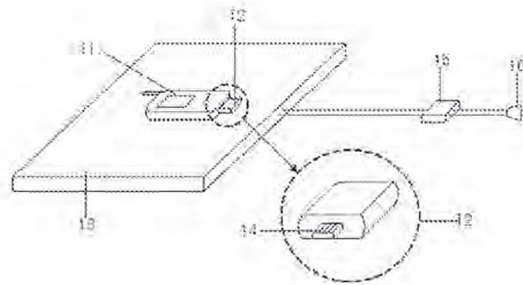
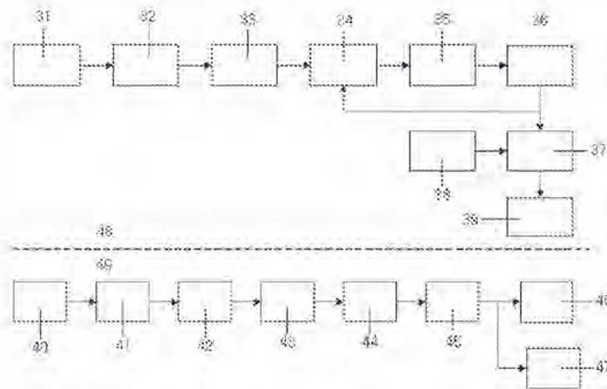


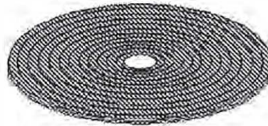
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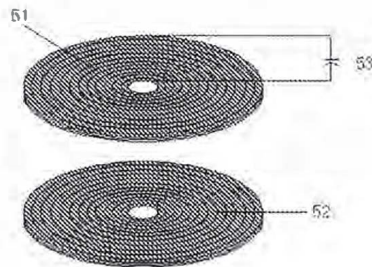
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도면3



도면4



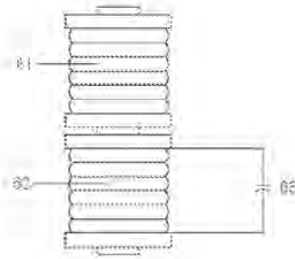
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도면6



도면7



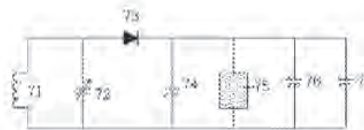
도면8



도면9



도면10





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 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 이 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

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 이 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 월 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 circuit Comes 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, FMP 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

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 될 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 될 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 ㄹ map with all, style it connects with the mammary gland each other, it separates and it composes the minute description ㄹ 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 될 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 될 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 될 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

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.

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 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 will 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 will 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 will the coil and the spy will 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 combination While 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 for the variable it is big the reception coil and a resonance circuit and the plaque seater and.

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 ㄹ 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 ㄹ 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

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 이 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 이 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 뭉 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 쥔 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 ㄹ.

Invention also, the different objective respects and AC 이 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 쥔 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,

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 ㄱ 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 ㄱ 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 ㄱ 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 ㄱ 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 ㄱ 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

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 3 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 ㄱ 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 ㄱ 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 ㄱ 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 ㄱ 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 ㄱ 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

observe. It tries to observe in about the transmission module which it follows in the invention which it sees first. When the transmission 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 $\frac{1}{2}$ 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 off 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 ㎐ to hundreds ㎐, 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 $\frac{1}{2}$ 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 of 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 (mm)	Coil type (N 通)	Gratitude possibility
Transmission coil	24	30	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 with the coil the induction magnetic field of the electromagnetic waves relay resonance the spy which connection composes the plaque seater big the spy of the elder brother repeater and prescribed distance 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 (mm)	Coil type (型)	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 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 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

possibility of doing.

