Patent public presentation No. 72832 [2004 to] Gazette
[Description of the Invention]
[Problem to be solved by the invention]
[0004]
The following are raised as problem of a conventional system. That is, the method of providing the stabilization circuit independent to the secondary has the loss of the stabilization circuit of a secondary, and will lower the whole efficiency.
When a secondary is a light load, the current of the primary side coil of a coupling transformer does not decrease, and the power consumption of a primary side coil does not reduce it.
[0005]
When the secondary of the method of changing the resonance frequency of the resonant circuit of a secondary is a light load, the current of the primary coil of a coupling transformer does not become small, and the power consumption of a primary side coil does not reduce it.
[0006]
In the method of carrying out stabilization control of the secondary side output voltage in the conventional non-contact transfer-of-power equipment described above, and the current, the whole efficiency is bad. Power consumption in case secondary side load is a light load cannot be reduced.
[0007]
An object of the present invention is to be efficient and to realize stabilization control of the secondary side output voltage in non-contact transfer-of-power equipment, and current.
[Means for solving problem]
[0008]
In order to attain the above-mentioned purpose, the non-contact transfer-of-power equipment of the present invention, Transmit the signal about the voltage and current in a secondary to a primary side unit at a primary side using a non-contact electromagnetic coupling coil, and the signal sent from the secondary in the primary side unit is received, The means which changes the drive frequency of the inverter of a primary side unit, and carries out stabilization control of the output voltage and current of a secondary is provided.
[Effect of the Invention]

[0009]
Since according to the non-contact transfer-of-power equipment of the present invention the voltage current information on a secondary is transmitted to a primary side by non-contact, the drive frequency of an inverter is changed and output voltage and current can be controlled, it is in the same regulated power supply as the switching power supply using a closed magnetic circuit core being realizable.
For this reason, chopper circuits and the series regulator for the stabilization independent to the secondary unit are unnecessary, and since there is no loss for the stabilization circuit of a secondary, efficient non-contact transfer-of-power equipment is realizable. Since the stabilization circuit independent to the secondary unit is unnecessary, it becomes unnecessary [the packaging area of this circuit], and a miniaturization changes possible and also reduces cost.
[0010]
By performing control which raises the drive frequency of an inverter at a light load or the time of no-load, [secondary side load] In order to detune from the resonance frequency of the primary side series resonant circuit of the coupling transformer to drive, the high frequency current of a primary side coil will also decrease, and it is effective in the ability to reduce the power consumption of AC power supply at a light load or the time of no-load. [secondary side load]
[Best Mode of Carrying Out the Invention]
[0011]
Fig.1 is the circuit diagram applied to the non-contact electric power unit.
An embodiment of the invention is described based on Fig.6 from Fig.1 below.
[0012]
In Fig.1, the inverter of a primary side unit uses the dc output of a primary side rectification circuit as a power supply. Half bridge connection is made and the aforementioned inverter is driven with an oscillating frequency variable 2 phase oscillator. Winding is coiled around the primary side core of a coupling transformer about, and a primary side coil is made. This primary side coil is set to L1. The resonance capacitors C1 are connected with L1 in series.
On the other hand, in a secondary unit, winding is coiled around a secondary core about and a secondary side coil is obtained. This secondary side coil is set to L2. High-frequency power is taken out from the line of magnetic force of L1 using the above L2. C2 is connected to L2 in series, and a secondary series resonant circuit is obtained. After the bridge rectifier circuit after C2 and the secondary rectification circuit constituted from C6 rectify, electric power is supplied to load.
[0013]
The inverter of Fig.1 connects the drain D of the field effect transistor Q1 to the VCC side of a primary side rectification circuit, connects the drain D of the sources S and Q2 of Q1 in series, and connects the source S of Q2 to the GND side of a primary side rectification circuit.
C1 side of a primary side series resonant circuit is connected at the node of the drain D of the sources S and Q2 of Q1. L1 side is connected to the source of Q2.
C4 is connected for C3 in parallel with the drain D and the source S of Q2 in parallel with the drain D and the source S of Q1.
D1 and D2 are body diodes of Q1 and Q2 which exist by a field effect transistor.
[0014]

The oscillating frequency variable 2 phase oscillator of Fig.1 is G-S of Q1. Between and G-S of Q2 It is with the oscillator with variable oscillating frequency which provides a DETTO time and carries out a voltage drive alternately in between.
[0015]
The voltage which drives G-S Hazama of Q1 in the timing chart of Fig.5 is expressed as Q1 VGS, and it is G-S of Q2. The voltage which drives between is expressed as Q2 VGS.
They are [in / similarly / the timing chart of Fig.5] Q1 VGS and Q2 VGS. The DETTO time of a between is expressed as Dt.
[0016]
Fig.4-A is what expressed the resonance frequency of the primary side series resonant circuit of a coupling transformer, and the relation of resonance frequency versus secondary load output voltage of the secondary series resonant circuit with Graf, and there is.
A vertical axis shows secondary load output voltage, and a horizontal axis shows the drive frequency of an inverter.
The resonance frequency of a primary side series resonant circuit is set as fp, and the resonance frequency of a secondary in-series series resonant circuit is set as fs.
It sets to the relation of fp < fs.
The use range of drive frequency is carried out to from fs of Fig.4-A to f1.
[0017]
There is Fig.4-B in the curve of the secondary rectified voltage which synthesized the resonance frequency characteristic of a drive frequency pair and a primary side series resonant circuit, and the resonance frequency characteristic of the secondary series resonant circuit.
[0018]
in the graph of Fig.4-B -- the point of fs -- the maximum output voltage of the use range -- a point -- it needs -- the resonance frequency of the primary resonant circuit [secondary] is set up, and the minimum drive frequency of an inverter is set as fs.
According to change of AC input voltage, or change of load, the variability region of drive frequency is set as the range of f0 to f1.
The drive frequency which can supply maximum output voltage to load becomes a point of fs.
At the time of rated load, frequency is set as f0, and when AC input voltage was deteriorated, or when load becomes heavy, it is set as the frequency fs. At the case where AC input voltage becomes high, or the time of a light load, frequency is set up f1.

One example of each frequency of fp, fs, f0, and f1 is shown below.
fp nearly equal to60kHz, fs nearly equal to74kHz, f0 nearly-equal-to77kHz, f1 nearly-equal-to100kHz
[0019]
Graf of Fig.4-B shows changing output voltage by changing the drive frequency of an inverter.
When secondary side output voltage is less from setting out, the information is sent to a primary side unit by non-contact using the transmission coil for signal controls, and feedback control is performed towards lowering the drive frequency of the inverter of a primary side unit. In the time of a light load, etc., when output voltage exceeds from setting out, the information is sent to a primary side unit by non-contact using the transmission coil for control, and feedback control is performed towards raising the drive frequency of the inverter of a primary side unit.
[0020]

The output voltage of a secondary rectification circuit is connected to an error amplifier in Fig.1, and this voltage and reference voltage are measured.
The output of an error amplifier is connected to a modulator and the output of a modulator is connected to the oscillating circuit for control.
The oscillator for control performs self-oscillation with the parallel resonance frequency of L4 and C7.
[0021]
In Fig.1, the parallel resonant circuit of L3 and C8 is connected to a detector circuit, and the output of a detector circuit is connected to a demodulator.
The output of a demodulator circuit is connected to an oscillating frequency variable 2 phase oscillator.
[0022]
There is Fig.3 by the example of an error amplifier, a modulator, the oscillator for control, a demodulator, and an oscillating frequency variable 2 phase oscillator.
Output voltage is divided by R201 and R202, and it connects with the inverter terminal (- terminal) of the operational amplifier of U202.
The seal of approval of the reference voltage is carried out to the non inverter terminal (+ terminal) of the operational amplifier of U202.
The output of U202 is connected to the inverter terminal (- terminal) of the comparator of U201.
The output of a triangular wave oscillator is connected to the non inverter terminal (+ terminal) of U201.
It is at about 10 kHz about the dispatch frequency of a triangular wave oscillator.
There is an oscillator for control with the LC oscillator which used the parallel resonant circuit of L4 and C7, and it is the oscillating frequency of a 8MHz degree. L4 is a transmission coil for control.
The output of U201 is connected to the oscillator for control, and the oscillation of the oscillator for control is made intermittent.
[0023]
On the other hand in a primary side unit, there is L3 with the receiver coil for control by which inductive coupling was carried out to L4. Let the parallel resonant circuit of L3 and C8 be a value aligned with the oscillating frequency of the oscillator for control.
The parallel resonant circuit of L3 and C8 is connected to the detector circuit which comprised D3 and C9.
The output of a detector circuit is connected to the non inverter terminal (+ terminal) of the comparator of U101. The seal of approval of the voltage which divided +12V by R103 and R104 is carried out to the inverter terminal (- terminal) of the comparator of U101.
The output of a detector circuit is considered as the output of U101 as compared with the voltage divided by R103 and R104. The output of U101 is connected to the base of NPN transistor Q103 via resistance.
The collector of Q103 is connected to the base of PNP transistor Q102 via resistance. The emitter of Q102 is connected to +12V power supply.
It connects with the emitter of Q102 in D101, L101, and the pulse width-voltage conversion circuit constituted from C102.
The output of a pulse width-voltage conversion circuit is connected to the base of NPN transistor Q101 via resistance.
R102 is connected to the emitter of Q101, and it connects with GND of a circuit.

2 phase oscillating circuit constitutes the CR oscillator of C101 and R101.
The collector of Q101 is connected to R101. Multiple connection of R101 is carried out through the collector emitter of R101 and Q101.
The output of 2 phase oscillating circuit has two outputs of an A phase and a B phase, and is outputted by an opposite phase, respectively.
The output of 2 phase oscillating circuit is connected to a DETTO time generating circuit, and few dead times are provided to an A phase and B interphase.
The output of a DETTO time generating circuit is connected to a half bridge driver.
D101 and C102 which are connected to the half bridge driver constitute the boost rise circuit in order to make the drive power source of Q1 of a high side switch.
The output of a half bridge driver is connected between the gate of Q1, between sources and the gate of Q2, and a source.
The voltage waveform between gate sources of Q1 and Q2 is set to Q1VGS and Q2VGS of Fig.5.
[0024]
An example of a coupling transformer which used U shape core for Fig.2 is shown.
The winding time of primary winding L1 is carried out to the drum section of U shape core provided to the primary side unit.
The winding time of secondary winding L2 is carried out to the drum section of U shape core provided to the secondary unit.
Between [of the coupling transformer / per order] secondary, it is separated in the outline made of resin of a primary side unit, and the outline made of resin of the secondary unit.
The tip of the leg of the primary side U shape core of a coupling transformer and the tip of the leg of a secondary U shape core separate a several millimeters interval, and are opposing.
L3 is arranged at the center of the biped of a primary side U character core, and the interface inside the outline made of resin of a primary side unit, and L4 is arranged at the center of the biped of a secondary U character core, and the interface inside the outline made of resin of a secondary unit.
L3 and L4 use an air-core coil.
[0025]
The description of feedback control is described using Fig.3, Fig.4, and Fig.6.
When the output voltage of a secondary unit is higher than a preset value in the state where electric power is transmitted to the secondary unit by non-contact from the primary side unit, (Left part of Fig.6) It is the voltage of the inverter terminal (- terminal) of the operational amplifier U202, By comparison of the reference voltage linked to the voltage which divided output voltage by R201 and R202, and a non inverter terminal (+ terminal), since the inverter terminal (- terminal) is more expensive, the output voltage of U202 changes to the lower one.
Since the output voltage of U202 is connected to the inverter terminal of U201 of a comparator (- terminal) and the triangular wave is applied to the non inverter terminal (+ terminal) of U201, the amplitude of a triangular wave becomes Hi level output voltage during the period higher than the inverter terminal of U201. Since there is a triangular wave with fixed frequency, the cycle is also fixing. Since the pulse width of U201 changes according to the voltage of the inverter terminal of U201 in the period of a constant period, the output of U201 can call it operation of Pulse Density Modulation.
When the output voltage of a secondary unit is higher than a preset value, a result in which the ON width of U201 spreads is brought.

[0026]
Control which is intermittent in the oscillation of the oscillator for control with the output of U201 is performed.
In the output of U201, the oscillator for control oscillates in the state of Hi level, and, in the output of U201, the oscillation of the oscillator for control stops in the state of a Low level.
The oscillator for period control of ON of the output of U201 oscillates, and the oscillator for period control of OFF of an output suspends an oscillation.
When the output voltage of a secondary unit is higher than a preset value, the period which the oscillator for control is oscillating becomes long.
[0027]
Since L3 provided by the primary side unit is carrying out inductive coupling to L4 of the secondary unit, the high-frequency-induction voltage of the parallel resonant circuit of L3 and C8 is intermittent according to intermittence of an oscillation of the oscillator for control.
[0028]
The output of the detector circuit connected to L3 and C8 serves as OFF, when the output of U201 is ON and the output of ON and U201 is OFF, and the ON width of a detector circuit synchronizes with the ON width of the output of U201.
[0029]
There is U101 of a demodulator with a comparator to amplify detector circuit voltage.
Since the output voltage of a detector circuit is connected to the non inverter terminal (+ terminal) of U101 and it is, if the voltage of the inverter terminal (- terminal) of U101 is higher than the reference voltage generated by R103 and R104, As for the output of U101, ON and PNP type Q102 is set to ON by ON and NPN type Q103.
The ON width of Q102 becomes the same as the ON width of U201.
[0030]
The pulse width-voltage conversion circuit using L201, D101, and C102 is the same composition as what is used for the secondary rectification circuit of the switching power supply circuit of a feedforward type.
Therefore, the output voltage proportional to the ON width of Q102 is obtained.
The output voltage proportional to the ON width of the result U201 is obtained.
As mentioned above, when the output voltage of a secondary unit is higher than a preset value, the output voltage of a pulse width-voltage conversion circuit also becomes high.
[0031]
Since the output of a pulse width-voltage conversion circuit is connected to the base of Q101 of NPN via resistance and it is, if the output voltage of a pulse width-voltage conversion circuit becomes high, the collector current of Q101 will increase.
The resistance of increase [the collector current of Q101] of R101 will decrease equivalent.
[0032]
Since 2 phase oscillator comprises a CR oscillator, if the resistance of R101 decreases, the oscillating frequency of 2 phase oscillator will become high. If the oscillating frequency of 2 phase oscillator becomes high, the drive frequency of an inverter will become high. Fig.4 - B shows that the output voltage of a secondary unit becomes low, when drive frequency becomes high.
[0033]
The output voltage of a secondary unit is lower than a preset value, and as for a case, in the oscillation width of narrowing and the oscillator for control, the oscillation width of the high

frequency current of the narrowing L4 narrows [the ON width of the comparator of U201] as shown in the right-hand side of Fig.6.

[0034]

If the oscillation width of the high frequency current of the narrowing L4 narrows in the oscillation width of the oscillator for control, in the ON width of the output of a detector circuit, the output voltage of narrowing and a pulse width-voltage conversion circuit will become low, and the collector current of Q101 will decrease. When the collector current of Q101 decreases, the resistance of R101 will be approached equivalent.

[0035]

Since 2 phase oscillator comprises a CR oscillator, the oscillating frequency of 2 phase oscillator becomes low. If the oscillating frequency of 2 phase oscillator becomes low, the drive frequency of an inverter will become low.

Fig.4 - B shows that the output voltage of a secondary unit becomes high, when drive frequency becomes low.

[0036]

As mentioned above, secondary voltage information is fed back to a primary side, changes the drive frequency of an inverter, and stabilizes the output voltage of a secondary.

[0037]

The current information of a secondary can be fed back at a primary side using the same technique, the drive frequency of an inverter can be changed, and the output current of a secondary can be stabilized.

[Brief Description of the Drawings]

[0038]

[Drawing 1]It is an outline circuit diagram showing the embodiment of the present invention.

[Drawing 2]Structural drawing of a coupling transformer.

[Drawing 3]The detail circuit diagram for feedback control.

[Drawing 4]The explanatory view showing the resonance frequency characteristic of a drive frequency pair and a primary side series resonant circuit, the resonance frequency characteristic of a secondary series resonant circuit, and the relation of secondary rectified voltage.

[Drawing 5]The time chart which describes operation of an inverter circuit and a coupling transformer.

[Drawing 6]The time chart which describes operation of feedback control.

[Explanations of letters or numerals]

[0039]

L1: The primary side winding inductance of a coupling transformer.

L2: The secondary winding inductance of a coupling transformer.

The capacitor for the C 1:1st side series resonance.

The capacitor for the C 2:2nd side series resonance.

L3: The receiver coil for control.

L4: The transmission coil for control.

C7: The capacitor for parallel resonance of L4.

C8: The capacitor for parallel resonance of L3.

fp: Resonance frequency of a primary side series resonant circuit.

fs : resonance frequency of a secondary resonant circuit.

f1 : Inverter drive frequency at the time of rated load.

f0: Inverter drive frequency at the time of heavy loading.

f2: Inverter drive frequency at the time of a light load.

TECHNICAL FIELD
[Field of the Invention]
[0001]
The present invention feeds back the voltage and current in a secondary to a primary side in non-contact transfer-of-power equipment, and relates to the non-contact transfer-of-power equipment which carries out stabilization control of secondary side output voltage and the current.

PRIOR ART
[Background of the Invention]
[0002]
In non-contact transfer-of-power equipment, when measuring stabilization of a secondary, there is the method of providing the stabilization circuit independent to the secondary. (For example, a Patent document 1, 2, three references.).
[Patent document 1] Patent public presentation No. 354711 [2002 to] Gazette
[Patent document 2] Patent public presentation No. 120915 [2004 to] Gazette
[Patent document 3] Patent application No. 252511 [2002 to] Gazette
[0003]
By changing the value of the capacitor for resonance of a secondary resonant circuit, resonance frequency is changed and the 2nd method includes a method stable using the method of changing the electric power which can receive transmitted electricity by a secondary. (For example, see Patent Document 4.).
[Patent document 4] Patent public presentation No. 72832 [2004 to] Gazette

EFFECT OF THE INVENTION
[Effect of the Invention]
[0009]
Since according to the non-contact transfer-of-power equipment of the present invention the voltage current information on a secondary is transmitted to a primary side by non-contact, the drive frequency of an inverter is changed and output voltage and current can be controlled, it is in the same regulated power supply as the switching power supply using a closed magnetic circuit core being realizable.
For this reason, chopper circuits and the series regulator for the stabilization independent to the secondary unit are unnecessary, and since there is no loss for the stabilization circuit of a secondary, efficient non-contact transfer-of-power equipment is realizable. Since the stabilization circuit independent to the secondary unit is unnecessary, it becomes unnecessary [the packaging area of this circuit], and a miniaturization changes possible and also reduces cost.
[0010]
By performing control which raises the drive frequency of an inverter at a light load or the time of no-load, [secondary side load] In order to detune from the resonance frequency of the primary side series resonant circuit of the coupling transformer to drive, the high frequency current of a primary side coil will also decrease, and it is effective in the ability to reduce the power consumption of AC power supply at a light load or the time of no-load. [secondary side load]

TECHNICAL PROBLEM

[Problem to be solved by the invention]

[0004]

The following are raised as problem of a conventional system. That is, the method of providing the stabilization circuit independent to the secondary has the loss of the stabilization circuit of a secondary, and will lower the whole efficiency.

When a secondary is a light load, the current of the primary side coil of a coupling transformer does not decrease, and the power consumption of a primary side coil does not reduce it.

[0005]

When the secondary of the method of changing the resonance frequency of the resonant circuit of a secondary is a light load, the current of the primary coil of a coupling transformer does not become small, and the power consumption of a primary side coil does not reduce it.

[0006]

In the method of carrying out stabilization control of the secondary side output voltage in the conventional non-contact transfer-of-power equipment described above, and the current, the whole efficiency is bad. Power consumption in case secondary side load is a light load cannot be reduced.

[0007]

An object of the present invention is to be efficient and to realize stabilization control of the secondary side output voltage in non-contact transfer-of-power equipment, and current.

MEANS

[Means for solving problem]

[0008]

In order to attain the above-mentioned purpose, the non-contact transfer-of-power equipment of the present invention, Transmit the signal about the voltage and current in a secondary to a primary side unit at a primary side using a non-contact electromagnetic coupling coil, and the signal sent from the secondary in the primary side unit is received, The means which changes the drive frequency of the inverter of a primary side unit, and carries out stabilization control of the output voltage and current of a secondary is provided.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[0038]

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[Drawing 6]The time chart which describes operation of feedback control.

[Brief Translation]

KOREAN INTELLECTUAL PROPERTY OFFICE
PATENT APPLICATION PUBLICATION (A)

Application No.: 10-2005-0072402 Publication No.: KR 10-2007-0017804 A
Applicant: JC PROTEK CO., LTD.

TITLE:

SMALL AND LIGHT WIRELESS POWER TRANSCEIVING DEVICE, CAPABLE OF PREVENTING ACCIDENT CAUSED BY DISCONNECTION OF CABLE AND ELECTRIC LEAKAGE AND CONVENIENTLY ANSWERING CALLS IN CHARGING PROCESS WITH SIMPLE INSTALLATION

ABSTRACT:

OBJECTIVE: A small and light wireless power transceiving device is provided to charge a battery of various electric devices quickly on one transmitting pad in a noncontact and wireless method.

CONSTITUTION: In a small and light wireless power transceiving device, a signal control unit includes a noise removing filter to remove a noise included in power inputted with AC 220V/110V or various types and a rectifying circuit rectifying an AC signal whose noise is removed, and transforms the rectified DC power to an electrical signal having a frequency in a range of several tens kHz to several hundreds kHz and the predetermined output by using a switching circuit. A transmitting output control unit includes a transformer transforming the electric signal generated from the signal control unit to a required voltage and a rectifying circuit rectifying the transformed power, and transmits the transformed signal as a constant-voltage source with the predetermined frequency and output to a transmission coil so as to control the frequency and the output. A transmitting pad (13) receives the signal from the transmission output control unit and generates an induced magnetic field of an electromagnetic wave to a solenoid or spiral type transmission coil.

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(54) 소형 · 경량의 무선 전력 송수신 장치

(57) 요약

본 발명은 전자파의 유도 자기장을 발생하는 송신패드 및 충전용 전자기기의 내외장형 수신용 모듈을 사용하여 핸드폰, 리모콘, MP3, PMP, PDA 및 배터리 충전이 필요한 다양한 전자기기들의 전원충전을 위하여 송신패드위에서 자유롭게 무접점 · 무선으로 동시에 여러 가지 전자기기들의 배터리에 전원을 충전할 수 있는 어댑터 및 송신패드로 구성된 송신모듈과, 송신모듈 및 수신모듈을 구비한 소형 · 경량의 무선 전력 송수신 장치에 관한 것이다. 보다 구체적으로 본 발명은 다양한 전자기기 내외장용 수신용 모듈의 사용하여 핸드폰, MP3 및 PDA등의 배터리 충전을 위하여 송신패드위에서 무접점 · 무선으로 충전할 수 있는 소형 · 경량의 무선 전력 송수신 장치에 있어서, 콘센트로부터 나오는 일반적인 교류전원을 AC 어댑터를 경유하여 수십㎑내지 수백㎑의 교류 정전압 신호로 변환한 후 높은 에너지 효율로 전력을 송신할 수 있도록 구성된 송신코일을 구비하고 전자파의 유도 자기장을 발생하는 송신패드와, 상기 송신패드에서 발생한 전자파의 유도 자기장을 수신하기 위하여 솔레노이드 혹은 스파이럴구조의 수신코일과, 수신코일을 통해서 수신된 전기 에너지를 극대화하기 위한 공진회로와, 공진회로를 거쳐서 나온 신호를 정류하는 정류 회로와, 정류된 소정 전류와 전압을 가진 전기에너지를 충전하는 충전회로 및 보호회로로 구성된 수신모듈을 구비하고 최대 유도 수신전력 변환 및 전력 전송으로 핸드폰, 리모콘, MP3, PMP, PDA 및 충전이 필요한 다양한 전자기기의 배터리에 전원을 충전함으로써 전선의 단선 및 누전에 의한 안전사고를 예방할 수 있고 소형 · 경량으로 취급이 용이하게 하는데 그 특징이 있다.

대표도

도 1

특허청구의 범위

청구항 1.

InductEV, Inc.
Exhibit 1025
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전자기파 유도자기장을 발생하기 위한 송신모듈에 있어서,

교류 220V/110V 또는 다양한 형태로 입력되는 전원에 포함된 노이즈를 제거하는 노이즈제거필터와, 노이즈가 제거된 교류신호를 정류하는 정류회로(33)와, 정류된 DC전원을 스위칭 회로를 사용하여 수십㎑내지 수백㎑ 주파수와 소정의 출력을 가진 전기신호로 변환하는 신호제어부와,

상기 신호제어부(34)에서 소정의 출력과 주파수를 가진 전기신호를 필요한 전압으로 변환하는 트랜스포머(35)와, 이를 정류하는 정류회로(36)를 거쳐서 필요한 정전압원으로 변환한 후 소정의 주파수와 출력을 가진 신호로 송신코일(39)로 전송하여 주파수 및 출력을 제어하는 송신 출력제어부와,

상기 송신 출력제어부로부터 전송된 신호를 수신하여 솔레노이드 혹은 스파이럴형태의 송신코일로 전자파의 유도 자기장을 발생하는 송신패드로 구성된 전자파의 유도 자기장을 발생하는 송신모듈.

청구항 2.

청구항1에 있어서,

상기 신호제어부와 출력제어부를 하나로 묶어서 어댑터를 구성하고, 서로 유선으로 연결되되 분리하여 송신패드를 구성하며, 상기 어댑터는 송신패드에서 떨어져 공급전원과 인접하여 위치시키거나 송신패드 가까이 위치시키는 구성으로 이루어진 전자파의 유도 자기장을 발생하는 송신모듈.

청구항 3.

청구항1 또는 청구항2에 있어서,

상기 송신패드는 소정의 외경과 내경을 가지고 소정의 회수로 감은 스파이럴 형태의 중계코일과, 상기 중계코일과 공진회로를 형성하기 위한 커패시터로 구성한 중계기와,

상기 중계기를 형성하고 있는 스파이럴코일 내부에 위치하며, 서로 유선으로 연결되지 않으면서 소정의 외경과 내경을 가지고 소정의 회수로 감은 스파이럴형태의 송신코일로 구성된 전자파의 유도 자기장을 발생하는 송신모듈.

청구항 4.

무접점·무선으로 다양한 전자기기를 충전할 수 있는 소형·경량의 무선 전력 송수신장치에 있어서,

소정의 전원을 사용하여 소정의 주파수와 출력을 가진 신호로 변환하여 출력신호를 발생하는 출력제어부와, 상기 출력제어부로부터 전송된 전기신호를 전송받아서 전자파의 유도자기장을 발생하는 송신코일로 구성된 송신모듈과,

상기 송신모듈에서 발생한 전자파의 유도 자기장을 수신하는 수신코일과, 수신코일에 유기된 유도기전력을 이용하여 충전에 필요한 소정의 직류전기에너지로 변환하는 수신모듈로 구성된 소형·경량의 무선 전력 송수신장치.

청구항 5.

무접점·무선으로 다양한 전자기기를 충전할 수 있는 소형·경량의 무선 전력 송수신장치에 있어서,

소정의 전원과 체결되며, 정류회로, 스위칭 회로 및 피드백회로를 사용하여 소정의 주파수와 출력을 가진 전기신호로 변환하여 출력신호를 발생하는 출력제어부를 가진 어댑터와, 상기 출력제어부에서 전송된 전기신호에 기초하여 전자파의 유도자기장을 발생하는 송신코일을 내장한 송신패드를 구비한 송신모듈과,

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상기 송신패드에서 발생한 전자파의 유도자기장을 수신하는 수신코일과, 상기 수신코일과 병렬로 연결되어 수신코일과 공진회로를 구성하면서 출력단으로 최대전력 전송을 위한 임피던스 매칭용 가변커패시터와, 상기 가변커패시터를 거쳐서 나온 신호를 직류전원으로 정류하는 정류회로와, 상기 정류회로를 거쳐서 나온 직류전원을 핸드폰, 리모콘, PMP, MP3 및 PDA 중에 어느 하나를 선택하여 충전용 접점에 맞도록 접속단자를 구성한 수신모듈을 구비한 소형·경량의 무선 전력 송수신장치.

청구항 6.

청구항4 또는 청구항5에 있어서,

상기 송신패드는 스파이럴 코일과, 전자파의 유도자기장을 중계하는 중계코일 및 상기 중계코일과 공진회로를 형성하기 위한 커패시터로 구성된 중계기와 상기 중계기와 유선으로 연결되지 않으면서 소정의 거리를 두고 설치된 스파이럴 코일과 결합한 구성과, 자성체 코어에 소정회수의 유도코일을 감은 솔레노이드 코일과, 하나의 자성체코어에 중계코일을 감고 중계코일과 공진회로를 형성하기 위한 커패시터로 이루어진 중계기와 상기 중계기와 유선으로 연결되지 않으면서 소정회수의 송신용 유도코일과 결합한 구성 중 어느 하나를 선택하여 구성한 소형·경량의 무선 전력 송수신장치.

청구항 7.

청구항4 또는 청구항5에 있어서,

상기 수신용 코일은 자성체 코어에 소정회수의 유도코일을 감은 솔레노이드코일과, 하나의 자성체코어에 소정회수의 수신코일과 상기 수신코일과 유선으로 연결되지 않으면서 전자파의 유도자기장을 강화하는 중계코일을 감고 중계코일과 공진회로를 형성하는 커패시터로 이루어진 중계기가 결합된 구성과, 스파이럴 코일과, 스파이럴코일과 상기 스파이럴코일과 유선으로 연결되지 않으면서 전자파의 유도자기장을 중계하는 중계코일과 상기 중계코일과 공진회로를 형성하는 커패시터로 구성된 중계기가 결합된 구성 중 어느 하나를 선택하여 구성한 소형·경량의 무선 전력 송수신장치.

청구항 8.

청구항4에 있어서,

상기 수신모듈은 상기 수신코일과 병렬로 연결되어 수신코일과 공진회로를 구성하면서 출력단으로 최대전력 전송을 위한 임피던스 매칭용 가변커패시터와,

상기 가변커패시터를 거쳐서 나온 신호를 직류전원으로 정류하는 정류회로 및 평활회로와,

상기 정류회로 및 평활회로를 거쳐서 나온 직류전원을 전기에너지의 충전을 필요로 하는 전자기기의 충전용 접점에 맞는 접속단자를 구비한 소형·경량의 무선 전력 송수신장치.

청구항 9.

청구항4 또는 청구항8에 있어서,

상기 수신모듈내부에는 충전용 배터리가 방전되어 작동되지 않을 경우에 사용할 수 있도록 충전용 배터리를 더 구비한 소형·경량의 무선 전력 송수신장치.

청구항 10.

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청구항4, 청구항5 및 청구항8 중 어느 한 항에 있어서,

상기 수신모듈은 핸드폰, 리모콘, PMP, MP3 및 PDA 중에 어느 하나를 선택하여 충전용 접점에 맞는 접속단자를 구비하고 외부기기와 체결되는 구성이나 핸드폰, 리모콘, PMP, MP3 및 PDA 중 어느 하나를 선택하여 내부에 내장시키는 구성으로 이루어진 소형·경량의 무선 전력 송수신장치.

명세서

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 소정의 전원을 공급받아서 전자파의 유도 자기장을 발생하는 송신패드 및 충전용 전자기기의 배터리 충전용 내외장형 수신용 모듈을 사용하여 핸드폰, 리모콘, MP3, PMP, PDA 및 배터리의 충전이 필요한 다양한 전자기기들의 전원충전을 위하여 송신패드위에 위치시켜 무접점·무선으로 동시에 충전할 수 있도록 어댑터 및 송신패드로 구성된 송신모듈과, 송신모듈 및 수신모듈을 구비한 소형·경량의 무선 전력 송수신 장치에 관한 것이다.

종래기술로는 전기에너지를 공급하는 전선들의 접촉에 의하여 전력이 전달되도록 구성된 핸드폰, MP3 및 PDA 등의 배터리를 충전하기 위하여서는 각각의 기종에 맞는 배터리 충전기가 필요하며 유선에 의한 충전 시 충전기의 접점단자의 접촉을 확인하여야 하는 번거러움과, 접점단자들이 대기 중에 노출되어 절연물질의 적층 및 부식에 의하여 사용할 수 없는 경우가 발생하거나 습기에 노출되어 충전 시 접점을 통한 감전의 위험성 및 방전이 발생하는 등의 문제점과 이외에 동시에 다양한 기종 및 다양한 전기기기들의 충전이 불가능한 문제점과, 부피가 비교적 크고 무거우며 충전 시 걸려온 전화를 받기가 불편하고, 핸드폰 배터리 방전시 일시적 충전을 위해 일회용 배터리 충전기를 사용하나 재충전이 불가능하다는 문제점이 있다.

발명이 이루고자 하는 기술적 과제

본 발명이 이루고자 하는 기술적 과제는 상기와 같은 종래기술의 문제점을 인식하고 창안된 것으로, 노이즈필터, 정류회로, 주파수 변환회로, 정전압 회로 및 다양한 크기와 출력의 전자파의 유도 자기장을 발생할 수 있도록 전기신호를 제어하는 출력제어부로 구성된 AC어댑터와 AC어댑터에서 전송된 전기신호로 전자파의 유도 자기장을 발생하는 송신코일로 이루어진 송신패드로 구성된 송신모듈를 구비하며, 상기 송신패드에서 발생한 전자파의 유도 자기장을 수신하기 위하여 솔레노이드 혹은 스파이럴구조의 수신코일과 수신된 전기에너지를 높은 효율로 출력단으로 전송하기 위한 공진 및 임피던스 매칭용 가변커패시터를 거쳐서 나온 신호를 정류하는 정류 회로와 정류되어 소정의 전류와 전압을 가진 전기에너지를 충전하는 충전회로 및 보호회로로 구성된 수신모듈을 구비하고 최대 유도 무선 전력 송수신 장치를 구현하여 핸드폰, 리모콘, MP3, PMP, PDA 및 충전이 필요한 전기기기의 배터리에 전원을 충전함으로써 전선의 단선, 및 누전에 의한 안전사고를 예방할 수 있고 소형·경량으로 설치가 간단하고 충전 시 걸려온 전화를 용이하게 받을 수 있도록 하는데 그 목적이 있다.

발명의 또 다른 목적은 AC어댑터와 송신용 유도 코일과 상기 유도코일과 공진을 이루기 위한 커패시터를 구비하고 최대한 효율이 높은 전자파의 유도 자기장을 발생하는 송신패드로 구성된 송신모듈과, 수신용 유도코일과 공진회로를 형성하면서 출력단과는 임피던스 매칭을 위한 가변커패시터를 구성하여 최대한 높은 효율로 수신 전기에너지를 얻을 수 있으면서 소형·경량으로 설계 제작되어 핸드폰, 리모콘, MP3, PMP, PDA 및 충전이 필요한 전기기기들의 충전용 접점단자에 맞는 내외장형 수신모듈을 제공함으로써 하나의 송신패드위에서 무접점·무선으로 다양한 전기기기들의 충전용 배터리를 효율적으로 신속하게 충전할 수 있고 유선충전 시 발생할 수 있는 여러 가지 불편을 모두 해결하는데 있다.

발명의 또 다른 목적은 충전시 수신모듈내의 용량이 작은 충전용 배터리와 핸드폰등 전자기기내의 충전용 배터리를 동시에 충전하여 수신모듈은 무선전력 변환 기능 외에 전자기기내 배터리의 방전시 응급시 짧은 시간 동안 전자기기내 전원공급을 할 수 있는 용도로도 사용되어질 수 있도록 하는데 있다.

발명의 구성

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본 발명은 소정의 전원 공급하여 전자파의 유도 자기장을 발생하는 송신패드 및 충전용 전자기기의 내외장형 수신용 모듈을 사용하여 핸드폰, 리모콘, MP3, PMP, PDA 및 배터리의 충전을 필요로 하는 다양한 전자기기들의 전원충전을 위하여 송신패드위에서 무접점·무선으로 동시에 여러 대의 충전용 전자기기들을 배터리를 충전할 수 있는 송신패드로 구성된 송신모듈과 상기 송신모듈 및 수신모듈을 구비한 소형·경량의 무선 전력 송수신 장치에 관한 것이다.

종래기술로는 전기에너지를 공급하는 전선들의 접촉에 의하여 전력이 전달되도록 구성된 핸드폰, MP3 및 PDA 등의 배터리를 충전하기 위하여서는 각각의 기종에 맞는 배터리 충전기가 필요하며 유선에 의한 충전 시 충전기의 접점단자의 접촉을 확인하여야 하는 번거러움과, 접점단자들이 대기 중에 노출되어 절연물질의 적층 및 부식에 의하여 사용할 수 없는 경우가 발생하거나 습기에 노출되어 충전 시 접점을 통한 감전의 위험성 및 방전이 발생하는 등의 문제점과 이외에 동시에 다양한 기종 및 다양한 전기기기들의 충전이 불가능한 문제점과, 부피가 비교적 크고 무기우며 충전 시 걸려온 전화를 받기가 불편하고, 핸드폰 배터리 방전시 일시적 충전을 위해 일회용 배터리 충전기를 사용하나 재충전이 불가능하다는 문제점이 있다.

본 발명은 상기와 같은 종래기술의 문제점을 해결하기 위하여 창출된 것이다. 본 발명의 용이하게 이해할 수 있도록 하는 도면에 대하여 살펴본다. 도1은 본 발명에 따른 AC 어댑터와 송신패드로 구성된 송신모듈과 수신모듈로 구성된 소형·경량의 무선 전력 송수신장치의 개략도이며, 도2는 본 발명에 따른 AC 어댑터와 송신패드에 내장된 회로의 블록다이아그램과 수신모듈에 내장된 회로의 블록다이아그램을 나타낸 것이다. 도3은 본 발명의 실시 예를 위하여 설계 제작된 스파이럴 송신코일을 나타낸 것이고, 도4는 본 발명의 실시 예를 위하여 설계 제작된 스파이널 코일로 구성된 중계코일과, 중계코일과 공진회로를 형성하기 위한 공진커패시터 구성의 중계기 및 소정거리의 스파이널 코일로 구성된 송신코일을 보여주고 있다. 도5는 본 발명의 실시 예를 위하여 설계 제작된 스파이널 코일로 구성한 중계코일과, 중계코일과 공진회로를 형성하기 위한 공진커패시터와, 상기 중계코일 내부에 스파이널 코일로 구성된 송신코일을 보여주고 있으며, 도6은 본 발명의 실시 예를 위하여 설계 제작된 하나의 자성체 코어에 유도코일을 감은 수신코일을 나타낸 것이다. 도7은 본 발명의 실시 예를 위하여 설계 제작된 하나의 자성체를 공통코어로 사용하여 수신코일과 중계코일을 감아서 구성한 수신코일을 나타낸 것이며, 도8은 일반적인 스파이널 코일로 구성한 수신코일을 보여주고 있다. 도9는 본 발명의 실시 예를 위하여 설계 제작된 도5의 송신코일과 동일한 구조로 형성한 수신코일을 나타낸 것이며, 도10은 본 발명에 따라 설계 제작된 수신모듈의 회로도이다.

본 발명에 따른 구성수단들을 구체적으로 살펴본다. 본 발명은 무선으로 전력을 수신할 수 있도록 전자파의 유도 자기장을 발생하기 위하여 설계 제작된 AC 어댑터(15)와 송신패드(13)로 구성된 송신모듈과, 상기 송신모듈에서 발생한 전자파의 유도 자기장을 수신하여 유도기전력을 발생하는 수신코일(71)과, 수신된 유도기전력을 극대화하여 출력단으로 전송하기 위하여 수신코일(71)과 병렬로 체결된 공진 및 임피던스 매칭을 위하여 사용되는 가변커패시터(72)와, 가변커패시터(72)를 거쳐서 나온 신호를 다이오드로 정류하는 정류회로(73)와, 정류된 전압을 평활하여 DC전원으로 변환하는 평활콘덴서(74)로 이루어진 수신모듈로 크게 2가지로 구성된 소형·경량의 무선 전력 송수신장치이다. 상기 송신모듈은 핸드폰, 리모콘, MP3, PMP, PDA 및 배터리의 충전이 필요한 다양한 전기기기들의 전원충전을 위하여 수신모듈이 필요로 하는 전자파의 유도자기장을 발생하는 장치로서 가정 또는 산업용으로 사용되는 일반적인 전원 AC 220V/110V로부터 입력되는 전원에 포함된 노이즈를 제거하는 노이즈제거필터(32)와, 노이즈가 제거된 교류전원(신호)을 정류하는 1차 정류회로(33)와, 정류된 DC전원을 스위칭 회로를 사용하여 수십㎑내지 수백㎑ 출력의 주파수를 가진 전기신호로 변환하는 신호제어부(34)와, 신호제어부에서 소정의 출력과 주파수를 가진 전기신호를 필요한 전압으로 변환하는 트랜스포머(35)와 이를 정류하는 2차 정류회로를 거쳐서 필요한 정전압 전원으로 만든 후 필요한 출력과 주파수를 가진 전기신호로 변환하여 송신코일로 전송하는 주파수 및 출력을 제어하는 출력제어부(37)와, 출력제어부(37)를 거쳐서 나온 신호를 전송받아서 전자파의 유도 자기장을 발생하는 송신코일로 구성되어 있다. 상기 출력제어부는 다양한 충전용전자(전기)기기에 필요한 전기에너지를 고려하여 송신출력을 제어할 수 있도록 구성되어 있다. 상기 출력제어부에서 출력되는 신호의 출력을 일정하게 유지하기 위하여 출력신호를 감지하여 신호제어부로 피드백시켜 출력제어부에서 송신코일로 전송되는 전기신호의 출력이 증가하면 감소시키고 출력이 감소하면 증가시켜 일정한 송신출력을 유지시켜주는 피드백회로를 가진다. 상기 어댑터에서 발생한 소정의 주파수 및 출력전압을 일정하게 발생하는 신호에 기초하여 충전에 필요한 전자파의 유도 자기장을 높은 효율로 발생하도록 유도코일과 커패시터를 체결시켜 구성한 송신패드가 설계 제작된다. 상기 AC어댑터(15)와 송신패드(13)로 구성되어 전자파의 유도 자기장을 발생하는 송신부를 송신모듈이라 한다. 상기 AC어댑터와 송신패드는 필요에 따라 일체형 또는 다소 거리를 두고 분리하는 분리형으로 설계 제작할 수 있다. 상기 송신모듈에서 발생한 전자파의 유도 자기장을 수신하기 위하여 솔레노이드 혹은 스파이럴구조의 수신코일과 수신된 전기에너지를 높은 효율로 출력단으로 전송하기 위하여 공진회로 및 전자파의 유도 자기장을 중계하는 중계코일이 부가로 연결되며, 상기 공진회로 및 중계코일을 거쳐서 나온 신호를 정류하는 정류회로와 정류되어 소정의 전류와 전압을 가진 전기에너지를 충전하는 충전회로와, 핸드폰, 리모콘, MP3, PMP, PDA 및 배터리의 충전이 필요한 다양한 전자(또는 전기)기기들의 전원충전을 위하여 각각의 전자기기에 전원을 충전하기 위하여 형성된 접점들과 결합되는 접속단자를 구비한 수신모듈(12)로 구성되어 있다. 상기 수신코일, 증폭중계기

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(상기 중계코일에 해당함) 및 이들의 구성회로에 대하여서는 본원 출원인이 출원한 출원번호 10-2004-0093696호 및 10-2005-0059562호에 자세하게 기재되어 있다. 본 발명에 따른 송신모듈의 출력전압, 주파수 및 출력전력을 제어하여 필요한 송신출력으로 전자파의 유도자기장을 송신패드를 통해서 송신하고, 수신모듈의 접속단자를 충전을 원하는 다양한 전자기기에 형성되어 있는 접점에 맞추어 설계 제작할 경우에 핸드폰(11), MP3, 및 PDA 뿐만 아니라 충전이 필요한 대부분의 전자기기들에 내장시키거나 외부의 접점에 수신모듈(12)에 형성된 접속단자를 체결하여 충전할 수 있다. 본 발명의 송신패드와 AC어댑터는 필요에 따라 일체형 또는 도1에서와 같이 분리형으로 설계 제작할 수 있다. 본 발명에 따른 송신패드와 수신모듈을 구비한 소형·경량의 무선 전력 송수신 장치에 관한 구체적이고 다양한 실시 예를 살펴본다.

[실시 예]

본 발명에 따른 구체적인 실시 예를 도면에 기초하여 살펴본다. 먼저 본 발명에 따른 송신모듈에 대하여 살펴본다. 송신모듈은 일반적인 전원 AC 220V 또는 다양한 형태로 제공되는 전원으로부터 입력되는 전원에 포함된 노이즈를 제거하는 노이즈제거필터와 노이즈가 제거된 교류전원(신호)을 정류하는 정류회로(33)와, 정류된 DC전원을 스위칭 회로를 사용하여 수십㎑내지 수백㎑ 출력의 주파수를 가진 전기신호로 변환하는 신호제어부(34)와, 신호제어부(34)에서 소정의 출력과 주파수를 가진 전기신호를 필요한 전압으로 변환하는 트랜스포머(35)와, 이를 정류하는 정류회로(36)를 거쳐서 필요한 정전압 전원으로 만든 후 필요한 출력으로 공급하면서 소정의 주파수와 전압을 가진 신호를 송신코일(39)로 전송하는 주파수 및 출력을 제어하는 송신 출력제어부와, 송신 출력제어부(37)를 거쳐서 나온 신호를 전자파의 유도 자기장을 발생하는 송신코일로 구성되어 다양한 충전용전자기기에 필요한 전기에너지를 고려하여 송신출력을 제어하여 공급하는 구성들을 구비한다. 상기 출력제어부에서 출력되는 전기신호의 출력을 일정하게 유지하기 위하여 송신패드로 전송되는 출력신호를 감지하여 신호제어부로 피드백시켜 출력제어부에서 송신코일로 전송되는 전기신호의 출력이 증가하면 감소시키고 출력이 감소하면 증가시켜 항상 일정한 송신출력을 유지시켜주는 피드백회로를 가진다. 상기 송신모듈에서 유도코일이 내장된 송신패드의 앞단에 설치되는 AC어댑터(15)는 다양한 방법에 설계 제작하여 안정된 출력을 가지면서 소정의 주파수와 AC 출력전압을 발생할 수 있도록 구성되어야 한다. 본 발명에 따른 송신패드에 내장된 송신코일의 구성은 수신모듈(12)에 내장된 수신코일에서 최대한 많은 전기에너지가 유도될 수 있도록 전자파의 유도자기장을 발생할 수 있도록 다양하게 형성할 수 있다. 표1은 도3에서 구성한 스파이널 코일의 직경, 감은 수, 내경 및 외경을 나타낸 것이며, 본 발명의 실시 예에서 사용된 송신코일의 샘플1에 해당한다.

표1. 도3의 스파이널 코일의 직경, 감은 수, 내경 및 외경(송신샘플1)

도3	내경(㎜)	외경(㎜)	코일종류(㎜)	감은수
송신코일	24	80	0.2*8	34

표2는 도4와 같이 설계 제작된 스파이럴 코일로 전자파의 유도자기장을 중계를 위한 중계코일과, 중계코일과 공진을 형성하기 위해 공진커패시터를 연결 구성한 스파이럴형 중계기와 소정거리의 스파이럴 송신코일의 직경, 감은 수, 내경 및 외경을 나타낸 것이며, 본 발명의 실시 예에서 사용된 송신코일의 샘플2에 해당한다.

표2 :도4의 중계코일 및 송신코일의 직경, 감은 수, 내경 및 외경(송신샘플2)

도4	내경(㎜)	외경(㎜)	코일종류(㎜)	감은 수
중계코일	24	80	0.2*8	34
송신코일	24	80	0.2*8	34

표3은 도5와 같이 설계 제작된 스파이럴 코일로 전자파의 유도 자기장의 중계를 위한 중계코일과, 중계코일과 공진회로를 형성하기 위한 커패시터로 구성되어진 중계기와 상기 전자파의 유도자기장의 강화를 위한 중계코일 내부에 스파이럴 코일로 송신코일을 구성한 송신코일의 샘플에 대한 중계코일 및 송신코일의 직경, 감은 수, 내경 및 외경을 나타낸 것이며, 본 발명의 실시 예에서 사용된 송신코일의 샘플3에 해당한다. 송신코일과 중계기는 유선으로 연결되어져 있지 않으며, 패드의 크기와 형태에 따라 중계코일 및 송신코일을 감은 수, 외경 및 내경 등을 다르게 수성할 수 있다.

표3 :도5의 중계코일 및 송신코일의 직경, 감은 수, 내경 및 외경(송신샘플3)

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도5	내경(㎜)	외경(㎜)	코일종류(㎜)	감은 수
송신코일	20	30	0.2*8	9
중계코일	30	80	0.2*8	29

본 발명에 따라 설계 제작되는 송신코일은 상기 샘플1, 샘플2 및 샘플3에서 설계 제작된 스파이럴로 구성된 송신코일 대신에 본 발명의 특허 출원인 2005년 출원한 출원번호 10-2005-0059562호에 기재된 자성체 코어와 코일을 이용하여 송신코일과 중계코일(상기 특허출원에서는 전자파의 유도자기장 증폭중계기라고 기재되어 있습니다)을 구성할 수 있다.