Ticket 3: Diameter of relay coil and transmission coil of 5, gratitude possibility, inside diameter and major diameter (transmission sample 3)

3	Inside diameter (mm)	Major diameter	Coil type (mm)	Gratitude possibility
Transmission one	20	30	0.3*8	9
Relay coil	30	80	0.2*8	29

According to the invention which it sees plan the transmission coil which is produced plan the spy which is produced 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

4	Diameter (mm)	Height (mm)	Coil type (mm)	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 (mm)	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 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 (mm)	Coil type (mm)	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 it respects a composition as the relay coil and the competitive exhibition it uses strengthens the

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 4 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)

9	Inside diameter (mm)	Major diameter (mm)	Coil standard (mm)	Gratitude possibility
It will be a reception	5	20	0.2"e	9
Relay coil	20	40	0.43*1	21

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 쥔 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 쥔 the variable to be big contracting composes the plaque seater with the reception coil, and arranging in a row resonance and the impedance whip 쥔 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 쥔 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 쥔 low-end it got of the 쏜 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

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 sample 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 ㉠ 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 seater 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 only 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 ㉡ of the invention which it sees and AC ㉠ 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 ㉠ 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 ㉠ map the reception coil and maximizes the electric energy which is received the resonance for and the impedance whip ㉡ 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 seater big and have occurs the induction magnetic field

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 ㉔ 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 ㉔ transmission coil
 - 4: The spy ㉔ 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 ㉔ the transmission coil which is composed of the coil
 - 5: The spy ㉔ 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 ㉔ 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 ㉔ 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
 - ㉔ map 16; Cone cent 31; All the member (110V and 220V)

32; Fuse 33; Noise filter 34; Stop circuit 35; Control circuit

36; With electric current safety circuit 37; off above 38

circuit 38; updated lance former 39; Output signal 40;

Reception coil

41; Resonance and the impedance whip 42 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 73 the variable it is big

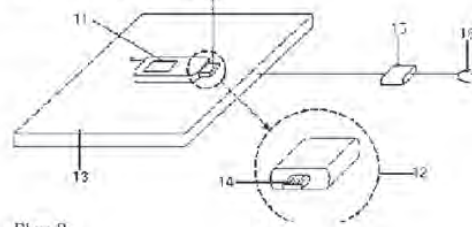
the plaque seater

73 ; Stop diode 74; Criticism bow condenser

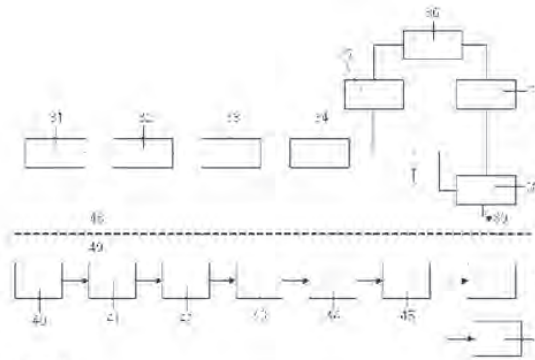
75 ; Really voltage and safety circuit

76 ; Reception module internal charging battery 77:

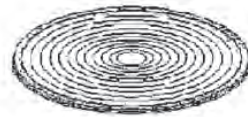
Electronic instrument charging battery plan



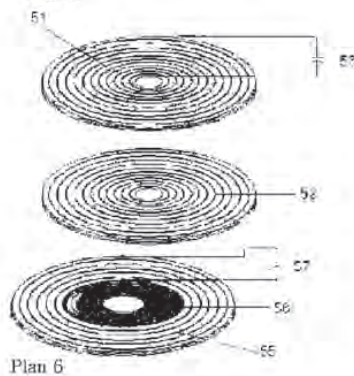
Plan 2



Plan 3



Plan 4

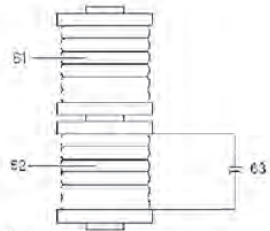


Plan 6

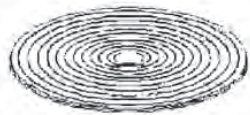
Plan 5



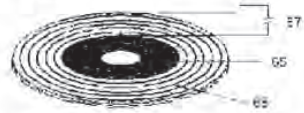
Plan 7



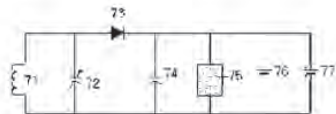
Plan 8



Plan 9



Plan 10



Electronic Acknowledgement Receipt	
EFS ID:	14169686
Application Number:	12649635
International Application Number:	
Confirmation Number:	5891
Title of Invention:	WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-Q RESONATORS
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:	01997-0359015 / MIT 11757
Receipt Date:	07-NOV-2012
Filing Date:	30-DEC-2009
Time Stamp:	13:36:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		359015-IDS.pdf	44535	yes	2
			5000addamd068Pla10107009F000094AA1C a1129		

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	art1.pdf	474293	no	20
			20f5d1c799838679d50f4e5579080f1443a14c		
Warnings:					
Information:					
3	Foreign Reference	art2.pdf	1219461	no	31
			9999f0c27eb2ec71776dd153097f34a5db11a76b		
Warnings:					
Information:					
Total Files Size (in bytes):			1738289		
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. <u>New Applications Under 35 U.S.C. 111</u> 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. <u>National Stage of an International Application under 35 U.S.C. 371</u> 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. <u>New International Application Filed with the USPTO as a Receiving Office</u> 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 : Unknown
Serial No. : 12/649,635 Examiner : Unknown
Filed : December 30, 2009 Conf. No. : 5891
Title : WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-
Q RESONATORS

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 within three months of the filing date of the application or before the receipt of a first Office Action on the merits. Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 11/7/12



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/649,635	12/30/2009	John D. Joannopoulos	01997-0359015 / MIT 11757	5891
26161 7590 12/21/2012 FISH & RICHARDSON P.C. (BO) P.O. BOX 1022 MINNEAPOLIS, MN 55440-1022			EXAMINER FLEMING, FRITZ M	
			ART UNIT 2836	PAPER NUMBER
			NOTIFICATION DATE 12/21/2012	DELIVERY MODE 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. 12/649,635	Applicant(s) JOANNOPOULOS ET AL.	
	Examiner FRITZ M. FLEMING	Art Unit 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 27 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) 1-36 is/are pending in the application.
- 5a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 6) ☐ Claim(s) _____ is/are allowed.
- 7) ☒ Claim(s) 1-36 is/are rejected.
- 8) ☐ Claim(s) _____ is/are objected to.
- 9) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

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

Application Papers

- 10) ☐ The specification is objected to by the Examiner.
- 11) ☒ The drawing(s) filed on 30 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).

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

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

Attachment(s)

- | | |
|---|---|
| 1) ☒ Notice of References Cited (PTO-892) | 3) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date, _____ |
| 2) ☒ Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date <u>See Continuation Sheet</u> . | 4) ☐ Other: _____ |

Continuation of Attachment(s) 2). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :11/7/12,10/15/12,9/12/12,7/31/12,5/24/12,11/30/11,10/5/11,6/6/11,2/24/11,2/8/11,6/16/10,4/23/10.

DETAILED ACTION

Terminal Disclaimer

1. The terminal disclaimer filed on 12/27/11 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of 7,741,734 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Response to Amendment

2. The claims as amended in the preliminary amendment filed 12/27/2011 are examined in this office action.

Double Patenting

3. Claims 1-36 of this application conflict with claims 1-36 of Application No. 11/649,904. 37 CFR 1.78(b) provides that when two or more applications filed by the same applicant contain conflicting claims, elimination of such claims from all but one application may be required in the absence of good and sufficient reason for their retention during pendency in more than one application. Applicant is required to either cancel the conflicting claims from all but one application or maintain a clear line of demarcation between the applications. See MPEP § 822.

4. The claims are word for word duplicates.

5. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory

Art Unit: 2836

obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

6. Claims 1-36 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-22 and 1-20 and 1-10,14-19,21-24 of copending Application No. 12/649,777 and 12/649,852 and 12/649,813. Although the conflicting claims are not identical, they are not patentably distinct from each other because the pending claims broadly recite near field transfer of

electromagnetic energy with first and second resonators, Q's greater than 100, and other features. The co-pending applications claim similar subject matter in different combinations, thus provisional obviousness type double patenting exists across numerous applications. Regarding claims 4 and 8 acoustic near field region, I take official notice that such is a known method. Thus to substitute one known method of power transfer for another is the mere substitution of parts to achieve the desired outcome with a reasonable expectation of success.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

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 feedback mechanism 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

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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

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

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

2. 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.

3. 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

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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).