다음은 본 발명에 따라 설계 제작된 수신코일에 대하여 구체적으로 살펴본다. 핸드폰, MP3 및 PDA 등에 채용될 수 있는 내외장형 수신모듈에 삽입되도록 설계 제작된 소형·경량의 수신코일의 샘플구조들을 살펴본다. 도6은 자성체 코어에 유도코일을 감은 솔레노이드 코일로 구성한 수신코일이며, 표4는 수신 솔레노이드 코일의 직경, 높이, 코일종류 및 감은 수를 나타낸 것으로 수신코일 샘플1이다.

표4. 수신코일의 직경, 높이, 코일종류 및 감은 수(수신샘플1)

도6	직경(㎜)	높이(㎜)	코일종류(㎜)	감은 수
수신코일	10	7	0.1*30	10

도7은 하나의 자성체(페라이트)를 공통코어로 사용하여 수신코일과 전자파의 유도자기장을 중계하는 중계코일을 감아서 구성한 수신코일이며, 표5는 수신코일 및 중계코일의 직경, 높이, 코일규격 및 감은 수를 표시한 것으로 수신코일샘플2에 해당한다.

표5. 수신코일 및 중계코일의 직경, 높이, 코일규격 및 감은 수(수신샘플2)

도7	내경(㎜)	외경(㎜)	코일규격(㎜)	감은 수
수신코일	5	20	0.2*8	9
중계코일	20	40	0.43*1	21

도8은 일반적인 스파이럴 코일로 구성한 수신코일이며, 표6은 코일의 직경, 감은 수, 내경 및 외경을 나타낸 것으로 수신코일샘플3에 해당한다.

표6. 스파이널 코일의 직경, 감은 수, 내경 및 외경(수신샘플3)

도8	내경(㎜)	외경(㎜)	코일종류(㎜)	감은 수
수신코일	10	25	0.2*8	8

도9는 도5의 송신코일과 동일한 구조로 외부에는 스파이럴 중계코일과 공진회로 구성을 위한 커패시터를 사용하여 전자파의 유도 자기장을 강화하는 중계기를 구성하고, 내부에 스파이럴 수신코일로 결합된 구조로 수신코일 샘플4에 해당한다. 표7은 상기 수신코일 샘플4에 사용된 중계코일 및 수신코일의 직경, 감은 수, 내경 및 외경을 나타낸 것이다.

표7. 중계코일 및 수신코일의 직경, 감은 수, 내경 및 외경(수신샘플4)

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도9	내경(㎜)	외경(㎜)	코일규격(㎜)	감은 수
수신코일	5	20	0.2*8	9
중계코일	20	40	0.43*1	21

상기 도3내지 도9 및 표1내지 표7에서와 같이 구성한 송신코일 및 수신코일로 설계 제작된 송수신코일의 샘플들을 조합하여 핸드폰, MP3 및 PDA 등에 채용될 수 있는 내외장형 수신모듈에 삽입되어 소형·경량의 무선 송수신장치를 얻기 위한 샘플구조에 있어서, 상기 송신모듈의 출력제어부에 송신출력을 10W, AC 100㎑ 주파수로 송신하여 전자파의 유도자기장을 발생시키고, 상기 수신코일 샘플1내지 4에서 설계 제작한 다양한 수신 샘플코일들을 사용하여 수신모듈의 충전 회로도를 구성하여 출력단에서 DC 전력이 3.7V 전자기기(핸드폰) 충전용 배터리에 전기에너지를 충전 시에 수신전압, 전류 및 전력 값을 측정한다. 수신모듈은 핸드폰 등의 전자기기에 필요한 전기에너지를 충전하는 수단만 내장시키거나 소정의 용량을 가진 충전용 배터리를 상기 충전수단과 동시에 내장시켜 병렬로 동시에 충전되도록 구성할 수 있다. 상기 수신코일샘플 1내지 4의 뒷단에 높은 효율로 전기에너지를 전송하기 위하여 공진 및 임피던스 매칭용 가변 커패시터가 체결되고, 커패시터를 거쳐서 나온 전기신호를 다이오드를 이용하여 직류신호로 변환하기 위한 정류회로와, 정류된 신호를 평활하기 위한 커패시터로 구성되며 충전을 필요로 하는 전자기기의 배터리에 전기에너지를 충전하게 된다. 즉, 도10의 수신모듈은 수신코일에서 수신된 유도기전력을 출력단으로 높은 효율로 전기에너지를 전송하기 위하여 공진 및 임피던스 매칭용 가변 커패시터를 수신코일과 병렬로 체결 구성하고, 공진 및 임피던스 매칭용 가변 커패시터를 거쳐서 전송된 신호를 정류 다이오드와 평활커패시터를 거쳐서 정전압 및 보호회로를 거친 후, 수신모듈 내에 내장된 소정용량의 3V내지 4V 충전용 배터리와 전자기기내의 3내지 4V 충전용 배터리에 동시에 전기에너지를 충전할 수 있는 구성으로 이루어지거나 전자기기내의 3내지 4V로 충전용 배터리에만 충전할 수 있도록 수신모듈로 구성할 수 있다. 표8은 상기 본 발명의 실시 예에서 설계 제작한 송신코일의 샘플1내지 샘플3 각각에 대하여 상기 수신코일의 샘플1내지 샘플4에 대한 각각의 수신회로를 구성하여 출력단 전자기기의 충전배터리에서 측정한 충전하는 수신전압, 전류 및 전력 값을 나타낸 것이다. 표8을 통해서 알 수 있듯이 전자파의 유도 자기장을 중계하는 중계코일을 결합한 송신코일과 전자파의 유도 자기장을 중계하는 중계코일을 결합한 수신코일로 전자파의 유도자기장을 발생하고 발생한 전자파 자기장을 수신하는 구조가 전자기기의 충전배터리에 전기에너지를 신속하고 높은 효율로 충전할 수 있는 높은 출력전력을 얻을 수 있다. 즉, 스파이럴코일 외부에 중계코일과 송신코일을 결합한 구성인 송신코일샘플3으로 송신패드를 구성하고, 수신코일 샘플2 구조인 하나의 페라이트 코어에 중계코일과 수신코일을 결합하여 구성한 수신모듈로 전자파의 유도 자기장을 송수신할 경우에 가장 큰 충전 수신전류인 1.32A와 충전전력 5.41W를 얻을 수 있었다. 상기 중계코일을 포함하지 않는 일반 송신코일 샘플1을 사용하여 송신코일로 구성하고, 중계코일을 사용하지 않은 일반 솔레노이드로 구성된 수신코일 샘플1과 스파이럴 수신코일인 샘플3의 구조에서는 아주 낮은 0.24W, 0.28W의 충전전력을 얻었다.

표8. 본 발명의 실시 예에서 설계 제작한 송신코일의 샘플1내지 샘플3 각각에 대하여 수신코일의 샘플1내지 샘플4에 대하여 수신모듈의 출력단 전자기기내 충전 배터리 에서 측정한 수신전압, 전류, 전력값

송신	수신			
송신샘플	수신샘플	수신전압(V)	수신전류(A)	수신전력(W)
송신샘플1	수신샘플1	4.1	0.06	0.24
	수신샘플2	4.1	0.2	0.82
	수신샘플3	4.1	0.07	0.28
	수신샘플4	4.1	0.18	0.73
송신샘플2	수신샘플1	4.1	0.17	0.69
	수신샘플2	4.1	0.4	1.64
	수신샘플3	4.1	0.20	0.82
	수신샘플4	4.1	0.37	1.51
송신샘플3	수신샘플1	4.1	0.74	3.03
	수신샘플2	4.1	1.32	5.41
	수신샘플3	4.1	0.81	3.32
	수신샘플4	4.1	1.13	4.63

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본 발명에 따라 구성되는 전자파 유도자기장 발생을 위한 송신패드를 구성하는 송신코일은 상기 실시 예에서 설계 제작한 다양한 종류의 송신코일 외에 본 발명의 특허 출원인 2005년 출원한 출원번호 10-2005-0059562호에 기재된 자성체 코어와 유도코일을 사용하여 구성한 송신코일과 중계증폭기(본 발명의 중계코일에 해당한다) 등을 사용하여 다양하게 구성할 수 있으며, 수신코일 또한 상기 실시 예에서 설계 제작한 다양한 종류의 수신코일 외에 본 발명의 특허 출원인 2005년 출원한 출원번호 10-2005-0059562호에 기재된 자성체 코어, 유도코일 및 가변커패시터를 사용하여 구성한 수신코일과 중계증폭기(본 발명의 중계코일에 해당한다) 등을 사용하여 다양하게 구성할 수 있다. 본 발명에 따른 송신모듈의 출력전압, 주파수 및 출력전력을 제어하여 송신출력을 제어하여 송신하고, 수신모듈의 접속단자를 충전을 원하는 다양한 전자기기에 형성되어 있는 접점에 맞추어 설계 제작할 경우에 핸드폰, 리모콘, MP3, PMP, PDA 뿐만 아니라 충전이나 전원공급이 필요한 대부분의 전자기기들에 내장 또는 외장형으로 설계 제작하여 배터리 충전에 적용할 수 있다. 본 발명의 송신패드와 AC어댑터는 필요에 따라 일체형 또는 도1에서와 같이 분리형으로 설계 제작할 수 있다.

발명의 효과

본 발명은 노이즈필터, 정류회로, 주파수 변환회로, 정전압 회로 및 다양한 크기와 출력의 전자파의 유도 자기장을 발생할 수 있도록 전기신호를 제어하는 출력제어부로 구성된 AC 어댑터와, 어댑터에서 전송된 전기신호와 연결된 송신코일로 전자파의 유도 자기장을 발생하는 송신패드로 구성된 송신모듈과, 상기 송신모듈에서 발생한 전자파의 유도 자기장을 수신하기 위하여 수신코일과 수신된 전기에너지를 극대화하기 위한 공진 및 임피던스 매칭 회로와 충전용 DC전원으로 변환하는 정류회로로 구성된 수신모듈을 구비하고 최대 유도 무선 전력 송수신 장치를 구현하여 핸드폰, 리모콘, MP3, PMP, PDA 및 충전이 필요한 기기의 배터리에 전원을 충전함으로써 전선의 단선 및 누전에 의한 안전사고를 예방할 수 있고 소형·경량으로 설치가 간단하고 충전 시 걸려온 전화를 용이하게 받을 수 있는 작용효과가 있다.

발명의 또 다른 효과는 AC어댑터와 송신용 유도 코일과 상기 유도코일과 공진을 이루기 위한 커패시터를 구비하고 최대한 효율이 높은 전자파의 유도 자기장을 발생하는 송신패드와, 수신용 유도코일과 공진회로를 형성하면서 출력단과는 임피던스 매칭을 위한 가변커패시터를 구성하여 최대한 높은 효율로 수신 전기에너지를 수신모듈내 소형 충전 배터리와 전자기기내 충전 배터리에 공급하면서 소형·경량으로 설계 제작되어 핸드폰, 리모콘, MP3, PMP, PDA 및 충전이 필요한 전기기기들의 충전용 접점단자에 맞는 내외장형 수신모듈을 제공함으로써 하나의 송신패드위에서 무접점·무선으로 다양한 전기기기들의 충전용 배터리를 효율적으로 신속하게 충전할 수 있고 유선충전 시 발생할 수 있는 여러 가지 불편을 모두 해결하고 수신모듈내 소정 크기의 충전용 배터리를 이용하여 전자기기내 충전 배터리의 방전시 응급용 전자기기내 전원공급으로도 사용할 수 있도록 하는데 있다.

도면의 간단한 설명

도1 : 본 발명에 따른 AC 어댑터를 구비한 송신패드와 수신모듈로 구성된 소형·경량의 무선 전력 송수신장치의 개략도

도2 : 본 발명에 따른 AC 어댑터와 송신패드에 내장된 회로의 블록다이아 그램과 수신모듈의 블록다이아 그램

도3 : 스파이럴 송신코일

도4 : 스파이럴 코일로 구성된 중계코일과, 중계코일과 공진회로를 형성하기 위한 공진커패시터 구성의 중계기 및 소정거리의 스파이럴 코일로 구성된 송신코일

도5 : 스파이럴 코일로 설계 제작된 중계코일과, 상기 중계코일과 공진회로를 형성하기 위한 공진커패시터와, 상기 중계코일 내부에 스파이럴 코일로 구성된 송신코일

도6 : 자성체 코어에 유도코일을 감은 솔레노이드 구조 수신코일

도7 : 자성체를 공통코어로 하여 수신코일과 중계코일을 감아서 구성한 수신코일

도8 : 일반적인 스파이럴 구조로 구성한 수신코일

도9 : 도5의 송신코일과 동일한 구조로 형성한 수신코일

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도10 : 본 발명에 따라 설계 제작된 수신모듈의 회로도

<도면부호의 간단한 설명>

11 ; 충전 대상인 핸드폰 12 ; 수신모듈

13 ; 송신패드 14 ; 접속단자

15 ; AC어댑터 16 ; 콘센트

31 ; 콘덴서 32 ; 노이즈제거회로

33 ; 1차 정류회로 34 ; 신호제어부

35 ; 트랜스포머 36 ; 2차 정류회로

37 ; 출력제어회로 38 ; 주파수변환 및 출력제어

39 ; 송신코일 40 ; 수신코일

41 ; 공진 및 임피던스 매칭용 가변커패시터 42 ; 정류회로

43 ; 평활콘덴서 44 ; 정전압, 보호회로

45 ; 접속단자 46 ; 수신모듈내 충전배터리

47 ; 전자기기 충전배터리 48 ; 송신모듈

49 ; 수신모듈

51 ; 중계코일 52 ; 송신코일

53 ; 공진커패시터 55 ; 중계코일

56 ; 송신코일 57 ; 공진커패시터

61 ; 수신코일 62 ; 중계코일

63 ; 공진커패시터 65 ; 중계코일

66 ; 수신코일 67 ; 공진커패시터

71 ; 수신코일

72 ; 공진 및 임피던스 매칭용 가변커패시터

73 ; 정류다이오드 74 ; 평활콘덴서

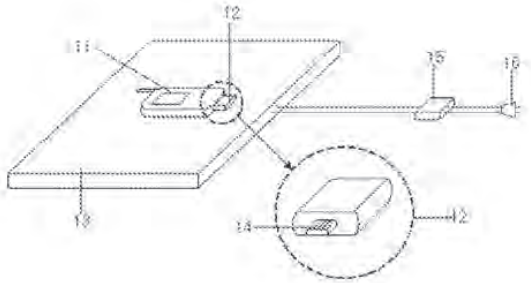
75 ; 정전압, 보호회로

76 ; 수신모듈 내부 충전용배터리 77 ; 전자기기 충전용 배터리

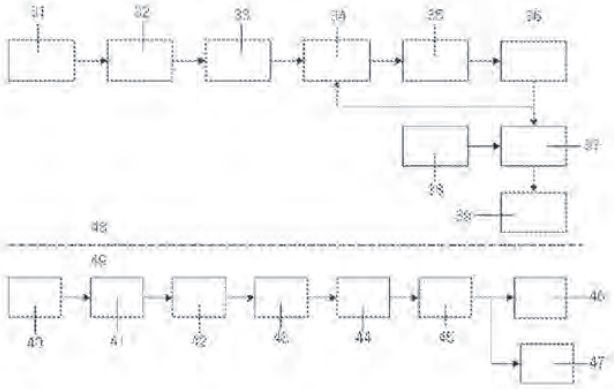
도면

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도면1



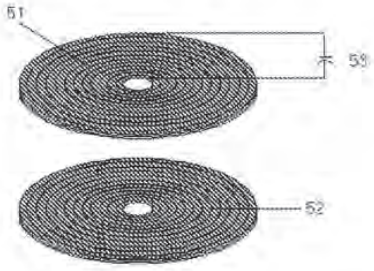
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도면3



도면4

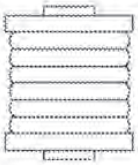


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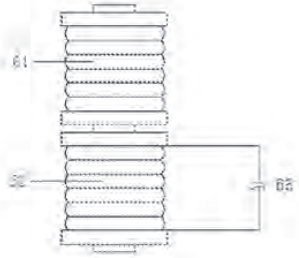
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도면6



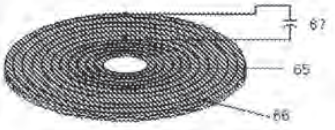
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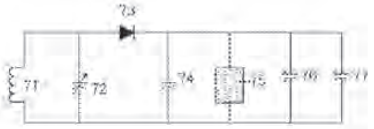
도면8



도면9



도면10



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Gyeongsangbuk-do Andong city 송 thousand eastern 388 Andong anti-aircraft electrification person engineering

(72) invention person elder brother week
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(74) Neck above substitute

(56) Preceding technical investigation literature
Opening to the public patent public information 특 1999-0086135 * it does in the examiner and the literature which is referred

Examiner: Around Kim year

Whole requisition clause possibility: Total 10 clauses

(54) small size • Radio war potential transmitting and receiving system of light weight

(57) Summary

The invention which it sees uses the husband and wife eldest brother reception module of the transmission pad which occurs the induction magnetic field of the electromagnetic waves from above the transmission pad and the charging electronic instrument and the cell phone, the wool cone, MP3 and PMP, PDA and for all the member charging of the electronic instruments which are various battery charging is necessary it is free nothing fold point • The small size which has the transmission module which is composed of 어 map with the radio simultaneously it will be able to charge all the member in the battery of the various branch electronic instruments and the transmission pad and a transmission module and a reception module • Around quantity is the thing in about radio war potential transmitting and receiving system. Sees the invention which it sees concretely to use the electronic instrument husband and wife market reception module which is various, the cell phone, for battery charging of MP3 and PDA etc. from above the transmission pad the

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nothing junction • The small size it will be able to charge with the nothing line • There is to radio war potential transmitting and receiving system of light weight, in order to receive the market which sleeps from the cone cent the ac power who is general comes out it passes through AC 어 map and after converting with tens 池 to hundreds 池 interchange constant voltage signals, it will be able to transmit a war potential with high-energy efficiency, is composed and the transmission coil which it has induction of the electromagnetic waves the market which sleeps induction of the transmission pad which occurs and the electromagnetic waves which occurs from the minute description transmission pad the solenoid or the spy 럴 the reception coil and the reception coil of structure it leads and is received the electric energy which it maximizes the stop circuit which stops the signal which comes out passing by the resonance circuit for and a resonance circuitComes and, the electric energy which has a prescribed electric current and the voltage which are stopped the low of charging to have the reception module which is composed of a charging circuit and a safety circuit all the member in the battery of the electronic instrument which is various charging is necessary, with the maximum induction reception war potential conversion and war potential transmission the cell phone and the remote control, MP3, PMP and PDA and it charges with there to be it will be able to prevent the accident in compliance with the broken wire and an electric leakage of front line, small size • With handling easily is the feature it does around quantity.

Representative

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Patents Administration old friendship scope

Requisition clause 1.

Electromagnetic wave induction above occurring the market which sleeps there is to one transmission module,

After stopping the ac power with direct current, to pass by a control circuit, a switching circuit and an electric current safety circuit and the updated lance former and the solenoid coil or the spy which is an output side load 릴 the coil to lead and the electromagnetic waves in order to radiate, the signal control department which is composed and,

From minute description signal control department with frequency of schedule the transmission coil to lead with the signal which has an output and the electromagnetic waves which has the output which is necessary in order to radiate, the transmission output control department which controls a frequency and an output and,

From minute description transmission output control department receives the signal which is transmitted and induction of the electromagnetic waves which is composed of the transmission pad which the induction magnetic field of the electromagnetic waves with the transmission coil of form the solenoid or the spy 릴 occurs the transmission module which occurs the market which sleeps.

Request Nine clauses 2.

Is to the requisition clause 1,

With minute description signal control department output control department it composes 어 map with all, style it connects with the mammary gland each other, it separates and it composes the minute description 어 map it falls supply all the member and it is contiguous and induction of the electron group which in the transmission pad which is located becomes accomplished with location module composition it occurs the market which sleeps it transmits from the transmission pad which it shakes off and the transmission pad.

Requisition clause 3.

Is to the requisition clause 1 or the requisition clause 2,

The minute description transmission pad has the major diameter and an inside diameter of schedule size and the gratitude spy 릴 it forms the relay coil and the minute description relay coil and a public position circuit of form it respects big is composed at frequency of schedule and the repeater which of the plaque seater and,

The spy which forms the minute description repeater 릴 it is located on the coil inside and or the outside schedule distance, it is located, with the mammary gland each other it is not connected not to be, has the major diameter and an inside diameter of schedule size and at frequency of schedule the gratitude spy 릴 the transmission module which occurs the induction magnetic field of the electromagnetic waves which is composed of the transmission coil of form.

Request Nine clauses 4.

Nothing junction•The small size it will be able to charge the electronic instrument which is various with the radio•There is to radio war potential transmitting and receiving system of light weight.

It uses all the member and with frequency of schedule it converts occurs a output signal the electric signal which is transmitted with the transmission module which is composed of the transmission coil which the induction magnetic field of the electromagnetic waves with the output control department which and minute description output control department and department transmission receives it stands occurs with the signal which has an output and,

It uses the induced electromotive force which abandons in the reception coil which receives the induction magnetic field

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of the electromagnetic waves which occurs from minute description transmission module and the reception coil and the small size which is composed of the reception module which it converts by the direct current electric energy which is necessary to charging •Radio war potential transmitting and receiving system of light weight.

Request Nine clauses 5.

Nothing junction•The small size it will be able to charge the electronic instrument which is various with the radio•There is to radio war potential transmitting and receiving system of light weight.

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It uses all the member and with frequency of schedule it converts occurs a output signal the electric signal which is transmitted with the transmission module which is composed of the transmission coil which the induction magnetic field of the electromagnetic waves with the output control department which and minute description output control department and department transmission receives it stands occurs with the signal which has an output and,

With the reception coil which receives the induction magnetic field of the electromagnetic waves which occurs from minute description transmission module,

It is connected with the minute description reception coil and arranging in a row and it composes it transmits the reception coil and a resonance circuit and the maximum war potential with output grade the impedance whip for 칭 the variable to be big the plaque seater and the minute description variable big to pass by the stop circuit which stops the signal which comes out passing by the plaque seater with the dc power and a minute description stop circuit, it stands the small size which has the reception module which the rock connection terminal the dc power who comes out the cell phone and the remote control, PMP, MP3 and PDA and the pot label selects which one in the electronic instrument and in the charging junction fit composes •Around quantity radio war potential transmitting and receiving system.

Request Nine clauses 6.

Request Is to nine clause 4 or the requisition clause 5,

The minute description transmission module respects and the spy 텔 forms the relay coil which relays the induction magnetic field of the coil and the electromagnetic waves with the repeater which is composed of the plaque seater and the minute description repeater and the mammary gland and the minute description relay coil and a resonance circuit big it is not connected not to be, distance of schedule, the spy which is established 텔 the coil and in the composition which it combines and the magnetic substance core the induction coil of schedule frequency it winds the relay coil in the gratitude solenoid coil and one magnetic substance core it forms the relay coil and a resonance circuit it respects and with the minute description repeater and the mammary gland with the repeater which becomes accomplished big with the plaque seater it is not connected not to be, the schedule meeting veterinarian transmission induction coil and the composition which it combines Selects middle which one and the small size which is produced•Radio war potential transmitting and receiving system of light weight.

Request Nine clauses 7.

Request Is to nine clause 4 or the requisition clause 5,

The minute description reception coil in the magnetic substance core the induction coil of schedule frequency is not connected schedule frequency with the gratitude reception coil and the minute description reception coil and the mammary gland in the gratitude solenoid coil and one magnetic substance core not to be, in order to strengthen the induction magnetic field of the electromagnetic waves it forms the gratitude relay coil and a resonance circuit composition and the spy where the repeater which becomes accomplished big with the plaque seater is combined 텔 the coil and the spy 텔 the coil and minute description off group like this it is not connected schedule frequency with the coil and mammary gland not to be, forms the relay coil which relays the induction magnetic field of the electromagnetic waves and the minute description relay coil and a resonance circuit big the repeater which is composed of the plaque seater combinationWhile the composing which becomes selects which one and the small size which it composes•Radio war potential transmitting and receiving system of light weight.

Request Nine clauses 8.

Is to the requisition clause 4,

The minute description reception module is connected with the minute description reception coil and arranging in a row and it composes above transmitting the maximum war potential with output grade, one impedance whip 칭 the variable it is big the reception coil and a resonance circuit and the plaque seater and,

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The minute description variable big the stop circuit which stops the signal which comes out passing by the plaque seater with the dc power and smoothing circuit and,

The dc power who comes out passing by a minute description stop circuit and a smoothing circuit the small size which has the connection terminal which hits to the charging junction of the electronic instrument which charges a electric energy in necessity •Around quantity radio war potential transmitting and receiving system.

Request Nine clauses 9.

Request Is to nine clause 4 or the requisition clause 8,

To the minute description reception module inside the charging battery will discharge and it will not be operated and it will be able to use in case in order, the cow elder brother who compared to has the charging battery•Radio war potential transmitting and receiving system of light weight.

Requisition clause 10.