4. Claims 1-36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Laue in view of iC-Haus and Shuder (Powering an Artificial Heart: Birth of the inductively Coupled-Radio Frequency System in 1960).

5. Please note that applicants have been given copies of Laue and iC-Haus (as well as the machine translations) in one of the numerous related applications, and no copies are being provided herewith. Applicants submitted Shuder, and thus no copy is provided.

6. For purposes of this rejection, a "resonator" is taken to be anything that resonates or operates at a resonant frequency.

7. Laue teaches the main parts of what is claimed. Note the two source coils (28,30) in the stall walls, each optionally coupled to the energy source (32), as shown in Figure 1. There is a third coil (Figure 2) as a rumen bolus that is optionally coupled to a drain (44-48), wherein both of the source coils are coupled to transfer electromagnetic energy to the third. Laue lacks High-Q resonators, and near field.

8. In the same field of endeavor, iC-Haus teaches the use of near field power coupling via a resonant frequency of 130kHz. Note also the use of feedback to correct for any detuning effects due to separation, as power changes can be considered a detuning for optimum power transfer. The near field exhibits both magnetic and electromagnetic fields.

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9. In the same field of endeavor, Shuder teaches the use of High-Q coils for transmit and receive at a resonant frequency.
10. Therefore it would have been obvious to one having ordinary skill in the art at the time that the invention was made to modify Laue per the teachings of iC-Haus and Shuder so that performance can be improved by the use of High-Q resonant coils.
11. Laue shows the sources coupled, as the sources are not required to be different, and the drain coupling.
12. The rumen bolus is a portable electronic device and is free to move.
13. Shuder teaches Q above 100 in the transmit and receive resonators.
14. For claims 8 and 9, Laue shows the source coils each energized to transmit electromagnetic energy to the rumen bolus.
15. Shuder teaches Q above 100 in the transmit and receive resonators.
16. As far as third resonators are concerned, Laue shows a third coil coupled to power, thus in combination this would be a resonator as well. A third resonator coupled to a drain would simply be another rumen bolus.
17. The use of a capacitor in iC-Haus and Shuder shows the ability to tune to a particular resonant frequency.
18. Laue shows relative movability via the cow in the stall. The range depends on the stall and cow sizes, the claimed ranges being consistent with a cow fitting in a stall.
19. Shuder teaches k to be the coupling coefficient per page 910, such coupling coefficient being indicative of an energy transfer rate, as a higher k indicates a better coupling and thus a better energy transfer rate. Efficiency would dictate operating at the

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best possible useful to lost power. Thus tuning for useful power is a known way to increase efficiency. As the references teach quite a range of values for the structural elements, the resultant value depends on the designed system, and as a design dependent variable, is the result of the application of ordinary skill in the art informed by the teachings of the references. Absent unexpected results at these values, the resultant values are deemed to be obvious design results.

20. Shuder teaches 5% transmission losses which would indicate at least 20% efficiency, and one would expect similar results over the range of distances.

21. The frequency per Shuder is 400kHz, with the teaching that losses would be expected to increase greatly at very high and low frequencies (page 912). Thus higher frequencies in the order of 5MHz would be expected to work with greater losses.

22. iC-Haus teaches feedback control of the transmitted power, so that should the received power fall below a desired value, the transmitted power is increased. This would compensate for any de-tuning losses.

23. The desire is for better efficiency and lower losses and better coupling per Shuder, and thus to configure the system to be driven to achieve a better ratio of useful to lost power (better efficiency) for varying energy transfer rates k (similar to the coupling k of Shuder, as explained above), is the mere application of ordinary skill in the art and the desire to achieve better operations. The same is to be said for adjustable tuning, as tuning all of the elements for resonant operation represents the application of routine skill in the art to adjust parameters for optimal results.

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24. The method claims that parallel the apparatus claims and are rejected for the same reasons.

25. Regarding acoustic resonant power transfer, I take official notice that such is a known method. Thus to substitute one known method of power transfer for another is the mere substitution of parts to achieve the desired outcome with a reasonable expectation of success.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Peshkovskiy et al. provides evidence of known resonant acoustic power transfer.

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.

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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. 12/649,635	Applicant(s)/Patent Under Reexamination JOANNOPOULOS ET AL.	
	Examiner FRITZ M. FLEMING	Art Unit 2836	Page 1 of 1

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	S					
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*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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*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.

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Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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							Yes	No
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Receipt date: 05/24/2012

12649635 - GAU: 2836

Sheet 1 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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	7,741,734	6/22/2010	Joannopoulos et al.			
	6	8,076,800	12/13/2011	Joannopoulos et al.			
	7	8,076,801	12/13/2011	Karalis et al.			
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	10	2003/0124050	7/3/2003	Yadav et al.			
	11	2003/0126948	7/10/2003	Yadav et al.			
	12	2004/0100338	5/27/2004	Clark			
	13	2004/0233043	11/25/2004	Yazawa et al.			
	14	2006/0202665	9/14/2006	Hsu			
	15	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	
	16	JP 02-097005	04/09/1990	Japan	H01F	21/06	Yes	No
	17	WO 2009/140506	11/19/2009	WIPO				
	18	WO 2010/039967	4/8/2010	WIPO				

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	19	Copy of Non-Final Office Action for U.S. Application Serial No. 12/648,604 by Examiner Justen Fauth dated December 5, 2011
	20	Copy of Non-Final Office Action for U.S. Application Serial No. 13/036,177 by Examiner Fritz M. Fleming dated May 15, 2012
	21	Copy of Non-Final Office Action for U.S. Application Serial No. 13/078,511 by Examiner Fritz M. Fleming dated May 15, 2012

Examiner Signature /Fritz Fleming/ (12/17/2012)	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)

Receipt date: 05/24/2012

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Sheet 2 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
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		Filing Date December 30, 2009	Group Art Unit

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. 12/726,742 by Examiner Fritz M. Fleming dated May 11, 2012
	23	Copy of Non-Final Office Action for U.S. Application Serial No. 13/030,395 by Examiner Fritz M. Fleming dated May 17, 2012
	24	Copy of Non-Final Office Action for U.S. Application Serial No. 13/040,810 by Examiner Fritz M. Fleming dated May 17, 2012

All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

Receipt date: 06/06/2011

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Sheet 1 of 1

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		Filing Date December 30, 2009	Group Art Unit

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	645,576	3/20/1900	Tesla			
	2	649,621	5/15/1900	Tesla			
	3	7,795,708	9/14/2010	Katti			
	4	2007/0145830	6/28/2007	Lee et al.			
	5						

Foreign Patent Documents or Published Foreign Patent Applications								
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
	6						Yes	No

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	7	John C. Schuder et al., "An Inductively Coupled RF System for the Transmission of 1 kW of Power Through the Skin", <u>IEEE Transactions on Bio-Medical Engineering</u> , Vol. BME-18, No. 4 (July 1971)
	8	J. C. Schuder et al., "Energy Transport Into the Closed Chest From a Set of Very-Large Mutually Orthogonal Coils", <u>Communication Electronics</u> , Vol. 64, pp. 527-534 (January 1963)
	9	John C. Schuder "Powering an Artificial Heart: Birth of the Inductively Coupled-Radio Frequency System in 1960", <u>Artificial Organs</u> , Vol. 26, No. 11, pp. 909-915 (2002)
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All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

Receipt date: 06/16/2010

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Sheet 1 of 1

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		Filing Date December 30, 2009	Group Art Unit

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1						
	2						

Foreign Patent Documents or Published Foreign Patent Applications								
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
							Yes	No
	3	WO 00/77910	12/21/2000	WIPO	H02J	5/00		
	4							
	5							

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	6	
	7	

All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

Receipt date: 07/31/2012

Sheet 1 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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.			
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	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 /Fritz Fleming/ (12/17/2012)	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)

Receipt date: 07/31/2012

Sheet 2 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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	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	

All references have been considered.