Request Nine clauses 4, requisition clause 5 and request there are to which one clauses in nine clause 8,

The minute description reception module the cell phone and the remote control, PMP, MP3 and PDA and the pot label to select which one in the electronic instrument and to hit fold to have with the external machinery and tools in order to be contracted the snap judgment person and to the charging junction and, it is composed and the cell phone and the remote control, PMP, MP3 and PDA and the pot label it selects which one in the electronic instrument and on the inside it has built-in the small size which becomes accomplished with composition it makes•Radio war potential transmitting and receiving system of light weight.

Specifications

The explanation which invention is detailed

Objective of invention

Hitherto technique of the technique where the invention belongs and the field

The invention which it sees supply receives all the member of prescribed and it stands and the induction magnetic field of the electromagnetic waves occurs the body exterior style reception module within battery charging of the transmission pad which and the charging electronic instrument and above the transmission pad it uses the cell phone and the remote control, MP3 and PMP, PDA and for all the member charging of the electronic instruments which are various charging of the battery is necessary it is located the nothing junction to make • It will be able to charge simultaneously with the radio in order, the small size which has the transmission module which is composed of 어 map and the transmission pad and a transmission module and a reception module • Around quantity is the thing transmitting and receiving system the before in about power the radio.

Hitherto in compliance with the contact of the front lines which supply a electric energy in order for the war potential to be delivered, the cell phone which is composed, it charges batter of MP3 and PDA etc. with technique to respect, the battery charger which hits to respectively emphysema is necessary and time must confirm the contact of the junction terminal of the charging at the time of charger in compliance with the mammary gland well! the 러 buds and the junction terminals are exposed in the atmosphere and in compliance with an insulating material question layer and the side food the light right it will not be able to use occurs and is exposed leads to moisture and the charging at the time of junction emphysema which simultaneously is various in problem point and other than of etc. the dangerousness and discharge of the electric shock which occur And the problem point and the bulk whose charging of the electric machineries and tools which are various is impossible are heavy charging at the time of incoming call receive the giga inconvenient relatively big, respects cell phone battery discharge at the time of temporary charging uses the one-time battery charger re-charging is skillful is a problematic point wrongly.

Invention by any means boil the technical subject

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The invention which it sees should by any means have been boiled the technical subject recognizes the problem point of technique hitherto same as above and with the fact that it is originated, with the noise filter and the stop meeting, frequency conversion circuit and constant voltage circuit and with the size which is various AC 어 maps where it will be able to occur in order, electric signal the low of controlling is composed the induction magnetic field of the electromagnetic waves of output with an output control department sprouts and with the transmission coil which occurs the induction magnetic field of the electromagnetic waves with the electric signal which is transmitted from AC 어 map this base to have the transmission module which is composed of the gentle transmission pad in order to receive the induction magnetic field of the electromagnetic waves which from the minute description transmission pad, occurs the brush The leno id or the spy 럴 the reception coil of structure and at the efficiency which is high the electric energy which is received it transmits with output grade the resonance for and the impedance whip 칭 the variable big to be stopped with the stop circuit which stops the signal which comes out passing by the plaque seater, the electric energy which has the electric current and a voltage of prescribed the insect it has the reception module which is composed of the charging circuit which it conveys and a safety circuit the maximum induction radio war potential transmitting and receiving system and all the member in the battery of the electric machinery and tools whose charging is necessary and it embodies the cell phone, the wool cone, MP3, PMP and PDA and it charges with there to be it will be able to prevent the accident in compliance with the broken wire and an electric leakage of front line, Small size • Lightweight the establishment is simple and charging at the time of incoming call easily, the possibility of receiving in order to be, the objective is 있.

Invention also, the different objective respects and AC 어 maps it sprouts the plaque seater big and with accomplishing the transmission induction coil and the minute description induction coil and resonance, it has is composed of the transmission pad which occurs the induction magnetic field of the electromagnetic waves where the maximum efficiency is high the transmission module which and the reception induction coil and a resonance circuit and the plaque seater big and it forms with output grade the impedance whip 칭 a possibility of getting a reception electric energy at high efficiency the variable for it composes the maximum there is, the cow elder brother • Lightweight plan it is produced and the cell phone and the remote control, MP3, PMP and PDA and the pot whose charging is necessary label it provides the husband and wife eldest brother reception module which hits to the charging junction terminal of the electric machineries and tools with from above one transmission pad the nothing junction • The charging battery of the electric machineries and tools which are various with the radio quickly efficiently, it will be able to charge and the mammary gland charging at the time of the various branch it will be able to occur it is all it solves inconveniently.

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Invention also different objective the charging battery where the charging at the time of reception module undergarment dosage is small and the charging battery of the cell phone etc. electromagnetic cabin it charges simultaneously and the reception module on the radio war potential conversion functional outside the discharge at the time of emergency at the time of the electromagnetic cabin battery during short time to be used even with the use which is the possibility cabin all the member worker of class electromagnetically qualitative possibility in order to been, it is.

Composition of invention

The invention which it sees application of power of prescribed, induction of the electromagnetic waves to use the transmission pad which occurs the market which sleeps and the husband and wife eldest brother reception module charging electromagnetic, the cell phone and the remote control, MP3 and PMP, PDA and the pot which is various charges the battery in necessity label for all the member charging of the electronic instruments from above the transmission pad the nothing junction • Simultaneously with the radio the various righteousness charging electronic instruments the small size which has the transmission module which had become nine characteristics with the transmission pad it will be able to charge the battery and a minute description transmission module and a reception module • Around quantity is the thing in about radio war potential transmitting and receiving system.

Hitherto in compliance with the contact of the front lines which supply a electric energy in order for the war potential to be delivered, the cell phone which is composed, it charges batter of MP3 and PDA etc. with technique to respect, the battery charger which hits to respectively emphysema is necessary and time must confirm the contact of the junction terminal of the charging at the time of charger in compliance with the mammary gland well! the 러 buds and the junction terminals are exposed in the atmosphere and in compliance with an insulating material question layer and the side food the light right it will not be able to use occurs and is exposed leads to moisture and the charging at the time of junction emphysema which simultaneously is various in problem point and other than of etc. the dangerousness and discharge of the electric shock which occur And the problem point and the bulk whose charging of the electric machineries and tools which are various is impossible are heavy charging at the time of incoming call receive the giga inconvenient relatively big, respects cell phone battery discharge at the time of temporary charging uses the one-time battery charger re-charging is skillful is a problematic point wrongly.

The invention which it sees in order to solve the problem point of technique hitherto same as above to be created. The invention which it sees easily, it will be able to understand in order, it tries to observe in about the plan. 1 sprouts AC 어 maps which it follows in the invention which it sees with the small size which is composed of the transmission module which is composed of the transmission pad and a reception module • Around quantity it is an abridged general view of radio war potential transmitting and receiving system. 2 AC 어 maps which it follows in the invention which it sees sprouts with the block die of the circuit which is had built-in the transmission pad Oh! is to show the block die yttrium aluminum garnet RAM of gram and the circuit which is had built-in reception module. 3 for the execution example of the invention which it sees plan the spy which is produced 빌 showing the transmission coil and, 4 for the execution example of the invention which it sees plan forms the relay coil which is composed of the spy board coil which is produced and the relay coil and a resonance circuit the resonance for big is showing the transmission coil which is composed of the spy board coil of the repeater and prescribed distance of plaque seater composition. 5 for the execution example of the invention which it sees plan the relay coil which it composes of the spy board coil which is produced and the relay coil and resonance circuit under forming the resonance for to be big is showing the transmission coil which is composed of the spy board coil in the plaque seater and the minute description relay coil inside. 6 for the thread hour example of the invention which it sees plan the induction coil is to show the gratitude reception coil in one magnetic substance core which is produced. 7 for the execution example of the invention which it sees plan uses one magnetic substance which is produced the reception coil and the relay coil with the common core and it winds and it is to show the reception coil which it composes. 8 is showing the reception coil which it composes of the spy board coil which is general. 9 for the execution example of the invention which it sees plan was produced is to show the reception coil which it forms with the structure which is identical with the transmission coil of 5. 10 according to the invention which it sees plan is with also the sliced raw fish of the reception module which is produced.

It tries to observe the composition means which it follows in the invention which it sees concretely. The invention which it sees it will be able to receive a war potential with the radio in order, AC 어 map (15) in order to occur plan it is produced the induction magnetic field of the electromagnetic waves comes receives the induction magnetic field of the transmission module which is composed of the transmission pad (13) and the electromagnetic waves which occurs from

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minute description transmission module and with the reception coil (71) which occurs a induced electromotive force the induced electromotive force which is received and, it maximizes in order to transmit with output grade with the reception coil (71) the resonance which is contracted with arranging in a row and the impedance whip 칭 for the variable which is used the plaque seater (72) it comes big, the variable big the signal which comes out passing by the plaque seater (72) The stop circuit (73) which stops with the diode comes, the voltage which is stopped it is smooth and the smooth condenser which it converts with DC all the member

(74) With at the reception module which becomes accomplished on a large scale the small size which is composed with 2 kind • It is a radio war potential transmitting and receiving system of light weight. When the minute description transmission module the cell phone, the wool cone, MP3 and PMP, PDA and the pot which is various charging of the battery is necessary label for all the member charging of the electric machineries and tools reception module under induction of the electromagnetic waves as the system which occurs the market which sleeps 110V of all the member 60Hz who is general is used with the family or industry or brave fighting circle (31) this at 220V is input in necessity, to have the noise cancellation filter (33) which, removes the noise which in the input at the time of is included in signal the signal where the noise is removed the diode and a stop circuit (34) to use to compose, with the dc power conversionIt becomes, it will be able to output the electromagnetic waves which has the output which is necessary in order, the users to control, it has the control circuit (35) which, is composed when with the electric current flows, it intercepts and it protects with to have an electric current safety circuit (36), it wants is efficient at the frequency where and voltage it occurs the electromagnetic waves which the switching circuit for (37) and the updated lance former (38) under having, the user wants the voltage which and frequency (For example, tens! 他 to hundreds 池, the high frequency, low frequency etc.) with the signal (39) which it has it outputs, the signal which is output to be input with the transmission coil and in order to radiated the electromagnetic waves, it is composed. Frequency and output voltage of prescribed it occurs from minute description 어 map uniformly, it establishes in the signal which occurs and induction of the electromagnetic waves which is necessary to charging in order to occur at high efficiency, with the induction coil big contracts the plaque seater, the transmission pad which it composes plan is produced the market which sleeps to be made Minute description AC 어 map (15) it comes to be composed of the transmission pad (13) and induction of the electromagnetic waves occurs the market which sleeps transmits department the transmission module. The minute description AC 어 map sprouts and with the transmission pad according to necessity all style or some distance minute plan it will be able to produce in the crisis style which it does. In order to receive the induction magnetic field of the electromagnetic waves which occurs from minute description transmission module in order at the efficiency which is high the electric energy which is received to transmit with output grade the solenoid or the spy 뭔 the reception coil of structure and the relay coil where relays the magnetic field also of the electromagnetic waves type as the minute description competitive exhibition and is connected with an addition as the competitive exhibition, and the stop circuit which stops the signal which comes out passing by the relay coil the charging circuit which charges the electric energy which the electric current and a voltage of prescribed comes to be stopped has and the cell phone and the remote control, MP3 and PMP, PDA and the pot which is various charging of the battery is necessary label for all the member charging of the electronic instruments respectively In order to charge it was formed all the member fold points and it is composed of the reception module (12) which has the connection terminal which is combined in the electronic instrument. The minute description reception coil, against the amplification repeater (corresponding to the minute description relay coil,) and these composition circuit in application numbers 10-2004-0093696 where the long-cherished desire application person makes an application to under character three it is recorded and 10-2005-0059562 units. It will control the output voltage, a frequency and an output war potential of the transmission module which it follows in the invention which it sees with the transmission output which is necessary the induction magnetic field of the electromagnetic waves the transmission pad it will lead and it will transmit, it wants is various charging in the junction where it is formed in the electronic instrument which fit loach plan in case it will produce the cell phone (11), not only MP3 and PDA the internal organs hour height it will hang, in reception module (12) is formed in the junction the outside the connection terminal which it will contract, it will be able to charge the connection terminal of reception module in the electronic instruments of the most whose charging is necessary. The transmission pads and AC 어 maps of the invention which it sees it will shake off and according to it will bloom all style or from like 1 and plan it will be able to produce with separation style. With the transmission pad which it follows in the invention which it sees the small size which has a reception module • It tries to observe the execution example which and various is concrete in about radio war potential transmitting and receiving system of light weight.

[Execution example]

It establishes the execution example which is concrete it follows in the invention which it sees in the plan and it tries to

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observe. It tries to observe in about the transmission module which it follows in the invention which it sees first. When the transmission wool module 110V of all the member 60Hz who is general or 220V commercial business supply all the member (31) this it is input, it has the job sound removal filter (33) which removes the noise which in the input at the time of is included in signal, it uses the diode and it composes with the dc power conversion is, it will be able to output the electromagnetic waves which has the output which is necessary, the users to control the signal where in order for the noise is removed, is composed the control circuit (35) which, it has with electric current the 흐 time it intercepts and it protects a stop circuit (34) and with to have an electric current safety circuit (36). It wants is efficient at the frequency where and voltage the electromagnetic waves which above occurring, above one off청 it has a circuit (37) and the updated lance former (38), the user outputs wants has the voltage where and a frequency (For example, tens 池 to hundreds 池, cycle, low frequency etc.) with the signal (39) which, the signal which is output to be input with the transmission coil and in order to radiated the electromagnetic waves, it is composed and the charging brave fighting which is various the electric energy which is necessary to it sleeps a transmission output and it considers it controls it supplies the compositions which it has. In order uniformly, to maintain the output of the electric signal which is output in order in minute description output control department to stand when to perceive the output signal which is transmitted with the transmission pad the output of the electric signal which with signal control department from feed hundred making output control department is transmitted with the transmission coil increases, when to decrease the output decreases, it increases and it rises always and the feedback circuit it maintains the transmission output which it decides, it has, to make AC 어 map (15) it is established front grade of the transmission pad where the induction coil is had built-in from minute description transmission module plan it produces in the method which is various and is stabilized and the output which it has it will be able to occur the frequency and AC output voltage of prescribed must be composed 있 the rock. The composition of the transmission coil which is had built-in the transmission pad which it follows in the invention which it sees the maximum the many electric energy could be induced from the reception coil which in reception module (12) is had built-in it will be able to occur the induction magnetic field of the electromagnetic waves in order, variously, it will be able to form. Diameter of the spy board coil which also the ticket 1 silver composes from 3, gratitude possibility, it is to show an inside diameter and a major diameter, it corresponds to the sample 1 of the transmission coil which is used from execution example of the invention which it sees.

Ticket 1. Diameter of spy board coil of 3, gratitude possibility, inside diameter and major diameter (transmission sample 1)

3	Inside diameter (mm)	Major diameter (am>	Coil type (N 通)	Gratitude possibility
Transmission coil	24	SO	0.2*8	34

In order to form the up one relay coil and the relay coil and resonance also the ticket 2 4 in order to come like plan the spy which is produced 럴 with the coil the induction magnetic field of the electromagnetic waves relay resonance the spy which connection composes the plaque seater big 럴 the spy of the elder brother repeater and prescribed distance 럴 diameter of the transmission coil, gratitude possibility, is inside diameter and to show around the outside, it corresponds to the sample 2 of the transmission coil which is used from execution example of the invention which it sees.

Ticket 2: Diameter of relay coil and transmission coil of 4, gratitude possibility, inside diameter and major diameter (transmission sample 2)

4	Around me (mm)	Around the outside ac)	Coil type (艇)	Gratitude possibility
Relay coil	24	30	0.2*8	34
Transmission one	24	30	0.2*8	34

Also the ticket 3 silver respects 5 comes like plan the spy which is produced 럴 forms the relay coil for the relay of the induction magnetic field of the electromagnetic waves with the coil and the relay coil and a resonance circuit and big with the repeater which comes to be composed of the plaque seater on the relay coil inside for the reinforcement of the induction magnetic field of the minute description electromagnetic waves the spy 럴 diameter of the relay coil and the transmission coil, gratitude possibility, it is to show an inside diameter and a major diameter in about the sample of the transmission coil which composes the transmission coil with the coil, it corresponds to the sample 3 of the transmission coil which is used from execution example of the invention which it sees. The transmission coil and the repeater are not coming to be connected with the mammary gland not to be, according to size and form of the pad the relay coil and the transmission coil gratitude possibility, major diameter and inside diameter etc. to be different hydrogenous there is a

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possibility of doing.
Ticket 3: Diameter of relay coil and transmission coil of 5, gratitude possibility, inside diameter and major diameter (transmission sample 3)

5	Inside diameter (mm)	Major diameter	Coil type (mm)	Gratitude possibility
Transmission one	20	30	0.3*8	9
Relay coil	30	80	Cl.2*8	29

According to the invention which it sees plan the transmission coil which is produced plan the spy which is produced 릴 with 2005 it is a patent application of the invention which it sees in the transmission coil substitution which is composed will use the magnetic substance core and the coil which are recorded in application number 10-2005-0059562 unit which makes an application the transmission coil and the relay coil (as the induction magnetic field amplification repeater of the electromagnetic waves it is recorded.) from minute description patent application from minute description sample and 1, sample 2 and sample 3 it will be able to compose.

The next tries to observe according to the invention which it sees plan concretely in about the reception coil which is produced. The cell phone, MP3, PDA and the pot label in order to be inserted in the husband and wife eldest brother reception module it could be employed electronic instrument etc., plan the small size which is produced • It tries to observe the sample structures of the reception coil of light weight. 6 is the reception coil which composes the induction coil of the gratitude solenoid coil in the magnetic substance core, the ticket 4 reception coil sample 1 is with the fact that it shows the diameter, a height, a coil type and a gratitude possibility of the reception solenoid coil.

Ticket 4. Diameter, height, coil type and gratitude possibility (reception sample 1) of reception coil

6	Diameter (m)	Height (t 匡)	Coil type (腿)	Gratitude possibility
Reception coil	10	7	0.1*30	10

7 uses one magnetic substance (ferrite) with the common core and relays the induction magnetic field of the reception coil and the electromagnetic waves the relay coil which it winds and it is a reception coil which it composes. the ticket 5 corresponds to reception coil sample 2 with the fact that it indicates the diameter, a height, a coil standard and a gratitude possibility of the reception coil and the relay coil.

Ticket 5. Diameter, height, coil standard and gratitude possibility (reception sample 2) of reception coil and relay coil

7	Around me (m)	Major diameter (mm)	Coil standard	Gratitude possibility
Reception coil	5	20	0.2*8	9
Relay coil	20	40	0,43*1	21

8 the spy which is general 릴 is the reception coil which it composes of the coil. the ticket 6 diameter of the coil, gratitude possibility, corresponds to the sample 3 which will be a reception nose with the fact that it shows an inside diameter and a major diameter.

Ticket 6. Diameter of spy board coil, gratitude possibility, inside diameter and major diameter (reception sample 3)

8	Inside diameter (mm)	Major diameter (mu)	Coil type (匪)	Gratitude possibility
Reception coil	10	25	0.2*8	8

The plaque seater big and with the structure whose as many as 9 is identical with the transmission coil of 5 to the outside the spy 릴 it respects a composition as the relay coil and the competitive exhibition it uses strengthens the

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induction magnetic field of the electron group the repeater which with the structure which is combined with the reception coil. it composes on the inside the spy 될 it corresponded to reception coil sample 4. The ticket 7 diameter of the relay coil which is used in minute description reception coil sample 4 and the reception coil, gratitude possibility, is to show an inside diameter and a major diameter.

Ticket 7. Diameter of relay coil and reception coil, gratitude possibility, inside diameter and major diameter (reception sample 4)

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9	Inside diameter (mra)	Major diameter (M)	Coil standard (뭔)	Gratitude possibility
It will be a reception	5	20	o.£"e	9
Relay coil	20	40	0.43-1	27

Minute description as many as 3 inlands 9 and like ticket 1 to from ticket 7 and with the transmission coil which it composes and the reception coil plan the woman cell phone under the union. MP3 and PDA and the pot label to be inserted the samples of the transmitting and receiving coil which is produced in the husband and wife eldest brother reception module it could be employed electronic instrument etc., small size • Getting the radio transmitting and receiving system of light weight, there to be to a sample structure for, in output control department of minute description transmission module transmission output 10W and AC 100! It transmits with a frequency and it occurs minute description reception coil sample 1 to plan the charging circuit diagram of reception module it uses it composes the induction magnetic field of the former person, group the reception sample coils which are various it produces from 4 and from output grade DC war potential 3.7V electronic instruments (cell phone) in the charging battery electric energy measures a reception voltage, an electric current and a war potential price in the charging at the time of. The reception module hangs, or only the means which charges the electric energy which is necessary to the electronic instrument of cell phone etc., minute description charging means and in order to charge simultaneously simultaneously with having built-in percentage arranging in a row, it could be composed the charging battery which the dosage of prescribed the internal organs hour height has. In order in minute description reception coil sample 1 to rear grade of 4 to transmit a electric energy at high efficiency resonance and the impedance whip 청 the variable the plaque seater is contracted big, big the electric signal which comes out passing by the plaque seater it uses the diode and it converts with direct current signal the stop circuit for and, new Hu when it is stopped, it is smooth and it respects and it is composed charges and a electric energy to the battery of the electronic instrument which in necessity it charges of the plaque seater big. Namely, the reception module of 10 in order with output grade to transmit a electric energy at high efficiency the induced electromotive force which is received from the reception coil resonance and being the plaque seater big and the off whip which blooms 청 the variable to be big contracting composes the plaque seater with the reception coil, and arranging in a row resonance and the impedance whip 청 the variable passes by 3V of the prescribed dosage which passes by the stop diode and the smooth plaque seater big and after the constant voltage and safety circuit being rough, is had built-in the signal which is transmitted within reception module to 4V charging batteries and 3 of the electromagnetic cabin to with the composition simultaneously it will be able to charge a electric energy in 4V charging batteries To accomplish and well! with 3 to 4V of the B electromagnetic cabin it will be able to charge in order to only the charging battery, it will be able to compose of a reception module. The ticket 8 minute description from thread hour example of the invention which it sees plan sample 1 of the transmission coil which it produces to sample 3 about respectively composes a respectively reception circuit in about sample 1 of the minute description reception coil to sample 4 and output only it measured it is to show the reception voltage which charges, an electric current and a war potential price from the charging battery of the electronic instrument. Ticket 8 it leads and the possibility of knowing it is with the reception coil which combines the relay coil which relays the induction magnetic field of the transmission coil which combines the relay coil which relays the induction magnetic field of this electromagnetic waves and the electromagnetic waves induction of the electromagnetic waves the market which sleeps occurs and the structure which receives the electromagnetic waves magnetic field which occurs in the battery before the insect of the electronic instrument electric energy is quick and it will be able to charge at high efficiency and a possibility of getting a high output war potential there is. Namely, the spy 텔 it composes the transmission pad in the transmission coil sample 3 which, is a composition which combines the relay coil and the transmission coil on the coil outside the relay coil and the reception coil in one ferrite core which is a reception coil sample 2 structure and combines it will transmit and receive the induction magnetic field of the electromagnetic waves with 1.32A where in case it is biggest charging reception electric current the possibility of getting a charging war potential 5.41W it was at the reception module which it composes. It used the general transmission coil sample 1 which and does not include the minute description relay coil it composed the reception coil sample 1 which is composed of the general solenoid which does not use the relay coil 0.24W and 0.28W charging war potential quite from structure of the sample 3 which is a reception coil and the spy 텔 low-end it got of the 송 new coil.

Ticket 8. Plan sample 1 of the transmission coil which it produces to sample 3 about respectively from execution example of the invention which it sees in sample 1 of the reception coil to sample 4 output of large river woman reception module the reception voltage which only it measures from the electromagnetic cabin charging battery, electric current and war potential price

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Transmission	Reception			
Transmission sample	Reception sample	Reception voltage (V)	Reception electric	Reception war potential
Transmission sample 1	Reception sample 1	4.1	0.06	0.24
	Reception sample 2	4 that	0.2	0.82
	Reception sample 3	4 that	0.07	0.23
	Reception sample 4	4.1	0.18	0.73
Transmission sample 2	Reception sample 1	4 that	0.17	0.69
	Reception sample 2	4.1	0.4	1.84
	Reception sample 3	4.1	0.20	0.82
	Reception sample 4	4.1	0.37	1.51
Transmission sample 3	Reception spring 표 1	4.1	0.74	3.03
	Reception sample 2	4.1	1.32	5.41
	Reception sample 3	4.1	0.81	3.32
	Reception sample 4	4.1	1.13	4.63

According to the invention which it sees the transmission coil which composes the transmission pad for the electromagnetic waves induction magnetic field occurrence which is composed plan 2005 it is a patent application of the invention which it sees on the transmission coil outside of the wide selection it produces with magnetic substance nose 이 who is recorded in application number 10-2005-0059562 unit which makes an application uses the induction coil from minute description execution example and the transmission coil which it composes etc. and invention which relay amplifier (it sees it corresponds to the relay coil.) it uses variously, it will be able to compose. the reception coil also from minute description execution example plan 2005 it is a patent application of the invention which it sees on the reception coil outside of the wide selection it produces application numbers 10-2005-0059562 where it makes an applicationThe magnetic substance core which is recorded. the induction coil and the variable it uses the plaque scater big and the reception coil which it composes etc. and invention which relay amplifier (it sees it corresponds to the relay coil.) it uses variously, it will be able to compose. Before outputting the transmission module which it follows in the invention which it sees it will control a pressure, a frequency and an output war potential and it will control it will transmit. with the internal organs and or the body exterior style the connection terminal of reception module it wants it is various charging in the junction where it is formed in electromagnetic fit loach plan in case it will produce the cell phone and the remote control. not •nly MP3. PMP and PDA in battery charging in the electronic instruments of the most whose charging or application of power is necessary plan it will produce it will be able to apply a transmission output. Transmission plaques 드 of the invention which it sees and AC 이 maps according to the necessity which it shakes off all style or from like 1 and plan it will be able to produce with separation style.