Examiner Signature /Phil Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

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12649635 - GAU: 2836

Sheet 1 of 1

Substitute Form PTO-1449 (Modified) Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
	Applicant John D. Joannopoulos et al.		
	Filing Date December 30, 2009	Group Art Unit	

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	2005/0151511	07/14/2005	Chary			
	2	2005/0288741	12/29/2005	Hassler, Jr, 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 No
	3						

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	4	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/639,958 by Examiner Fritz M. Fleming dated August 16, 2012 (21 pages)
	5	Copy of Non-Final Office Action with regard to U.S. Application Serial No. 12/639,963 by Examiner Fritz M. Fleming dated August 31, 2012 (20 pages)

All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

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Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

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	2007/0021140	1/25/2007	Keyes, IV et al.			
	4	2008/0266748	10/30/2008	Lee			

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

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	6	Andre Kurs et al., "Simultaneous mid-range power transfer to multiple devices", <u>Applied Physics Letters</u> , Vol. 96, No. 044102 (2010)
	7	David Schneider, "A Critical Look at Wireless Power", <u>IEEE Spectrum</u> , (May 2010)
	8	Marin Soljacic, "Wireless nonradiative energy transfer", <u>Visions of Discovery New Light on Physics, Cosmology, and Consciousness</u> , Cambridge University Press, New York, NY pp. 530-542 (2011)
	9	Joseph C. Stark III, "Wireless Power Transmission Utilizing a Phased Array of Tesla Coils", <u>Master Thesis, Massachusetts Institute of Technology</u> (2004)
	10	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

All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Sheet 1 of 1

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1						

Foreign Patent Documents or Published Foreign Patent Applications								
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
							Yes	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	

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	4	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)
	5	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)
	6	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)
	7	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)
	8	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)
	9	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)

All references have been considered.

Examiner Signature /Fritz Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

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12649635 - GAU: 2836

Sheet 1 of 1

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
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U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1						

Foreign Patent Documents or Published Foreign Patent Applications								
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
							Yes	No
	2	2006-074848	3/16/2006	Japan	H02J	17/00	X	
	3	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
	4	

All references have been considered.

Examiner Signature /s/ Fleming/ (12/17/2012)	Date Considered
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Substitute Disclosure Form (PTO-1449)

Search Notes 	Application/Control No. 12649635	Applicant(s)/Patent Under Reexamination JOANNOPOULOS ET AL.
	Examiner FRITZ M FLEMING	Art Unit 2836

SEARCHED			
Class	Subclass	Date	Examiner
307	104	12/17/2012	FMF

SEARCH NOTES		
Search Notes	Date	Examiner
EAST,PLUS	12/17/2012	FMF

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

	/FRITZ M FLEMING/ Primary Examiner,Art Unit 2836
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Receipt date: 11/30/2011

12649635 - GAU: 2836

Sheet 1 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
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U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	1	8,022,576	9/20/2011	Joannopoulos et al.			
	2	2009/0174263	7/9/2009	Baarman et al.			
	3	2009/0267709	10/29/2009	Joannopoulos et al.			
	4	2009/0267710	10/29/2009	Joannopoulos et al.			
	5	2009/0284083	11/19/2009	Karalis et al.			
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	11	2010/0127573	5/27/2010	Joannopoulos et al.			
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	16	2010/0133920	6/3/2010	Joannopoulos et al.			
	17	2010/0148589	6/17/2010	Hamam et al.			
	18	2010/0187911	7/29/2010	Joannopoulos et al.			
	19	2010/0207458	8/19/2010	Joannopoulos et al.			
	20	2011/0043046	2/24/2011	Joannopoulos et al.			
	21	2011/0074218	3/31/2011	Karalis et al.			
	22	2011/0074347	3/31/2011	Karalis et al.			
	23	2011/0089895	4/21/2011	Karalis et al.			
	24	2011/0193419	8/11/2011	Karalis et al.			

Examiner Signature /Fritz Fleming/ (12/17/2012)	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.	

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Sheet 2 of 2

Substitute Form PTO-1449 (Modified)	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
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Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
	25						Yes	No

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
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All references have been considered.