Effect of invention

The invention which it sees the noise filter. stop circuit and frequency conversion circuit. constant voltage circuit and with the size which is various it will be able to occur the induction magnetic field of the electromagnetic waves of output. in order to receive the induction magnetic field of the transmission module which is composed of the transmission pad which occurs the induction magnetic field of the former person group with the transmission coil which is connected and the electromagnetic waves which occurs from minute description transmission module AC 이 maps which are composed with the output control department which controls a electric signal in order to sprout and. the electric signal outside which is transmitted from 이 map the reception coil and maximizes the electric energy which is received the resonance for and the impedance whip 칩 with circuit with charging DC all the member the low of converting It has the reception module which is composed of a stop circuit and it embodies the cell phone and the remote control. MP3. PMP and PDA and it charges the maximum induction radio war potential transmitting and receiving system and all the member in the battery of the machinery and tools whose charging is necessary with there to be it will be able to prevent the accident in compliance with the broken wire and an electric leakage of front line. the cow elder brother • Lightweight the establishment is simple and charging at the time of incoming call easily. there is an action effect which is the possibility of receiving.

Invention also. the different effect to respect and with AC connectors accomplishing the transmission induction coil and the minute description induction coil and resonance, the plaque scater big and have occurs the induction magnetic field

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of the electromagnetic waves where the maximum efficiency is high the transmission pad which and the reception induction coil and a resonance circuit and the plaque seater big and to form with output grade is and the off whip which blooms 청 a reception electric energy in the small-sized charging battery and the electromagnetic cabin charging battery within reception module the variable for to compose the maximum at high efficiency to supply, small size • Lightweight plan it is produced and the cell phone and the remote control, MP3, PMP and PDA and it provides the husband and wife eldest brother reception module which hits to the charging junction terminal of the electric machineries and tools whose charging is necessary with from above one transmission pad the nothing junction • It is quickly efficiently, it will be able to charge and the mammary gland charging at the time of the charging battery of prescribed size within reception module and even with discharge at the time of emergency electromagnetic cabin application of power of the electromagnetic cabin charging battery the various branch it will can occur all it will solve inconveniently and it will use it will be able to use in order, the charging battery of the electric machineries and tools which are various with the radio.

The brief description the plan

1: With the transmission pad which has AC connectors which it follows in the invention which it sees the small size

which is composed of a reception module • Abridged general view of radio war potential transmitting and receiving

system of light weight 2: With AC connectors which it follows in the invention which it sees the block die of the circuit

which is had built-in the transmission pad Oh! the block die of gram and reception module Oh! gram 3: Spy 릴

transmission coil

4: The spy 릴 it forms the relay coil which is composed of the coil and the relay coil and a resonance circuit the resonance for big the repeater of plaque seater composition and the spy small stop 릴 the transmission coil which is composed of the coil

5: The spy 릴 plan it forms the relay coil which is produced and the minute description relay coil and a resonance circuit with the coil the resonance for to be big on the inside which will be a plaque seater and a minute description relay nose the spy 릴 the transmission coil which is composed of the coil

6: In magnetic substance core induction coil gratitude solenoid structural reception coil

7: Magnetic substance and with the common core it winds the reception coil where it composes the reception coil and the

relay coil and

8: The spy which is general 릴 the reception coil which it composes of a structure

9: The reception coil which it forms with the structure which is identical with the transmission coil of 5

10: According to the invention which it sees plan the circuit

diagram of the reception module which becomes workth

<brief description plan code>

11; The cell phone 12 which is the charging object; Reception

module 13: Transmission pad 14: Connection terminal 15: AC

어 map 16: Cone cent 31: All the member (110V and 220V)

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32: Fuse 33: Noise filter 34: Stop circuit 35: Control circuit

36: With electric current safety circuit 37: off above 칭

circuit 38: updated lance former 39: Output signal 40:

Reception coil

41: Resonance and the impedance whip 칭 the variable it is

big plaque seater 42: Stop circuit 43: Smooth condenser 44:

Constant voltage and safety circuit 45: Connection terminal

46: Charging batter 47 within reception module: Electronic

instrument charging battery 48: Transmission module 49:

Reception module

51: Relay coil 52: Transmission

coil 53: Resonance it is big

plaque seater 55: Relay coil 56:

Transmission coil 57:

Resonance it is big plaque

seater 61: Reception coil 62:

Relay coil 63: Resonance it is

big plaque seater 65: Relay coil

66: Reception coil 67:

Resonance it is big the plaque

seater

71 : Reception coil

72 : Resonance and the impedance whip 칭 the variable il is big

the plaque seater

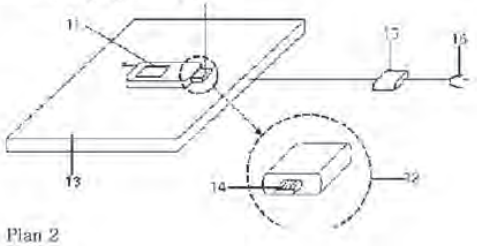
73 : Stop diode 74: Criticism bow condenser

75 : Really voltage and safety circuit

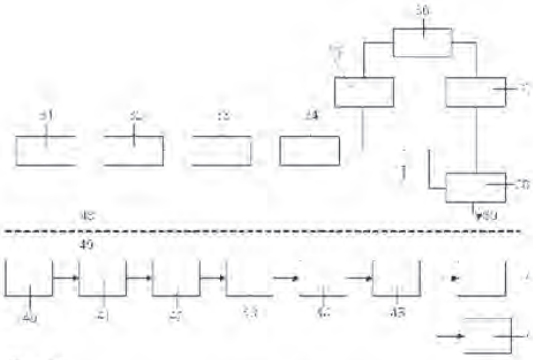
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76 : Reception module internal charging battery 77:

Electronic instrument charging battery plan



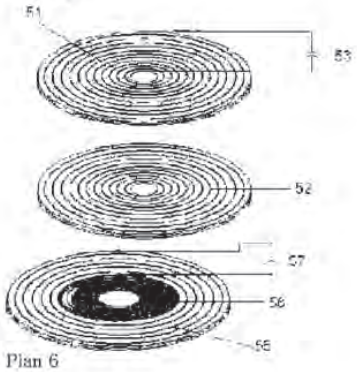
Plan 2



Plan 3



Plan 4



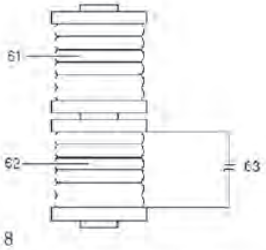
Plan 6

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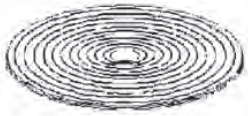
Plan 5



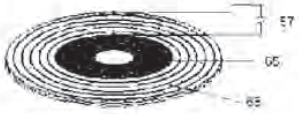
Plan 7



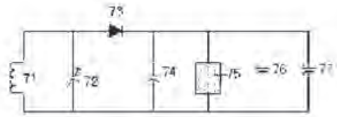
Plan 8



Plan 9



Plan 10



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Electronic Patent Application Fee Transmittal

Application Number:	12639963
Filing Date:	16-Dec-2009
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Filer:	Marc M. Wefers/Cheryl Forrest
Attorney Docket Number:	01997-0359009 / MIT 11757

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in Excess of 20	1202	2	62	124
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 3 months with $0 paid	1253	1	1290	1290
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**1594**

Electronic Acknowledgement Receipt	
EFS ID:	15074385
Application Number:	12639963
International Application Number:	
Confirmation Number:	7811
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Customer Number:	26161
Filer:	Marc M. Wefers/Cheryl Forrest
Filer Authorized By:	Marc M. Wefers
Attorney Docket Number:	01997-0359009 / MIT 11757
Receipt Date:	28-FEB-2013
Filing Date:	16-DEC-2009
Time Stamp:	10:33:28
Application Type:	Utility under 35 USC 111(a)

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Payment was successfully received in RAM	$1594
RAM confirmation Number	12371
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Extension of Time	PetforExt.pdf	40490 a8f9100d198c012977aaf16aaa08fbe37fc09591940	no	1
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Information:					
2		Response.pdf	725007 d78e143e15b016b7776425985e2d75f1841c120d	yes	27

	Multipart Description/PDF files in .zip description		
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	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Specification	2	3
	Claims	4	11
	Drawings-only black and white line drawings	12	12
	Applicant Arguments/Remarks Made in an Amendment	13	25
	Drawings-only black and white line drawings	26	27

Warnings:					
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3		IDS.pdf	101019 51d9136eeca8b7436080807616ec00bb70e13c	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
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4	Foreign Reference	art2.pdf	365566 4b37a4ba415df93971a5090b16a625c776745d01	no	14
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5	Foreign Reference	art3.pdf	635114 ab14c0b38c6c335f92b21c56de5491e80d5a08d	no	21

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15	Non Patent Literature	NPL17.pdf	2832623 ae8c50f5846f62d0591dc66dac68de1e6de38a25e	no	43
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17	Non Patent Literature	NPL19.pdf	2740116 33a8a35c94d07b9321fc4ab4a629eb1881010e1b0	no	41
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18	Non Patent Literature	NPL20.pdf	2943527 91a1e4d99e98cb3345889f557d6c6a1fec72373	no	43
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Fritz Fleming
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

PETITION FOR THREE-MONTH EXTENSION OF TIME UNDER 37 C.F.R. §1.136

Please extend the period for response to the action dated August 31, 2012, for three months to and including February 28, 2013.

The fees in the amount of $1290 are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: February 28, 2013

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	To be Mailed
12/639,963	12/16/2009	☐

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			N/A	
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☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
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APPLICATION AS AMENDED – PART II

AMENDMENT 02/28/2013	(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))	* 50	Minus	** 48	= 2	X $ =		OR	X $62=	124
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $250=	0
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☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	124

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
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Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	5,034,658	7/23/1991	Hiering et al.			
	2	6,459,218	10/1/2002	Boys et al.			
	3	8,362,651	1/29/2013	Hamam et al.			
	4	8,395,282	3/12/2013	Joannopoulos et al.			
	5	8,395,283	3/12/2013	Joannopoulos et al.			
	6	8,400,018	3/19/2013	Joannopoulos et al.			
	7	8,400,019	3/19/2013	Joannopoulos et al.			
	8	8,400,020	3/19/2013	Joannopoulos et al.			
	9	8,400,021	3/19/2013	Joannopoulos et al.			
	10	8,400,022	3/19/2013	Joannopoulos et al.			
	11	8,400,023	3/19/2013	Joannopoulos et al.			
	12	8,400,024	3/19/2013	Joannopoulos et al.			
	13						

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	14	WO 95/11545	4/27/1995	WIPO	H02J	17/00		
	15							

Other Documents (include Author, Title, Date, and Place of Publication)

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(74) Agents: PIPER, James, William et al.; James W. Piper & Co., 46 Brown Street, Ponsonby, Auckland 1002 (NZ).

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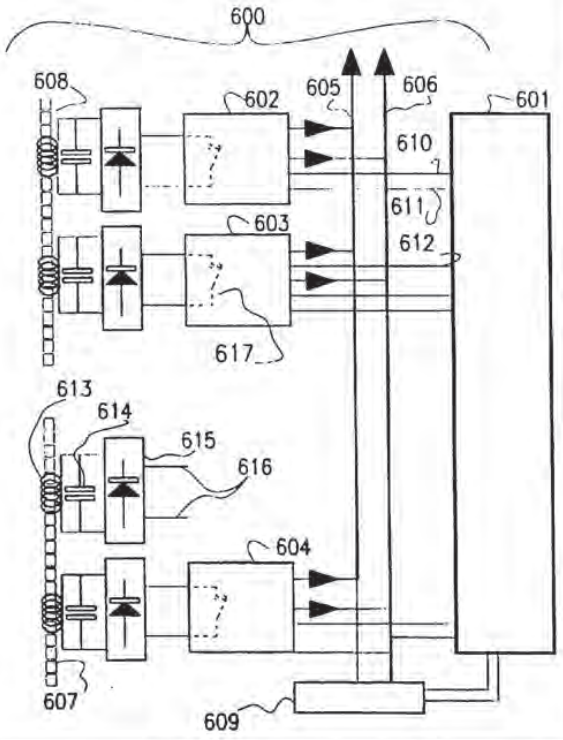
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Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: INDUCTIVE POWER PICK-UP COILS

(57) Abstract

A loosely coupled inductive power transfer system suitable for transferring power to a mobile conveyer platform or a vehicle has pick-up coils wound on flux concentrator(s). One or more large flat horizontal ferrite cores (607, 608) are used to concentrate the horizontal component of magnetic flux from an extended volume into one or more secondary or pick-up coils (613). Each shock-resistant core comprises an array of many individual strips of ferrite held in close contact. One, more usually two, or perhaps more resonant pick-up windings are wound about each core and each winding has a shorting switch (within 602, 603, ...) placed across it. A controller (601) connects a controlled output voltage on to an output bus (605, 606) from the best-placed pick-up winding on any one core at any moment, while holding the others in a shorted hence inactive state.



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INDUCTIVE POWER PICK-UP COILS

TECHNICAL FIELD OF THE INVENTION

This invention relates to the field of inductive power transfer for loosely coupled combinations and in particular to means to enhance the collection of said power at the receiving side.

BACKGROUND

Inductive power transfer is capable of providing electric power across a significant space to often moving apparatus without a physical connection for the electricity (such as sliding or rolling contacts). It can be carried out at low or high frequencies, in a loosely or a tightly coupled configuration, and with or without magnetically permeable materials.

We have described such a system in our US Patent 5,293,308 (and in the corresponding International application filed as PCT/GB92/0220).

Advantages of the preferred loosely coupled inductive power transfer means over various tightly coupled transfer arrangements include that:

(a) Effective transfer is possible across a larger space, thus the primary and the secondary need not be constrained in space to move within such close limits.

(b) The larger area results in a lower peak power density or a less tightly focused field to carry power, which is less hazardous and places less stress on components or on incidental objects within the flux field.

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(c) The pick-up coil need not surround the primary conductor so a system can be constructed in which a flat receiving surface containing secondary windings may be brought near another flat surface containing one or more embedded transmitting (primary) conductors, so permitting much freedom of movement for vehicles over a roadway, for example.

(d) Useful power control means applied to the secondary side may be implemented by shorting the secondary coil (which is generally a resonant inductor) without material effect on currents in the primary side. A shorted secondary coil has little effect on primary current flow, so unaffected primary current can reach another consumer further from a power supply.

Exploiting the above advantages of loosely coupled inductive power transfer systems to utilise IPT in an optimised way uncovers the inherent disadvantages between loosely and tightly coupled systems, mainly that the available power may be limited and that secondary pick-up coils are large, expensive, have unnecessary ohmic resistance, and have large magnetic fields of their own when in use. Means to make the transfer process more effective across wider gaps are required and therefore there is a need to enhance the ability of secondary windings to collect as much of the available flux as possible.

DEFINITIONS

IPT is used a s an abbreviation for "inductive power transfer".

A **tightly coupled** pair of inductors exhibit a close correspondence or ratio between current in one and in the other. Substantially all of the magnetic flux generated by current in one inductor is coupled to the second inductor. An example is the relationship between windings in a power transformer. Thus a shorted turn in a typical power transformer secondary causes large and usually damaging currents to flow in the primary winding.

A **loosely coupled** pair of inductors do not exhibit a close correspondence. Only a portion of the flux emanating from the primary conductor passes through the secondary conductor. Changes in the induced current in the secondary inductor has only a small

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effect in the primary inductor.

A **primary** winding is one which generally acts as a source of magnetic flux, some of the flux intersecting the windings of a **secondary** winding which then passes the power onwards for consumption. The direction of power transfer is of course reversible. In this specification we use the names primary and secondary to refer to the usual direction of power flow.

OBJECT

It is an object of the present invention to provide an improved means for the transfer of electric power across a gap by inductive means, or one which will at least provide the public with a useful choice.

STATEMENT OF THE INVENTION

In one aspect the invention provides an inductive power pick-up means comprising a plurality of pick-up coils mounted on a movable support said coils being spaced apart from one another, each coil being adapted to pick-up inductive power from a primary conductor so that each coil can act as a secondary conductor when located relative to a said primary conductor, and control means capable of identifying from time to time the pickup coil or coils in best alignment with a said primary conductor, said control means including switching means capable of switching "on" the identified pickup coil or coils which are best sited to collect inductive power from a said primary conductor, and to render functionally inactive the coil or coils (if any) which are remote from a said primary conductor.

Preferably the control means is capable of determining from time to time the short-circuit current available at each pickup coil.

Preferably the control means has means to measure the rate of voltage increase that occurs when the coil is released from a shorted state.

More preferably the control means maintains those coils which are not loaded, or only partly loaded, in a short-circuited state.

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Preferably each pick-up coil is mounted on a ferromagnetic flux concentrator adapted for capturing flux lines and feeding them through the core of a said pickup coil.

In another aspect the invention provides a core for collecting magnetic flux from a space and concentrating the flux through a secondary winding of a loosely coupled inductive power transfer system; the core comprising an elongate mass of magnetically permeable material having a length, a width, and a height, and having low losses at the operating frequency.

Preferably the magnetic permeability of the magnetic core is relatively high, so that in use the magnetic core serves as a concentrator or collector of at least some of the flux generated by a primary conductor of the inductive power transfer system.

A preferred permeability is 1000 or greater - where air is 1.

Preferably the magnetic core is flexible or at least capable of undergoing distortion without permanent loss of function.

In a related aspect the core is composed of a ferrite material, provided as a modular array comprising at least four fingers of material, each finger having at least one shaped side, the fingers being laid side by side along the length of the elongate mass in an array with these shaped sides held in close contact with each other by a compliant force exerting a compression force along the length of the array, so that the permeability of the array is substantially similar to that of an equivalent single mass of the ferrite material.

Preferably the shaped sides are flat, although alternatively other mating shapes may be used.

Preferably the flatness of the flat sides is such that, if two clean strips are brought together, the magnetic permeability of the strips in contact is not substantially lower than that of the bulk ferrite material.

Alternatively the ferrite material of the core may be made up of modules having shapes other than rectangles.

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In a further related aspect the core is provided with one or more coil-carrying sections which support a coiled conductor wound as one or more turns around the core, which coil or winding is a secondary coil as herein defined and which comprises the inductive portion of a resonant tank circuit.

Optionally more than one secondary coil may be provided on a single core.

Preferably a conducting sheet is placed on the side of the magnetic core far from the source of magnetic flux and preferably this sheet is not in contact with the magnetic core or associated windings.

Preferably the conductive sheet is capable of supporting the flow within it of significant eddy or reaction currents and for this reason a preferred material is aluminium substantially free of defects and surface scratches.

Preferably each secondary coil is tuned with its own resonating capacitor and each has its own rectifier so that a DC output can be taken from it.

In another aspect this invention provides a magnetic flux enhancement controller capable of sensing the relative magnitude of the current flowing in any one shorted pick-up or secondary coil and capable of controlling each shorting switch, and provided with a controlling set of instructions to utilise, by opening the shorting switch for, or unshort that coil exhibiting the highest short-circuit current.

Preferably the choice is made amongst one set of coils on a shared core and so several coils may be in simultaneous use in an installation having several cores.

In a related aspect the controller also includes means to sense the output voltage, means to short out all coils if the output voltage is higher than a predetermined limit, and means to unshort the selected coils if the output voltage is lower than another predetermined limit.

Optionally both predetermined limits may be the same voltage.

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In a further aspect this invention provides a magnetic flux enhancement controller capable of sensing the relative magnitude of the current flowing in any shorted coil wound over a single magnetic core, and capable of determining by a logic process based on relative magnitudes of all coil short-circuit currents the position of the elongated source of magnetic flux or primary conductive pathway which is providing magnetic flux passing through the or each magnetic core.

In another aspect this invention provides a movable vehicle equipped with a magnetic flux enhancement controller and with one or more magnetic cores capable of concentrating a magnetic flux, built onto or into a surface of the vehicle close to the primary conductive pathway.

DRAWINGS

The following is a description of a preferred form of the invention, given by way of example only, with reference to the accompanying diagrams.

Fig 1: is an illustration of a prior art inductive power transfer arrangement using a vertical field.

Fig 2: is an illustration of a ferrite core according to the present invention, using a horizontal field from conductors below a surface.

Fig 3: is an illustration of a ferrite module or finger of the present invention.

Fig 4: is an illustration of a ferrite core assembly of the present invention, including three pick-up coils.

Fig 5: is a section along a ferrite core showing one secondary winding in place.

Fig 6: is a wiring diagram for an IPT controller for the vehicle of Fig 13

Fig 7: is a circuit diagram for a pick-up coil controller for the vehicle of Fig 13

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Fig 8: is an illustration to show the placing of cores and coils as they would be installed beneath a vehicle.

Fig 9: is a block diagram for instructions for estimating the position of the primary conductor in relation to the array of secondary coils for the controller of Fig 6.

Fig 10: is an illustration of the present invention in principle; in an idealised, solid-ferrite form.

Fig 11: is an illustration of a preferred embodiment of the present invention constructed from discrete ferrite elements as seen from below.

Fig 12: is an illustration of a preferred embodiment of the present invention constructed from discrete ferrite elements as seen from one end.

Fig 13: is an illustration from below of a preferred embodiment of the present invention, comprising a vehicle having ten separate pickup units embedded in the underneath surface adjacent to the road.

Fig 14: is an illustration of a preferred embodiment of the present invention showing how a pickup coil within a pickup unit may be controlled.

INTRODUCTION

In our loosely coupled inductive power transfer (IPT) systems, we prefer to use:

(a) Alternating currents of medium frequency; using presently available semiconductor switches it is possible to generate effective power at around 10 KHz and while higher frequencies would result in more compact IPT systems, losses within tuning capacitor dielectrics, switching-duration delays and the generation of radio-frequency interference becomes more likely. Hence, at present 10 KHz is the centre of the preferred frequency range. Furthermore we prefer to use reasonably pure sine waves; that is, alternating currents having a low harmonic content, as these radiate less electromagnetic interference and dissipate less energy than do waveforms with added

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harmonics.

(b) A primary conductor carrying resonant current. This provides a higher circulating current than that actually passing through the semiconductor switches which provide the power at any moment, and enhances the sine-wave nature of the circulating current. A typical primary Q is of the order of 3, in a lightly loaded state. We also prefer to use a heavy litz wire to carry the primary current as this type of wire provides a good ratio of surface (skin) to volume. In its most commonly used form, the primary conductor laid out along or within a substrate is formed as a closed loop with the outward wire running parallel to the return wire at a reasonably constant spacing, although other configurations such as open loops are possible. In order to extend the length of track that can be driven with a limited voltage we use pi-coupling and zero-inductance coupling methods as described in our PCT applications published as WO93/23908 and WO93/23909.

(c) A secondary conductor (pick-up coil) also carrying resonant current. Again we prefer to use litz wire for the windings and as a typical secondary Q is of the order of 10 a significant secondary current can flow in the pick-up coil and through its resonating capacitor.

(d) Secondary power control means. We have found that one convenient way to control circulating current, which if too high can interfere with propagation of primary current, is to short out the secondary coil. Only a small quantity of electricity is dissipated at the moment of shorting or while being shorted, in a loosely coupled IPT system. The shorting action is typically under the control of a controller seeking to provide a steady voltage, so that if the (usually rectified) output voltage available at a certain load is in excess of a first threshold value the coil is shorted until the output voltage is under a second threshold value. In this way, the resonating current in a secondary coil does not rise to high levels if the consumption of power from it happens to be light.

PREFERRED EMBODIMENT

Originally we used a relatively large coil having its axis orientated vertically (assuming a vehicle operating on a substantially flat surface) and wound on a low-permeability former (equivalent to an "air-cored" coil) to pick up the flux from the primary

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conductor, relying on a reasonable length of parallel conductors to intersect a useful amount of flux. While an air core is unsaturable its permeability is only one. The preferred form of this invention is concerned with means to overcome several problems associated with that approach, including that as the pick-up coil is inherently large its series resistance is significant, leading to power dissipation and inefficiency, and that its physical size is inconvenient and leads to wastage of resources. In addition those portions of the pick-up coil bridging between the actively collecting portions that run parallel to the primary conductor are not used to pick up flux and in a sense are wasted copper.

The invention will now be described in general terms with reference to figures 10-14, then in more detail with reference to figures 1-9.

Example 1:

Various embodiments of our earlier inventions directed towards the transfer of electric power from a fixed primary element to a mobile or at least portable secondary element have generally involved the use of a rectangular, air-cored pickup coil which is constructed and placed so that its long sides are, during use, placed as close as reasonably possible to the one or more turns of the primary inductor. Our more recent embodiments have used ferrites which have projections that practically surround the primary inductor which for the purpose has been mounted so as to project from a surface. The close tolerances and projecting components involved are somewhat undesirable for applications involving road vehicles or even for railway vehicles which use switches or points.

It has surprisingly been found that an arrangement as shown conceptually at 1100 in Fig 11, essentially consisting of a large sheet of ferrite oriented more or less tangentially to the direction of current flow, or in other words, in a plane that would intersect along the length of the conductor were it not shifted away at right angles from the conductor, acts as a flux collector and is capable of channeling flux from a relatively large space about the primary conductor through one or more relatively small secondary coils. A suitable ferrite would be cheap, have a relatively large saturation point, and would have low losses at the operation frequency. The secondary coil has no "waste copper" bridging gaps between active pickup areas - a problem in air-only rectangular coils.

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Advantages of this flux collector in inductive power pickup applications include that, as the spacing and orientation of the vehicle (see Fig 13) is not closely constrained, it is possible to lay an array of conductors beneath a roadway to allow powering of vehicles whether they are proceeding in a direct path or involved in passing or parking manoeuvres or the like. Therefore this application provides for the electric powering of vehicles from stationary power sources without unduly altering driving styles. Furthermore, the relatively high frequency of the power provided in the primary conductors (ca 10 KHz) eliminates the need for ferromagnetic aids at the primary side - as used in 120 Hz installations. Simple slits cut as parallel pairs in the roadway with a diamond saw or the like, to accommodate the preferred litz wire array, are all that are needed.

In a warehouse, an inductively powered vehicle used for shifting goods may pick up power from anywhere if an array of cables carrying primary inductive current is laid over the floor.

In Fig 10 the entire ferrite sheet is 1101 - 1104 - 1106, wherein the raised portions 1102, 1105 have been raised in order to accommodate the turns of the pickup coil (indicated as 1103) wrapped around the ferrite at that point. An aluminium cover sheet 1107 is applied relatively closely to the upper surface of the ferrite - herein the primary conductors are located beneath the lower surface of the ferrite. The aluminium cover sheet may be made structurally and electrically continuous with an outer skin of the vehicle. It serves to further restrict spread of the flux and to screen the interior of the vehicle from stray induced currents.

A large single sheet of ferrite such as shown in Fig 10 is a relatively impractical solution. Effective ferrites are extremely brittle and are hard to fabricate as single units in the form shown. A unit cost of at least NZ$4000 is likely. On the other hand, ferrite slabs and bars are already available as standard products and Figs 11 and 12 illustrate a preferred embodiment of our "flux concentrator", made from standard slabs and bars (fingers). The advantages of this approach include that the ferrite elements are protected, there is freedom to slip within the ferrite mass if the assembly is distorted, and replacement of individual modular elements is easy, should there be breakage. The unit cost of an assembly made from discrete ferrite elements is of the order of NZ$400. Preferably at least the adjacent surfaces between individual elements of the ferrite

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elements are finished by grinding so that the adjacent surfaces have little or no air gap between them. Preferably the entire assembly is held in compression by spring pressure from end to end, and by downwards pressure against the bridged from (for example) a sponge rubber sheet or other resilient material.

In Fig 11, 1200 indicates the entire assembly as seen from below, within a transparent support 1206. In fact a support made from "Tufnol" - a dimensionally stable engineering plastics comprising a resin in which layers of cloth are embedded - is preferred. In any case the support should not be of a material liable to interact with the magnetic flux. The preferred embodiment support comprises a sheet of 15 mm thick "Tufnol" into which a 10 mm deep depression has been milled to accommodate the several arrays of ferrite fingers (1201, 1204, 1205) and two non-magnetic (perhaps "Nylon") spacers (1202, 1203) which underlie the two bridges 1309, 1310 in Fig 12) carrying the pickup coils. The aluminium backing plate (1107 or 1311; not visible in this view) would preferably be screwed to the sheet 1206 by an array of fasteners. As an alternative to milling, an array of strips may be laminated onto a baseplate and glued or otherwise held in place, or an inert structure may be pressed, cast or otherwise formed from, for example, polycarbonate, polyethyleneterephthalate, or acrylic plastics.

Fig 12 illustrates the view 1300 from one end of the assembly of Fig 11. Two primary conductors 1312 and 1313 are indicated. The pickup coils 1307 and 1318 are indicated wrapped around a "bridge" made of ferrite slabs 1309, 1310 which are free to side over the raised bars at each end but which are pressed downwards against them. In practice the coils would preferably comprise thicker conductor - e.g. litz wire in a bundle of about 5 mm diameter. Also in practice some form of thermal connection between the windings of the coil and the aluminium sheet may be included in order to provide for the dissipation of heat from within the metal of the coil. Sections through ferrite bars or fingers are shown at 1301, 1304, and 1305.

A spring (not shown) may compress the bars along the length of the assembly from one end. One possibility for such a spring is to form the spacers 1302, 1303 out of a resilient material. The overall aluminium cover is indicated as 1311. It may be continuous with the underside of the vehicle, so that this assembly protrudes slightly, or the lower surface of the "Tufnol" or other sheet may be flush or even slightly depressed below the surrounding surface.

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It has been found that effective power transfer occurs over primary-to-ferrite spacings of up to 75 mm ± 25 mm, whereas earlier designs had preferred spacings of only 20 mm, ± 10 mm.

Fig 13 shows at 1400 an underneath view of a vehicle 1401 bearing a number of pickup assemblies or flux concentrators 1404, 1405, 1406; the units 1406 being inclined as they are near the steering wheels 1402. It will be evident that only some of the pickup coils will at a given time be suitably orientated with respect to the pair of primary conductors 1403.

Use of the preferred resonant, or tuned, primary and secondary inductive elements for the sake of greatly improved effectiveness carries the potential disadvantage that any lightly loaded or unloaded secondary resonant coil, because it will then develop a high resonating current within it, will interfere with the primary inductor and effectively prevent the transfer of inductive power to other consumers located further from the position where power is injected into the primary inductor. In effect, a closely coupled and lightly loaded coil terminates the primary inductive pathway at its present position.

It has been found that this disadvantage may be negated by shorting any lightly loaded pickup coils, thereby halting the flow of resonant currents and causing the coil to resemble a conducting sheet in which only eddy currents may circulate.

In a practical vehicle (or other such installation such as a boat or entertainment conveyance or the like), electronic means is provided to instantaneously and repetitively:

(a) determine which is the most appropriate coil or coils to use for power collection,

(b) to hold any unused coil or coils in a shorted state, and

(c) to control circulating currents within coils in use by shorting the flowing current from time to time so that the rectified output voltage remains within predetermined limits.

Part (a) is preferably carried out by periodically measuring the short-circuit current from any pickup unit or coil/rectifier assembly, and selecting the one pickup unit (or more, if high power transfer is required) having the highest short-circuit current. This process selects the coil capable of supplying the power at the lowest Q factor; each

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pickup coil 501 being resonant in combination with its parallel capacitor 502.

Parts (b) and (c) may be carried out at each pickup coil by a simple local comparator circuit with hysteresis driving a solid-state switch as illustrated in Fig 14, or alternatively by electronic means linking all the coils of a vehicle.

The electronic means in question may be integrated into a single digital controller unit including an embedded microprocessor, with gate drivers corresponding to the number of pickup coils as its outputs, and a corresponding number of A-to-D input channels to read voltage outputs as inputs to the microprocessor. The actual design of such a controller will be immediately apparent to a designer skilled in the art of electronic design.

Fig 14 indicates at 1500 one form of the circuitry that may be used. 1501 is a pickup coil with a preferred ferrite core, and 1502 is a capacitor which together form a resonant or tank circuit. Bridge rectifier 1503 rectifies the resonant current which is smoothed by capacitor 1507 and presented at the output terminals 1508. The solid-state switch (here a NPN transistor 1504 but preferably a low ON-resistance MOSFET device) may be controlled through its gate terminal 1505 and when closed will short the pickup coil 1501. Surprisingly, very little power is dissipated on closing such a switch. A stand-alone controller capable of overcoming the lightly-loaded pickup coil effect typically compares the output voltage with a reference voltage by means of a comparator preferably including some hysteresis, and closes the switch 1504 whenever the output is too high, and conversely opens the switch when the output is too low.

A preferred controller for use with a number of such coils within one installation may use a single embedded microcontroller to manage the entire system, taking voltage measurements from the terminals 1508 and returning control signals to the base/gate input 1505.

Example 2:

We have made use of materials with a high magnetic permeability to gather or concentrate the available flux into a smaller space, so that the secondary coil can be made smaller (both in its dimensions and in its length) and so that flux can be sucked into the core from a greater area. At the preferred operating frequencies (such as 10

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KHz) laminated metal cores and the like exhibit significant losses. We prefer to use ferrites, some preferred types of which have a permeability (μ) of 2000 to 3000.

For our moving vehicle projects, a secondary pick-up unit may be built around a slab of ferrite, for example 30 cm long, 2 cm thick and 10 cm wide. This slab is preferably orientated with its flat face parallel to the length of a primary conductor, and its long axis at right angles to the primary conductor. The pick-up coil is wound closely around the central part of the ferrite slab. Practical units are several times longer and have several coils wound around separate sections (as in Fig 2) and in use a controller may be instructed to select the most productive coil at any one instant.

As ferrites are a type of ceramic, slabs of this size are quite difficult and therefore expensive to make. They are brittle and may be broken easily during use. An air-filled crack of even 25 microns (1/1000 inch) width will substantially detract from the magnetic advantages of the ferrite. We have therefore developed a type of modular ferrite core which is easy to configure in various sizes, to make (and repair), and which may flex in use without suffering permanent damage.

Our flux concentrator is comprised of a stack of modules held together in a magnetically inert tray by means of spring pressure using a leaf spring or the like exerting pressure along the length of the core.

Each module (see Fig 3) is preferably a square or rectangular bar 300 of solid ferrite having a length (along the edge 303) equal to the desired width of the ferrite core and a height equal to the desired thickness of the core. The width (from side to side) of each module is of less importance and typically it is the same as the height. A ferrite core is made up by stacking a number of these modules side by side with the precision-ground edges 302 in close contact. Precision grinding is commonly applied to ferrite cores. As internal air gaps detract from the permeability of the assembled ferrite core it is desirable to form the sides of each module so that when one touches another there is substantially no air gap. Preferably any remaining air gap is less than one micron in thickness. Thus the typical surface finish required for the sides 302 of each module is "flat to within one micron over the length of the module" which is not far short of an optically flat surface. A typical price for finished modules according to our requirements is of the order of NZ$4 to $6, and so an example ferrite core using 20

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modular fingers may include $80 to $160 of ferrite.

Surfaces other than flat surfaces could be made as long as they mate together, but a flat surface is easier to create and to test for flatness and has no innate polarity or handedness.

A flux concentrator suitable for use in an inductively coupled vehicle would comprise a number of cores according to the description above. Each core of our preferred dimensions can provide about 500W of electric power before reaching a limit caused by core saturation. One core and its windings tends to interact with windings of other cores. Placement of cores over that surface of a vehicle to be adjacent to the primary conductors is the subject of conflicting constraints. On the one hand a widely scattered formation is preferred to collect useful flux even if lateral positioning is poorly controlled, while on the other hand if more cores can collect a high level of flux the total power collected is greater - assuming that the relative positioning of the vehicle to the primary conductive pathway is more precise. Core positioning is also constrained by the total surface available. If the total power from coils is not sufficient for brief peak loading conditions, power reserve elements such as capacitors of some farads capacity, a high-inertia dynamotor, or batteries may be used to supply extra power. Alternatively larger cores can be used to raise the flux density before saturation.

One preferred layout for three cores and six coils is shown in Fig 8. Numerals 810 to 830 inclusive refer to the table of dimensions below. The figure shows a plate 800 milled out with shallow troughs to hold a set of three cores and the three coils associated with each winding. Dimensions are in millimetres. The shorter axis is placed at right angles to the usual direction of primary conductors when the plate is in use. Three shallow channels 801, 803 and 804, each including two wider sections (e.g. 802) for accommodating coils, are shown. Note that the pairs of coils are offset from each other so that the total width effectively covered by any one coil is over 500 mm. The dimensions in this figure are given by way of example only.

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TABLE 1. Dimensions for Fig 8.

	810	900 mm	821	118 mm
	811	10 mm	822	600 mm
	812	199 mm	823	54 mm
	813	148 mm	824	49 mm
	814	290 mm	825	241 mm
	815	380 mm	826	380 mm
	816	241 mm	827	290 mm
	817	145 mm	828	199 mm
	818	266 mm	829	450 mm
	819	290 mm	830	10 mm
	820	276 mm		

This example plate would be suitable for a small personal conveyance similar in size to a dodgem car. "Tufnol" - the material preferred for at least prototype core mounting plates 800 - is a machinable composite material comprised of phenolic resin impregnated into layers of fabric. Other plastics, or wood, or resin-impregnated wood, or other non-conductors can be used as an alternative core mount. As the array of ferrite fingers forming a core has some tolerance to flexion (unlike a single ferrite slab) total rigidity of the mount even under impact is not required.

We prefer to use a layer of conducting medium a small distance above (on the far side from the primary conductors) the array of coils to restrict the flux to the area of the coils and enhance their effectiveness and operation. A suitable material is a plate of aluminium, 5 mm thick and a similar size to that of the "Tufnol" plate, placed about 10 mm above the highest part of any secondary winding. Preferably this plate has no surface defects such as deep scratches that might obstruct skin-effect induced currents.

DETAILS - PICK-UP COIL CONTROLLER

The pick-up coil controller shown in Fig 7 has the simple functions of (a) shorting out the coil, (b), reporting the short-circuit current, and (c) reporting the output bus voltage.

Connector P1 receives an already rectified input from the resonant coil, which input is filtered through L1 and taken to the insulated gate bipolar transistor (IGBT) Q1,

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preferably type IFRPG40U. If the transistor is ON, current passes to ground and returns to the coil via connector P1, passing through a paralleled pair of current sense resistors, here 0.05 ohms in value. These resistors are placed across the (+) input of a ground-referenced voltage amplifier, IC2:B, type LM358. The output of this amplifier passes to the microprocessor's A-D inputs (using line 611 in Fig 6) via connector P3. The transistor Q1 is caused to go ON by means of a nominally 5V logic pulse arriving from connector P3 to the paralleled IGBT driver device, IC1:A and IC1:B, type ICL 7667. The outputs are taken to the base of the IGBT. Current clamping means (Q2) and an indicator light-emitting diode are provided. The IGBT has a reverse diode D2 and a surge protector U1 (250V) wired between its emitter and its collector.

Only one of the usually six modules, some of which are shown in Figure 6, would usually be fitted with a bus voltage monitor as shown here. The nominally 310V DC line running across the top of the circuit is divided through the 560K resistor and the paralleled 22K and 120K resistors at the positive input to IC2:A wired as a voltage follower. The output is led through connector P3 to the main microprocessor or controller. The 310V DC line is provided with 940 microfarads of filtering capacitor and includes a steering diode D1 (type BY229-000) to provide a kind of wired-OR summing of the output power from whichever coils are selected for power transfer at any moment by being in the not shorted state. Different arrays under the same vehicle are likely to be in phase.

Inductive Power Transfer (IPT) CONTROLLER.

The wiring diagram of Fig 6 shows an IPT controller 600 comprising a microprocessor-driven unit 601 together with a number of pick-up coil controllers of which three out of six are shown (602, 603, 604). Each pick-up coil controller (see Fig 7 for a circuit diagram) accepts raw DC power along lines such as 616 from individual secondary resonant coil modules each having a coil 613, a capacitor 614 and a rectifier 615. The capacitor 614 may actually be a bank of capacitors in parallel. A one-microfarad unit is preferred for the bank because cooling is facilitated by using many small modules rather than one bulky capacitor. Cooling is preferred because of heat buildup due to dielectric losses at 10 KHz and electrode losses at often 30 or 40 A circulating current.

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Several (usually two) coils may share a common ferrite core 607, 608. A third core/controller set is not shown for clarity). The controller is instructed to maintain an output of 320 volts on the buses 505 and 506, and a wire-OR connection from the three selected coils (using either coil on a given core) on the three cores of the preferred embodiment provides this, assuming that the vehicle is in suitable proximity to the primary conductors and the instantaneous current demand is not too heavy.

The controller may short both coils of a given core if the output voltage rises above about 320 volts.

The preferred microprocessor 601 is one including a number of analogue-to-digital (A-D) converter inputs. Conveniently a "Philips" or second-sourced 83C552 is used as this has eight inputs and ample capacity for programming. A power supply 609 provides internal power for the microprocessor and for other electronic modules. One A-D input (e.g. 611) samples the short-circuit current from a corresponding one of six resonant secondary coil units, indicating the magnitude of the magnetic flux passing through that coil, and a single input (612) samples a suitably divided sample of the output voltage. A buffered output port 610 provides control voltages to the shorting switches. The conventional microprocessor circuit includes the usual latch for addressing a read-only program memory.

The operating algorithm is relatively simple and comprises two tasks; one subsidiary to the other. Various improvements may be made; for example providing duplication or instituting error checking in case of failure. A-D inputs for example are prone to fail if overloaded even briefly. Figure 9 is a flow chart illustrating these tasks.

Main task: (900)

1. Measure the output voltage (904).
2. Test the voltage (906) If the voltage is above a lower limit, then close all short-circuit switches (905).
3. Else if the voltage is below an upper limit, open those switches recorded (see below) as having the greatest short-circuit current (907).
4. Return to (1).

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Options include a reversion to battery backup power to boost the output voltage if inductive power transfer is insufficient.

A subsidiary task 901, which should be executed periodically (for instance several times a second):

1. Close all short-circuit switches (908).
2. For each coil, measure and record the present flux, as indicated by the short-circuit current sensed as a voltage (909).
3. For each array on its core, record in memory the coil having the greater (or greatest) current (910). (This task is linked to the main one through the information it deposits in memory - suggested by the connection 914).

This subsidiary task can be run as an interrupt, initiated by a timer interrupt event, 902, including the usual steps of

(a) setting up an interrupt timer at 912 and
(b) testing for completion of the time (913)

whereupon an interrupt 903 initiates the subsidiary task. There is also room for a further subsidiary task, namely reporting on the position of the primary conductor in relation to the several arrays of magnetic cores.

1. Consider (i.e. rank or enumerate) the records of short-circuit currents using the memory information 914 for instance.
2. Using (a) constants reflecting the disposition of coils beneath the vehicle and (b) the instant records of short-circuit currents...
3. derive the apparent primary conductor mean position.
4. Report the position as character strings to a navigation control device through a communications channel - I^2C or US-232 serial channels for example. Preferably this channel is optically isolated and then it is simpler to isolate the RS-232 serial channel.

Derivation of apparent primary position might for example take the form of assessing the relative proportion of flux in each coil along one array or magnetic core, to provide the position beneath that core, and then considering all cores in order to estimate the direction.

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Another derivation procedure uses fuzzy logic principles and this is preferred as it is better able to cope with loss of function by one or more individual coils.

Reporting of position is useful to a vehicle steering or navigation unit, which may for example be empowered to force the vehicle onto a track it if deviates by too much, or which may guide an automatically guided vehicle along a warehouse floor.

OPTIONS

As the maximum power from any coil is limited by saturation of the ferrite core (in this example slightly over 500 W, extra power can be obtained by increasing the cross-sectional area amount of ferrite - either by using thicker fingers in an array or by installing more arrays.

Surges of power can be provided from a battery backup or a capacitor bank.

ADVANTAGES

Using our preferred flux concentrator, the volume from which power-carrying flux can be enlarged while the size of the pick-up structure remains small.

The distance from primary to secondary can be extended.

Large monolithic ferrite structures are too brittle to be usable for pick-up coils for inductive power transfer, but by fingering them they gain some flexibility and become much easier to use and are more robust.

By using multiple coils the observed secondary-coil currents indicate which coils to select to obtain power.

Also by using multiple coils the observed secondary-coil currents can be used to determine the position of the flux concentration system relative to the track and hence can be used for guidance.

The primary conductors can be buried deeper in a substrate and so removed from proximity to damage to themselves or to inadvertently causing high induced currents in

nearby articles.

By using a horizontal field from a pair of conductors below a surface instead of using a vertical field, allows for greater flexibility in design and greater mobility of the vehicle relative to the placement of the conductors. The horizontal filed has a null output between the wires. The pick-up coils can be much smaller than those using a vertical field and have much smaller circulating currents in them. The horizontal filed also allows for multiple coils giving much better misalignment performance than for a vertical field.

The pick-up coil winding is a great deal shorter, and in particular has far less non-functional length over that of an air-cored version.

The pick-up coil is now compact enough for replacement by a superconducting coil, should the economics of superconductivity provide a material improvement in efficiency.

Finally, it will be appreciated that various alterations and modifications may be made to the foregoing without departing from the scope of this invention as set forth in the following claims.

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CLAIMS

1. Inductive power pick-up means comprising a plurality of pick-up coils mounted on a movable support said coils being spaced apart from one another, each coil being adapted to pick-up inductive power from a primary conductor so that each coil can act as a secondary conductor when located relative to a said primary conductor, and control means capable of identifying from time to time the pickup coil or coils in best alignment with a said primary conductor, said control means including switching means capable of switching "on" the identified pickup coil or coils which are best sited to collect inductive power from a said primary conductor, and to render functionally inactive the coil or coils (if any) which are remote from a said primary conductor.

2. Inductive power pick-up means as claimed in claim 1 wherein said control means is capable of determining from time to time the short-circuit current available at each pickup coil.

3. Inductive power pick-up means as claimed in claim 1 wherein said control means has means to measure the rate of voltage increase that occurs when the coil is released from a shorted state.

4. Inductive power pick-up means as claimed in claim 1 wherein said control means maintains those coils which are not loaded, or only partly loaded, in a short-circuited state.

5. Inductive power pick-up means as claimed in claim 1 wherein said control means includes means to control the amount of resonant current flowing in any pickup coil, by controlling the voltage output after rectification and smoothing.

6. Inductive power pick-up means as claimed in claim 1 wherein each pick-up coil is mounted on a ferromagnetic flux concentrator adapted for capturing flux lines and feeding them through the core of a said pickup coil.

7. Inductive power pick-up means as claimed in claim 6 wherein the ferromagnetic flux concentrator comprises an elongate mass of magnetically permeable material having a main face substantially parallel to a said primary conductor, said mass having

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a length, a width, and a height, wherein said mass is mounted on said support so that in use the length of the mass of magnetic material is substantially at right angles to said primary conductor to concentrate the horizontal component of the magnetic flux through the flux concentrator.

8. Inductive power pick-up means as claimed in claim 7 wherein the magnetic permeability of the magnetic core is 1000 or greater.

9. Inductive power pick-up means as claimed in claim 7 wherein the magnetic core is capable of undergoing distortion without permanent loss of function.

10. Inductive power pick-up means as claimed in claim 7 wherein the magnetic core is composed of a ferrite material, provided as a modular array comprising at least four fingers of material, each finger having at least one shaped side, the fingers being laid side by side along the length of the elongate mass in an array with these shaped sides held in close contact with each other by a compliant force exerting a compression force along the length of the array, so that the permeability of the array is substantially similar to that of an equivalent single mass of the ferrite material.

11. Inductive power pick-up means as claimed in claim 10 wherein the shaped sides are substantially optically flat.

12. Inductive power pick-up means as claimed in claim 7 wherein more than one pick-up coil is provided on a single core.

13. Inductive power pick-up means as claimed in claim 7 wherein a conducting sheet is positioned on the side of the magnetic core away from the source of magnetic flux.

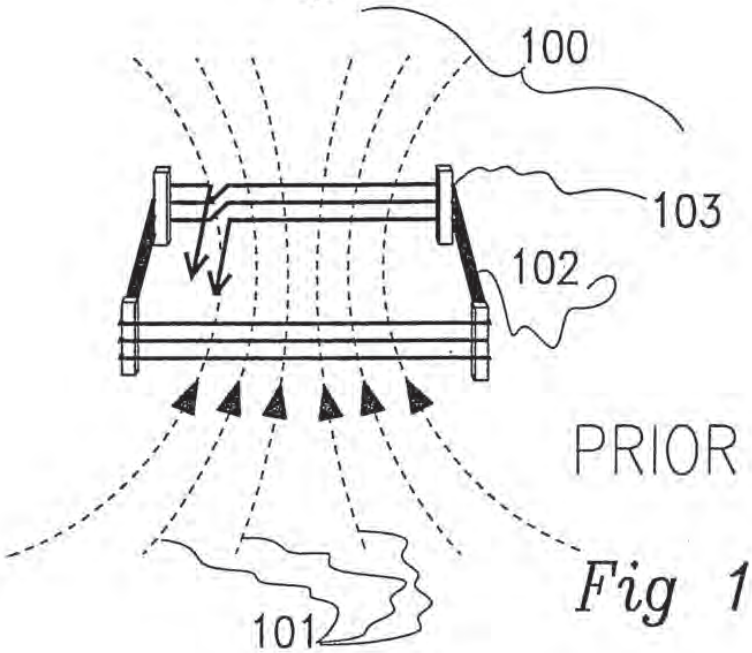
14. Inductive power pick-up means as claimed in claim 1 wherein each pick-up coil is tuned with its own resonating capacitor and each has its own rectifier so that a DC output can be taken from it.

15. Inductive power pick-up means as claimed in claim 1 wherein the movable support is a wheeled vehicle.

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16. Inductive power pick-up means as claimed in claim 1 wherein the wheeled vehicle has at least one steerable wheel controlled by a steering controller connected to said control means, and said steering controller is adapted to steer the vehicle in response to the detection of a said primary conductor by the control means so that the vehicle in use can follow a path defined by a said primary conductor.

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PRIOR ART

Fig 1

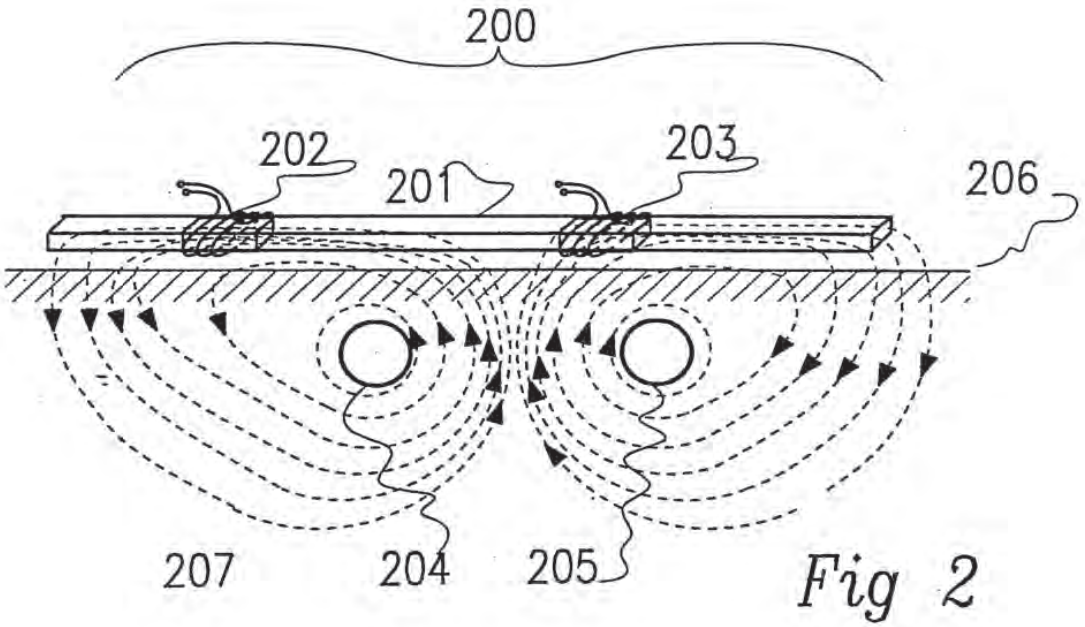


Fig 2

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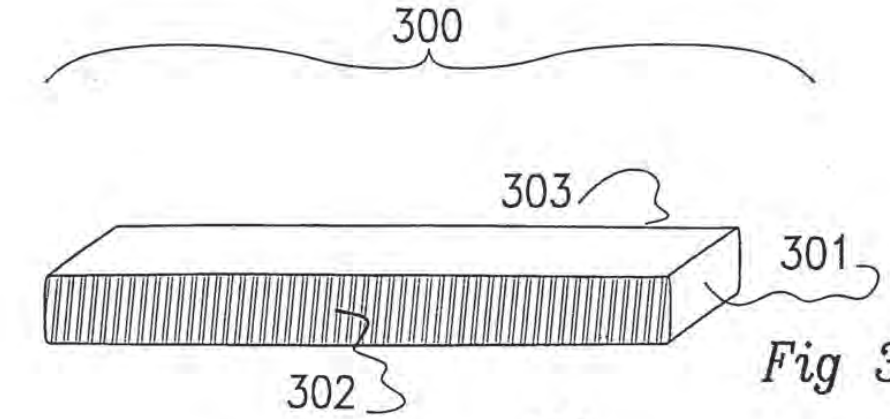


Fig 3

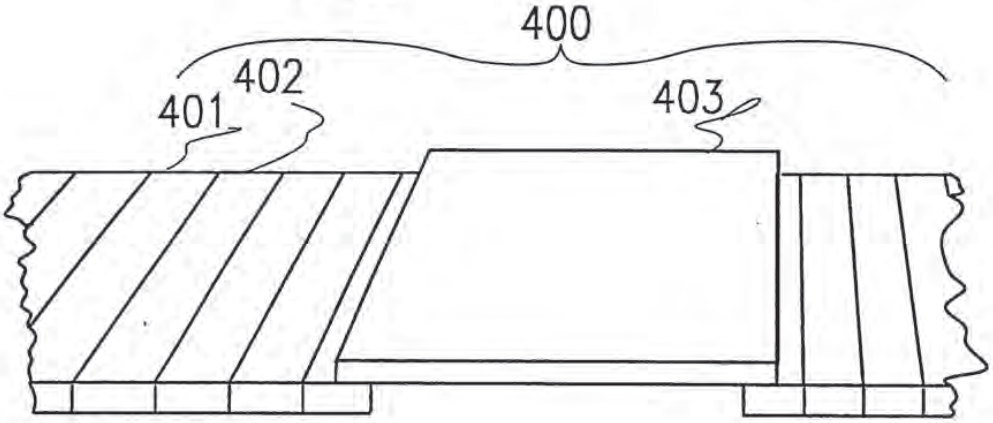


Fig 4

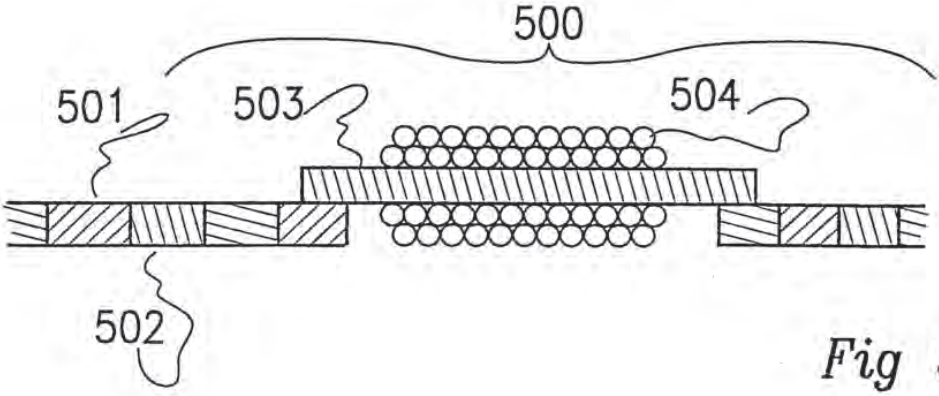


Fig 5

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Page 1024

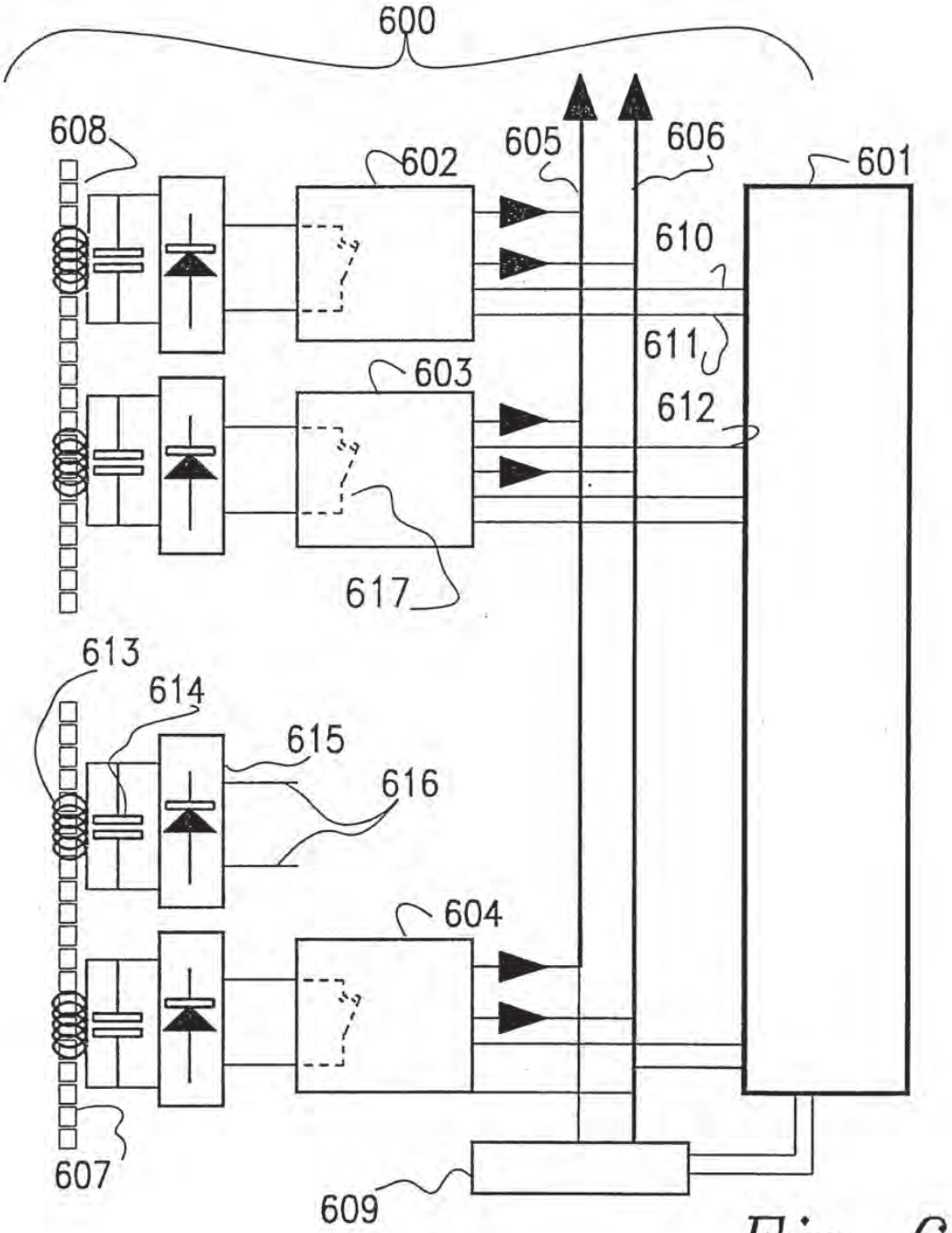


Fig 6

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Page 1025

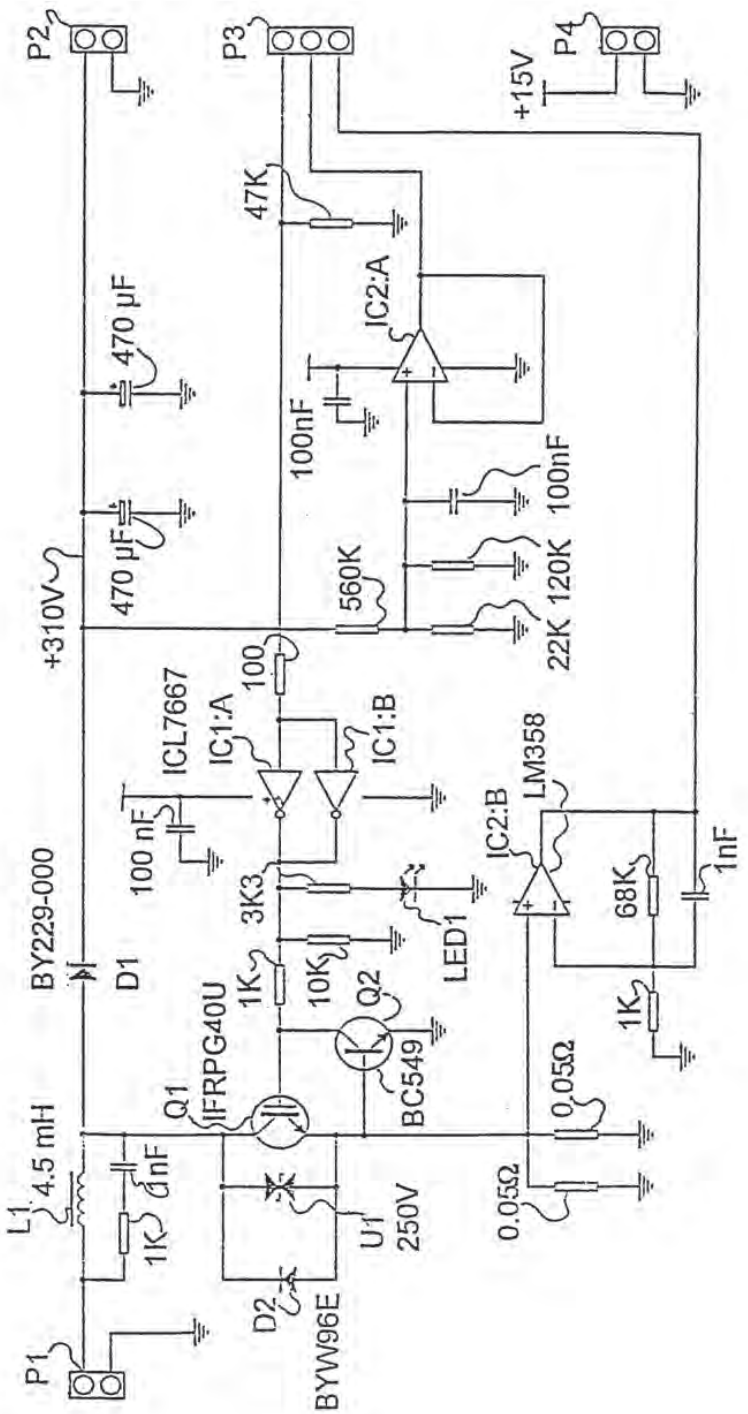


Fig 7

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Page 1026

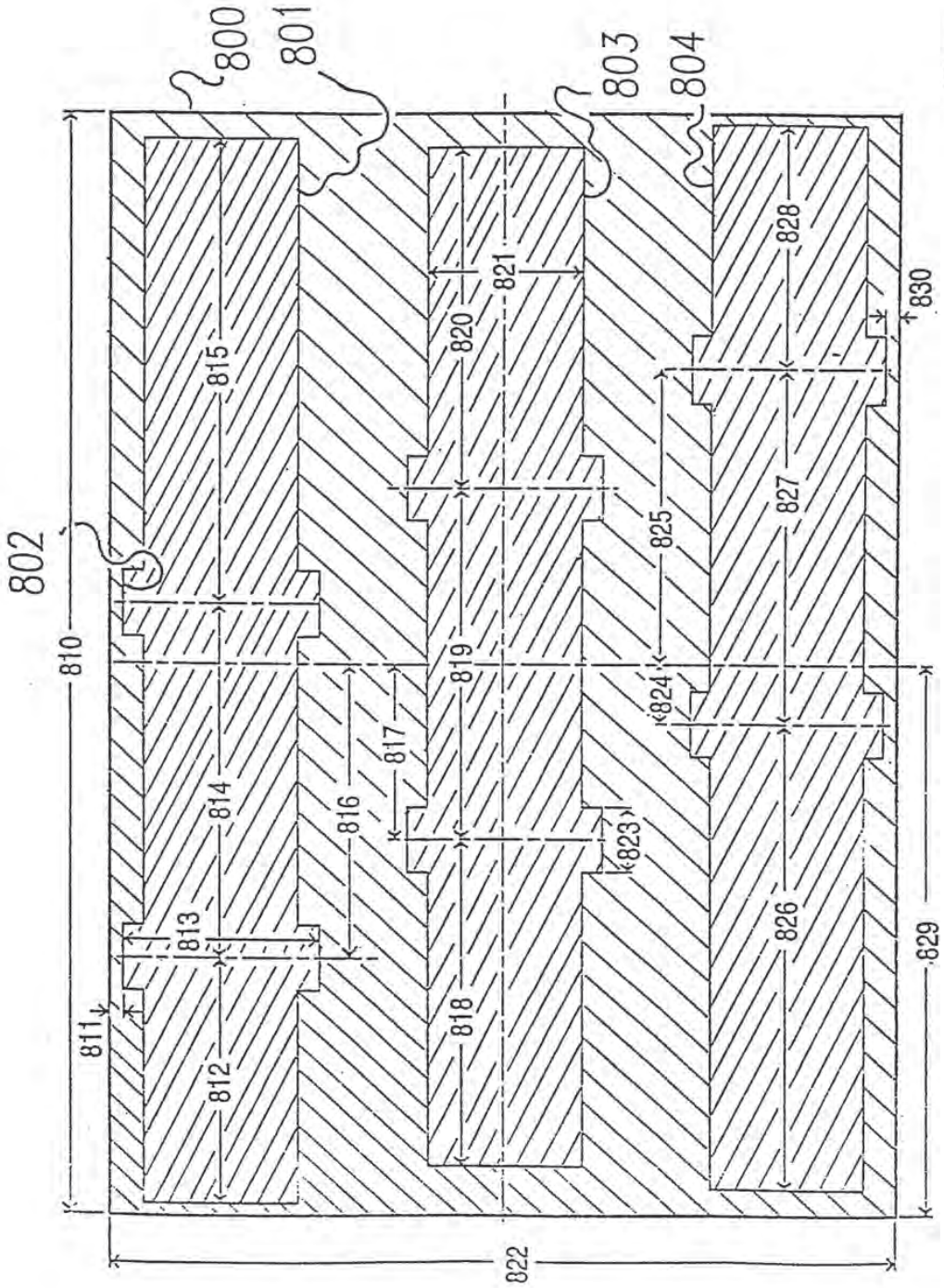


Fig 8

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Page 1027

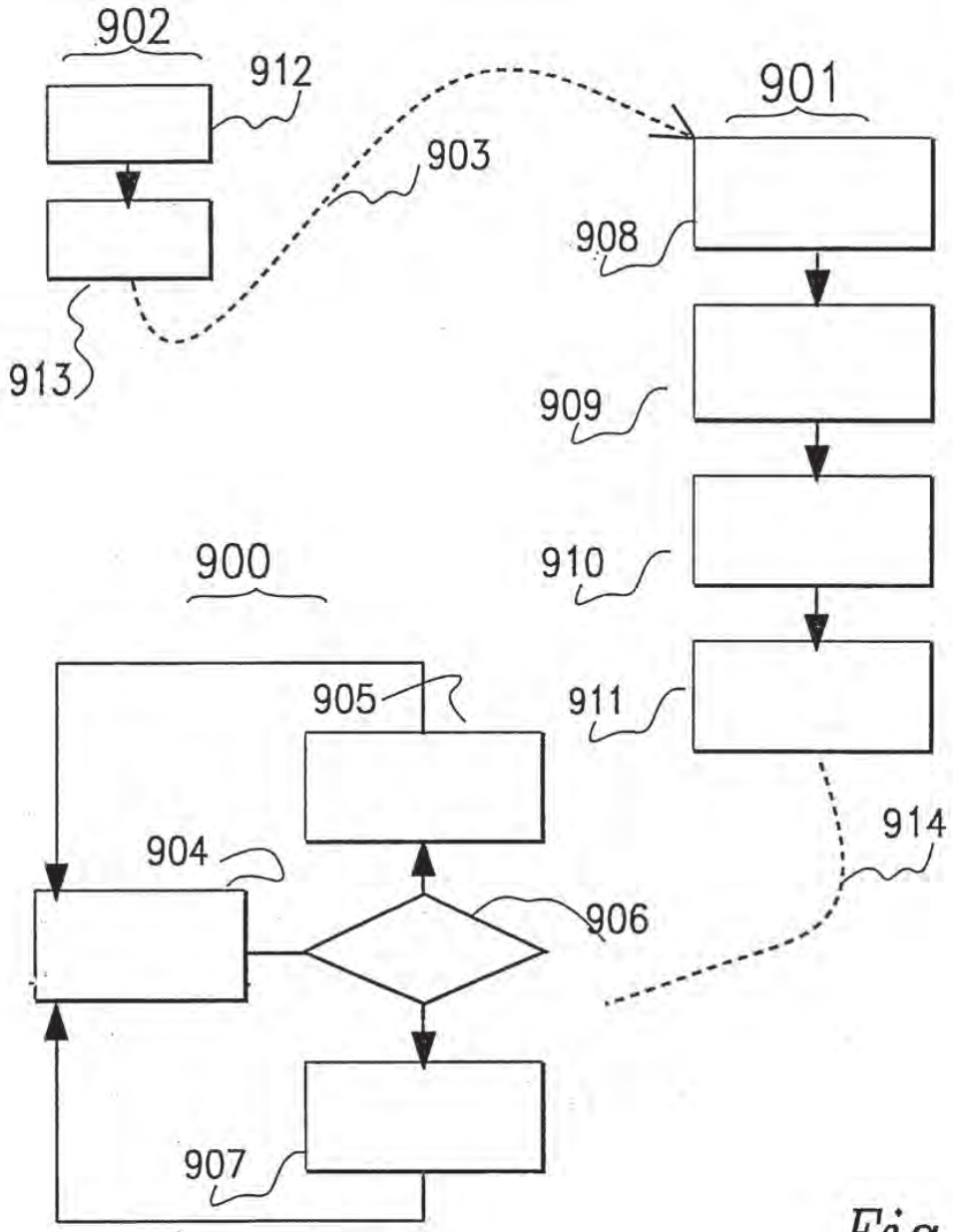


Fig 9

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Page 1028

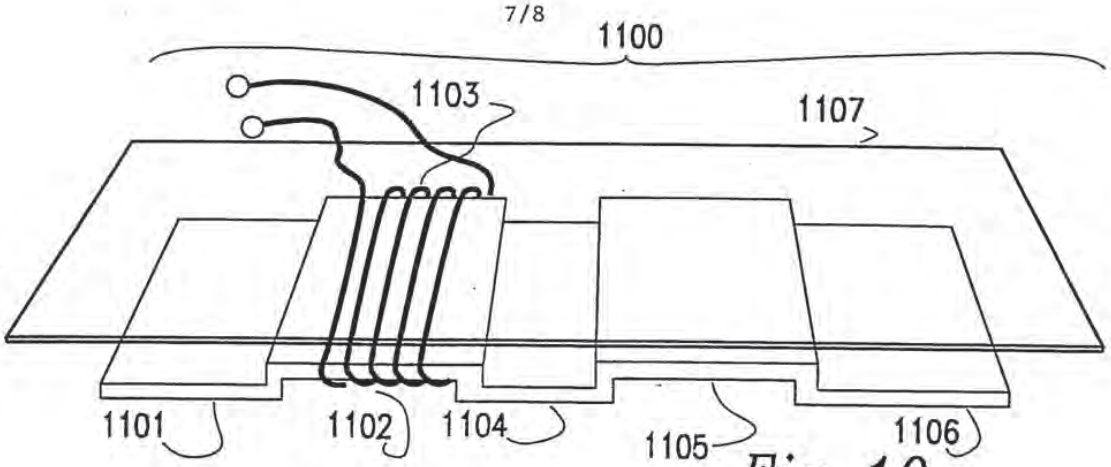


Fig 10

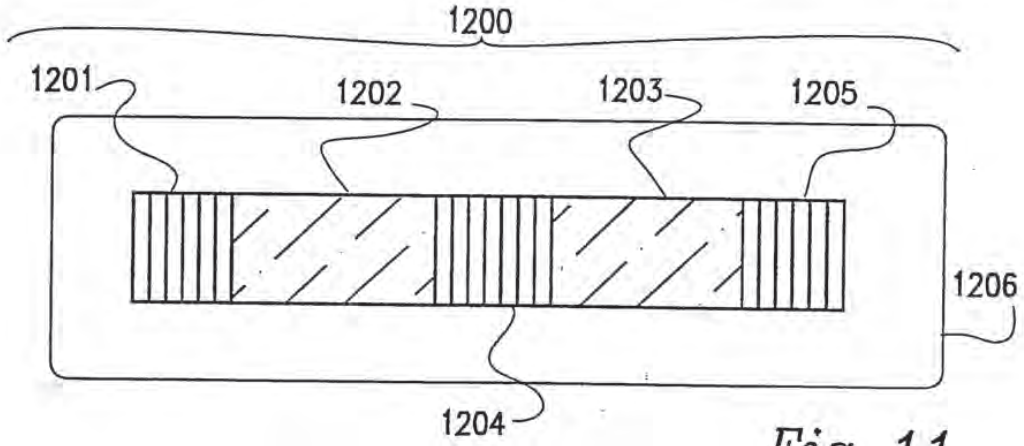


Fig 11

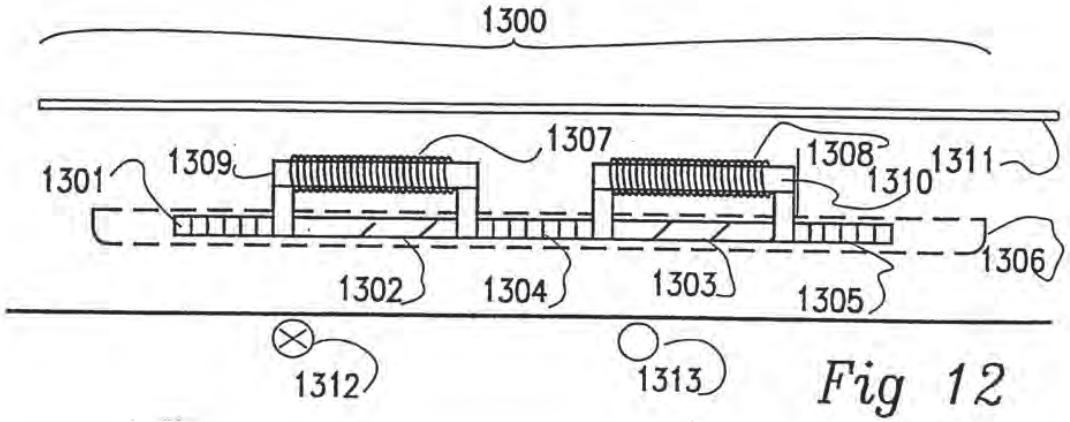


Fig 12

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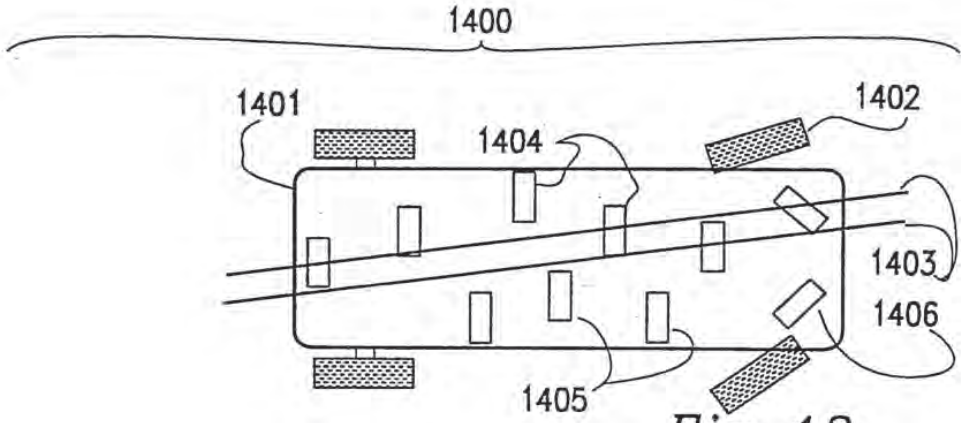


Fig 13

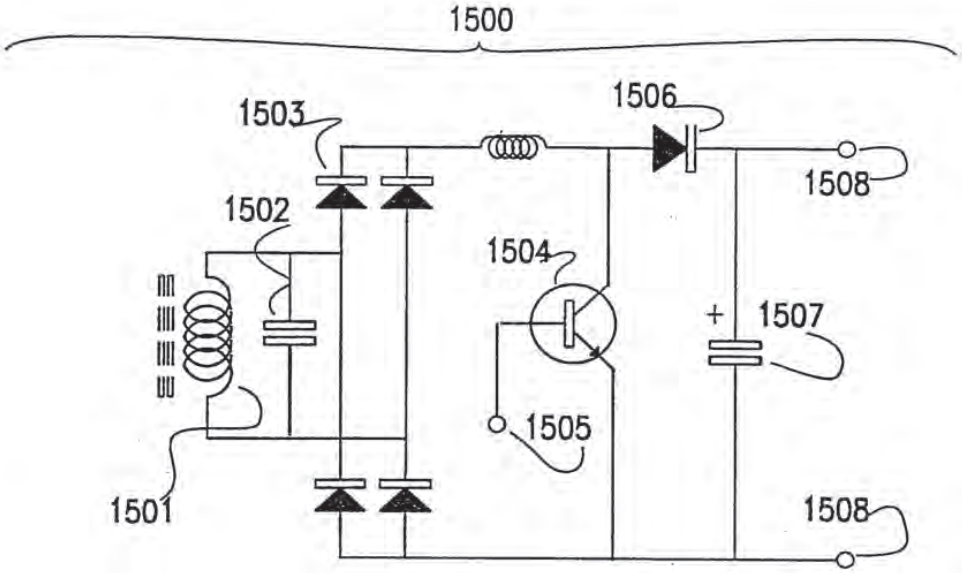


Fig 14

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ 94/00115

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[6] H02J 17/00, 5/00 H01F 23/00 B60L 5/00, 13/00

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 H02J 17/00, 5/00 H01F 23/00 B60L 5/00, 13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU:IPC as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A, 5293308 (Boys et al) 8 March 1994 (08.03.94) abstract, column 2 line 9 to column 4 line 17	1-4
A	Patent Abstracts of Japan, E1157, page 72, JP,A, 3-239135 (Mitsubishi Electric Corp) 24 October 1991 (24.10.91) abstarct	1-4
A	DE,A, 3915682 (Angewandte Digital Elektronik GmbH) 22 November 1990 (22.11.90) whole document	1

[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 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
24 February 1995 (24.02.95)	6 Mar 1995 (06.03.95)
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	Authorized officer R. FINZI Telephone No. (06) 2832213

Form PCT/ISA/210 (continuation of first sheet (2)) (July 1992) copyus

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Exhibit 1025
Page 1031

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	**Citation of document, with indication, where appropriate of the relevant passages**	**Relevant to Claim No.**
A	US,A, 4836344 (Bolger) 6 June 1989 (06.06.89) abstract, column2 lines 25 to 60	1
A	BE,A, 879677 (Mefina SA) 15 February 1980 (15.02.80) whole document	1
A	DT,A, 2613105 (Siemens AG) 29 September 1977 (29.09.77) whole document	1

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INTERNATIONAL SEARCH REPORT

Information on patent family memb

International application No.
PCT/NZ 94/00115

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					
US	5293308	AU	12373/92	CA	2106784	EP	577611
		MX	9201100	NZ	237572	WO	9217929
JP	32952	JP	3239135				
DE	3915682	None					
US	4836344	CA	1300698	EP	289868	JP	1039202
							END OF ANNEX

Form PCT/ISA/210(patent family annex)(July 1992) copyus

Electronic Patent Application Fee Transmittal	
Application Number:	12639963
Filing Date:	16-Dec-2009
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Filer:	Marc M. Wefers/Cheryl Forrest
Attorney Docket Number:	01997-0359009 / MIT 11757
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

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

Electronic Acknowledgement Receipt	
EFS ID:	15139403
Application Number:	12639963
International Application Number:	
Confirmation Number:	7811
Title of Invention:	WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE
First Named Inventor/Applicant Name:	John D. Joannopoulos
Customer Number:	26161
Filer:	Marc M. Wefers/Cheryl Forrest
Filer Authorized By:	Marc M. Wefers
Attorney Docket Number:	01997-0359009 / MIT 11757
Receipt Date:	07-MAR-2013
Filing Date:	16-DEC-2009
Time Stamp:	09:46:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	11659
Deposit Account	061050
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		359009-IDS.pdf	56801 14e9f8c00bb103e472a1d644b53c0f8e4732b85	yes	2
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	1	
	Information Disclosure Statement (IDS) Form (SB08)		2	2	
Warnings:					
Information:					
2	Foreign Reference	FA.pdf	1498162 f95912ebf21272b82248ad4fa02b604c86ea7c701	no	37
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30552 2eee8eaacf710ed6bd25e37089fc5901c8c20451	no	2
Warnings:					
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		Total Files Size (in bytes):	1585515		

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: John D. Joannopoulos et al.	Art Unit	: 2836
Serial No.	: 12/639,963	Examiner	: Fritz Fleming
Filed	: December 16, 2009	Conf. No.	: 7811
Title	: WIRELESS ENERGY TRANSFER WITH HIGH-Q TO MORE THAN ONE DEVICE		

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

INFORMATION DISCLOSURE STATEMENT

Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

This statement is being filed after a first Office action on the merits, but before receipt of a final Office action or a Notice of Allowance. The fees in the amount of $180 in payment of the late submission fee of 37 CFR §1.17(p) are being paid concurrently herewith. In addition, please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 3/6/13

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Reg. No. 56,842

Customer Number 26161
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Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359009	Application No. 12/639,963
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 16, 2009	Group Art Unit 2836

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	8,178,995	5/15/2012	Amano et al.			
	2	2005/0125093	6/9/2005	Kikuchi et al.			
	3						

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	4	EP 1 521 206	04/06/2005	Europe				
	5							

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	6	Copy of European Search Report with regard to Application Serial No. 11184066.6 by Examiner Konstantin Kanelis dated March 20, 2013
	7	

Examiner Signature	Date Considered

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 521 206 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.04.2005 Bulletin 2005/14

(51) Int Cl.7: **G06K 19/07**

(21) Application number: **04023231.6**

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(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
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AL HR LT LV MK

(30) Priority: **01.10.2003 JP 2003343616**

(71) Applicant: **SONY CORPORATION**
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  Tokyo (JP)

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Innere Wiener Strasse 17
81667 München (DE)

(54) Relaying apparatus and communication system

(57) A relaying device for providing optimum communication between a non-contact information medium and an information read/ write device, and a communication system employing the relaying device, in which the adverse effect on communication, brought about by limitations on the mounting site of the information read/ write device may be eliminated. The relaying device is formed by a resonance circuit 34 including a first antenna coil 31, electro-magnetically coupled to an antenna coil 11 of the information read/ write device 10, a second antenna coil 32, connected in series with the first antenna coil 31 and electro-magnetically coupled to an antenna coil 21 of the non-contact information medium 20, and a tuning capacitor 33 connected in series with the first antenna coil 31 and the second antenna coil 32. The first antenna coil 31, second antenna coil 32 and the tuning capacitor 33 making up the resonance circuit 34 is resonated with the same resonance frequency as that of the resonance circuit 13 of the information read/ write device 10 and that of the resonance circuit 23 of the non-contact information medium 20.

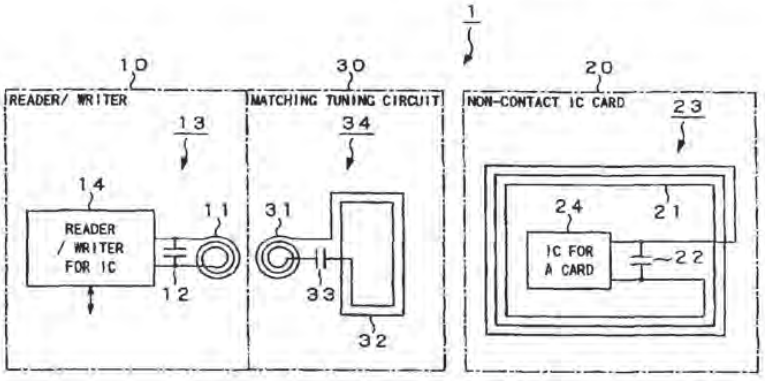


FIG. 1

EP 1 521 206 A2

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This Invention relates to an RFID (Radio Frequency IDentification) employing a non-contact information medium, such as a non-contact IC (Integrated Circuit) tag or a non-contact IC card. More particularly, it relates to a relaying device for providing optimum communication between a non-contact information medium and an information read/ write device, and to a communication system employing the relaying device.

[0002] The RFID system, as the communication system employing a non-contact information medium, such as a non-contact IC card or a non-contact IC tag, has been devised and put to practical use. The RFID system allows information communication to be performed between an IC chip enclosed in the non-contact information medium, and a reader/writer, and is utilized in an automatic ticket checker in a railroad station or for book lending in a lending library. It is estimated that, in near future, the system will be used for exchanging the private information in a wide variety of fields.

[0003] The non-contact IC card is a generic term for a card-shaped non-contact information medium, such as a so-called credit card. On the other hand, the non-contact IC tag is a generic term for a non-contact information medium of a shape other than the card shape, a non-contact information medium of a label size smaller than the credit card size, such as a stamp size or a size smaller than the stamp size, or a non-contact information medium of a round or a star shape.

[0004] In the RFID system by the electro-magnetic coupling system, the non-contact information medium receives electrical waves, transmitted from the reader/ writer, to obtain the operating power from the received electrical waves by electro-magnetic induction, and effects data communication with the reader/ writer by exploiting the received electrical waves. The non-contact information medium and the reader/ writer each include an antenna coil for transmitting/ receiving the electrical waves. The optimum communication distance between the reader/ writer of the electro-magnetic coupling system and the non-contact information medium is usually several cm to tens of cm.

[Patent Publication 1] Japanese Laid-Open Patent Publication 2000-315908

[0005] For example, if the non-contact information medium is a non-contact IC card, the card size of the same size as the credit card size (54 mm in length, 85.6 mm in width and 0.76 mm in thickness), as provided for by the ISO (International Organization for Standardization), is generally used.

[0006] In such case, the antenna coil 100, enclosed in the non-contact IC card, is sized to approximately the size of the non-contact IC card, in order to permit the largest amount possible of the flux from the reader/ writer as possible to traverse the inside of the coil, as shown in Fig. 17A. If the non-contact information medium is a non-contact IC tag, the antenna coil is of such a shape as to permit the largest amount possible of the flux to traverse the inside of the coil, depending on the standard or the size of the non-contact IC tag.

[0007] In this manner, the shape of the antenna coil of the non-contact information medium is determined to a more or less extent by e.g. the relevant standard.

[0008] On the other hand, the shape of the antenna coil of the reader/writer is appreciably influenced by the structure of the equipment carrying the reader/writer thereon.

[0009] In case the inside space of a casing of the device carrying the reader/writer thereon is occupied by densely arranged component parts, there is not sufficient space available for properly mounting the reader/ writer. In such case, the antenna coil area is decreased compared to the available space in the casing, or the reader/writer is mounted on the back side of the casing of the carrying device, in order to exploit the small space left in the casing.

[0010] In particular, if the reader/writer is mounted on the back side of the casing of the carrying device, an aperture must be formed in a portion of the casing in order to pass the magnetic flux emanating from the magnetic field generated by the antenna coil of the reader/ writer to the antenna coil of the non-contact information medium.

[0011] In general, the casing is provided for protecting the circuitry in the casing against impacts from outside, or for shielding the electro-magnetic noise, emanating from the electronic circuit in the casing and hence the processing such as perforating the casing is to be avoided as far as is possible. If the casing is to be perforated, out of necessity, the area of an aperture produced needs to be as small as possible.

[0012] Consequently, the antenna coil of the reader/ writer is of an extremely small size as compared the size of the antenna coil enclosed in the non-contact information medium. For example, an antenna coil 200 of the reader/writer, shown in Fig. 17B, is of a size appreciably smaller than the size of the antenna coil 100 enclosed in the inside of the non-contact IC card shown in Fig. 17A.

[0013] If the size of the antenna coil on the reader/ writer side is this small, the amount of the magnetic flux generated by the current flowing in the antenna coil is also extremely small, so that, if the non-contact information medium is moved to the vicinity of the antenna coil of the reader/ writer, the amount of the magnetic flux necessary to operate the non-contact information medium cannot be generated.

[0014] Fig.18 shows the manner in which the magnetic flux by the magnetic field generated by the antenna

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coil 200 provided to the reader/writer traverses the inside of the antenna coil 100 enclosed within the non-contact IC card. As may be seen from Fig. 18, since it is the magnetic flux by the magnetic field at the center of the antenna coil 200 that traverses the inside of the antenna coil 100, the antenna coil 100 must be moved to a position closer to the antenna coil 200 in order to procure an appropriate amount of the magnetic flux.

[0015] Fig. 19 shows a communication system 150, made up by a reader/ writer 201 having an antenna coil 200, mounted to the back side of the metal casing 205, and by a non-contact IC card 101, having an antenna coil 100.

[0016] The reader/writer 201 includes an antenna coil 200, as an inductor arranged on a substrate 204, a tuning capacitor 203, connected in series with the antenna coil 200, to form a parallel resonance circuit, and an IC for a reader/writer 202 for controlling the data transmission/ receipt with the non-contact IC card 101. A casing 205, having the reader/ writer 201 mounted thereon, is perforated at 205A in register with the antenna coil 200.

[0017] In a majority of cases, the casing 205 of the equipment, adapted for loading the reader/ writer 201 thereon, is formed of metal for procuring the strength or for preventing leakage to outside of the electro-magnetic noise caused by the internal electronic circuitry. However, if a substrate 204 is mounted to the metal casing 205, the magnetic flux of the magnetic filed, generated by the antenna coil 200, is lost in the casing 205, such that it is only the small amount of the magnetic flux generated at the center of the antenna coil 200 that is allowed to pass through the inside of the antenna coil of the non-contact IC card 101.

[0018] Thus, with the communication system 150, shown in Fig. 19, the non-contact IC card 101 and the reader/writer 201 cannot communicate with each other.

[0019] That is, a wide variety of constraints are imposed on the antenna coil of the reader/writer, by the structure of the equipment adapted for loading the reader/writer thereon, such that it is difficult to set the antenna coil shape or area in such a manner as to permit optimum communication with the non-contact information medium. There is also a problem that, given the limited space within the equipment adapted for loading the reader/ writer thereon, it is also extremely difficult to eliminate the adverse effect of the metal components interfering with the wireless communication.

[0020] For overcoming this deficiency, the antenna coil of the reader/ writer 201 is designed as an antenna coil 210 substantially coextensive as the antenna coil of the non-contact IC card, and is mounted on the back side of a resin cover 220, fitted to the casing 205, so as to operate as a relaying antenna, as shown in Fig.21. In this manner, it is possible to cope with the constraint of the antenna area or to eliminate the adverse effect from the metal casing 205.

[0021] The antenna coil 210 is connected to the substrate 204 by fitting a jack 212, mounted to the distal end of a lead wire 211, extending from the antenna coil 210, into a plug 213 provided to the substrate 202 exposed through the aperture 205A formed in the casing 205.

[0022] Consequently, the antenna coil 210 is inconvenient to mount or dismantle, especially for maintenance, such that, in the worst of cases, the lead wire 211 may be ruptured, or the reader/ writer 201 may be destroyed.

SUMMARY OF THE INVENTION

[0023] In view of the above-depicted status of the art, it is an object of the present invention to provide a relaying device and a communication system in which, in wireless communication by the electro-magnetic coupling system between an information read/write device and a non-contact information medium, mediated by a carrier wave of a preset frequency, the adverse effect on the communication, brought about by the limitation as to the mounting site of the information read/write device, may be eliminated, and the use configuration of the information read/write device and a non-contact information medium may be flexibly coped with to achieve optimum communication.

[0024] In one aspect, the present invention provides a relaying apparatus for relaying wireless communication of the electro-magnetic coupling system, mediated by a carrier wave of a preset frequency, between an information read/write device and a non-contact information medium. The relaying apparatus comprises a first antenna coil electro-magnetically coupled to an antenna coil of the information read/ write device, a second antenna coil, connected in series with the first antenna coil and electro-magnetically coupled with an antenna coil of the non-contact information medium, and a tuning capacitor connected in series with the first antenna coil and with the second antenna coil. The first antenna coil, second antenna coil and the tuning capacitor form a resonance circuit resonated at the resonance frequency which is the same as the resonance frequency of a resonance circuit of the read/ write device and the resonance frequency of a resonance circuit of the non-contact information medium.

[0025] In another aspect, the present invention provides a relaying device for providing optimum communication between a non-contact information medium and an information read/write device, and a communication system employing the relaying device, in which the adverse effect on communication, brought about by limitations on the mounting site of the information read/ write device may be eliminated. The relaying device is formed by a resonance circuit including a first antenna coil, electro-magnetically coupled to an antenna coil of the information read/ write device, a second antenna coil, connected in series with the first antenna coil and electro-magnetically coupled to an antenna coil of the non-contact information medium, and a tuning capacitor connected in series with the first antenna coil and the

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second antenna coil. The first antenna coil, second antenna coil and the tuning capacitor making up the resonance circuit is resonated with the same resonance frequency as that of the resonance circuit of the information read/ write device and that of the resonance circuit of the non-contact information medium.

[0026] In a further aspect, the present invention provides a communication system for wireless communication of the electro-magnetic coupling system, mediated by a carrier wave of a preset frequency, in which the communication system comprises an information read/ write device including a first resonance circuit made up by a first antenna coil and by a first tuning capacitor connected in series with the first antenna coil, with the information read/write device having wireless communication with a circuit electro-magnetically coupled to the first antenna coil, with the resonance frequency of the first resonance circuit as the frequency of the carrier wave. The communication system also comprises a non-contact information medium including a second resonance circuit made up by a second antenna coil and by a second tuning capacitor connected in series with the second antenna coil, with the second resonance circuit resonating with a resonance frequency which is the same as the resonance frequency of the first resonance circuit and having wireless communication with a circuit electro-magnetically coupled to the second antenna coil, and a relaying device including a third resonance circuit, made up by a third antenna coil, electro-magnetically coupled to the first antenna coil of the information write device, a fourth antenna coil connected in series with the third coil and electro-magnetically coupled with the antenna coil of the non-contact information medium, and a third tuning capacitor connected in series with the third and fourth antenna coils. The third relaying circuit resonates with the same resonance frequency as the resonance frequency of the first resonance circuit and the second resonance circuit. The relaying device relays the wireless communication between the information read/write device and the non-contact information medium.

[0027] In yet another aspect, the present invention provides a communication system for wireless communication of the electro-magnetic coupling system, mediated by a carrier wave of a preset frequency, in which the communication system comprises an information read/write device including a first resonance circuit made up by a first antenna coil and by a first tuning capacitor connected in series with the first antenna coil, with the information read/ write device having wireless communication with a circuit electro-magnetically coupled to the first antenna coil, with the resonance frequency of the first resonance circuit as the frequency of the carrier wave. The communication system also comprises a non-contact information medium including a second resonance circuit made up by a second antenna coil and by a second tuning capacitor connected in series with the second antenna coil, with the second resonance circuit resonating with a resonance frequency which is the same as the resonance frequency of the first resonance circuit and having wireless communication with a circuit electro-magnetically coupled to the second antenna coil, and a relaying device including a third resonance circuit, made up by a third antenna coil, electro-magnetically coupled to the first antenna coil of the information write device, a fourth antenna coil connected in series with the third coil and electro-magnetically coupled with the antenna coil of the non-contact information medium, and a third tuning capacitor connected in series with each of the third and fourth antenna coils. The third relaying circuit resonates with the same resonance frequency as the resonance frequency of the first resonance circuit and the second resonance circuit. The relaying device relays the wireless communication between the information read/write device and the non-contact information medium.

[0028] The relaying device of the present invention includes, for wireless communication by the electro-magnetic coupling system between the information read/ write device and the non-contact information medium, a first antenna coil, electro-magnetically coupled to an antenna coil of the information read/write device, and a second antenna coil, electro-magnetically coupled to an antenna coil of the non-contact information medium, and assures optimum wireless communication even in cases wherein the antenna coil of the information read/ write device has a shape and a size differing appreciably from those of the antenna coil of the non-contact information medium.

[0029] The wireless communication between the non-contact information medium and a wide variety of use configurations of the read/ write device may be optimized by a simple technique of changing the size/ shape of the first and second antenna coils of the relaying device so that the first and second antenna coils may be electro-magnetically coupled to the antenna coils of the information read/ write device and the non-contact information medium, respectively.

[0030] The communication system of the present invention includes, for wireless communication by the electro-magnetic coupling system between the information read/write device and the non-contact information medium, a third antenna coil, electro-magnetically coupled to the first antenna coil of the information read/ write device, and a fourth antenna coil, electro-magnetically coupled to the second antenna coil of the non-contact information medium, and assures optimum wireless communication even in cases wherein the antenna coil of the information read/write device has a shape and a size differing appreciably from those of the antenna coil of the non-contact information medium.

[0031] Moreover, the wireless communication between the non-contact information medium and a wide variety of use configurations of the read/write device may be optimized by a simple technique of changing the size/shape of the third and fourth antenna coils of the

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