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Substitute Disclosure Form (PTO-1449)

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
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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).OCLS.	USPAT; USOCR	OR	OFF	2012/03/20 17:35
S10	893	(320/108).OCLS.	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

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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
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		"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	transcutaneous 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).OCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/03/20 23:54
S27	893	(320/108).OCLS.	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

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		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
S136	1	("20110074347").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/27 12:22
S137	3	((("20110074347") or ("7825543") or ("7741734")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/27 12:23
S138	1	("20100237708").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/29 08:48
S139	1	S138 and housing	US-PGPUB; USPAT	OR	OFF	2012/08/29 08:49
S140	1	S138 and housing	US-PGPUB; USPAT	OR	ON	2012/08/29 09:17
S141	2	((("20101117456") or ("20080278264") or ("7825543")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/04 11:41
S142	3	((("20100117456") or ("20080278264") or ("7825543")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/04 11:42
S143	3	S142 and impedance	US-PGPUB; USPAT	OR	ON	2012/09/04 11:44
S144	0	S142 and (impedance same (match or matching))	US-PGPUB; USPAT	OR	ON	2012/09/04 11:45
S145	3	((("20100127573") or ("7741734") or ("7825543")).PN.	US-PGPUB; USPAT;	OR	OFF	2012/09/10 10:27

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			USOCR			
S146	3	S145 and characteristic	US-PGPUB; USPAT	OR	OFF	2012/09/10 10:28
S147	1706	(307/104).CCLS.	US-PGPUB; USPAT	OR	OFF	2012/09/10 12:09
S148	1095	(333/195).CCLS.	US-PGPUB; USPAT	OR	OFF	2012/09/10 12:09
S149	1017	(320/108).CCLS.	US-PGPUB; USPAT	OR	OFF	2012/09/10 12:09
S155	1	("20100096934").PN.	US-PGPUB; USPAT	OR	OFF	2012/09/10 13:29
S157	1	("20100102641").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/10 14:44
S159	1	("20110169339").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/11 07:05
S160	0	S159 and (voltage same capacitor)	USPAT	OR	OFF	2012/09/11 07:08
S161	1	S159 and (voltage same capacitor)	US-PGPUB; USPAT	OR	ON	2012/09/11 07:08
S162	1	S159 and (information same exchange)	US-PGPUB; USPAT	OR	ON	2012/09/11 07:09
S163	1	S159 and planar	US-PGPUB; USPAT	OR	ON	2012/09/11 07:18
S164	25	(high adj q) same feedback same (wireless\$ or (non adj contact) or contactless)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/11 08:16
S165	1110	q same feedback same (wireless\$ or (non adj contact) or contactless or inductive\$)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/11 08:18
S166	78	q same feedback same (wireless\$ or (non adj contact) or contactless or inductive\$) same power same transfer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/11 08:18
S167	1019	(320/108).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2012/09/11 08:21
S168	1794	(307/104).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2012/09/11 08:21
S169	0	("032or33").PN.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2012/09/11 08:22

file:///C:/Users/fleming/Documents/e-Red%20Folder/12649635/EASTSearchHistory.12649635_AccessibleVersion.html[12/17/2012 7:22:55 AM]

S170	2717	S167 or S168	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 08:22
S171	485	S170 and feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 08:22
S172	507	S170 and (secondary same current same voltage)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 09:33
S173	128	S170 and (secondary same current same voltage same resonant)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 09:33
S174	145	(implant\$) and (secondary same current same voltage same resonant)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 10:29
S175	9	tet same (secondary same current same voltage same resonant)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 10:39
S176	45	tet and (secondary same current same voltage same resonant)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 10:40
S177	54	tet and (secondary same power same resonant)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/09/11 10:40
S178	316	tet and (power same feedback)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	OFF	2012/09/11 10:45

file:///C:/Users/fleming/Documents/e-Red%20Folder/12649635/EASTSearchHistory.12649635_AccessibleVersion.htm[12/17/2012 7:22:55 AM]

			DERWENT; IBM_TDB			
S179	126	high same q same wireless same power same transfer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/11 11:12
S180	1790	(307/104).OCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2012/09/21 20:55
S181	1013	(320/108).OCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2012/09/21 20:56
S183	0	2001665u1	EPO; DERWENT	OR	OFF	2012/09/30 18:52
S184	9	"2001665"	EPO; DERWENT	OR	OFF	2012/09/30 18:52
S185	3	"10221484"	EPO; DERWENT	OR	OFF	2012/09/30 18:53
S186	0	("20090267710").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/30 19:05
S187	1	("20090267710").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/30 19:05
S188	0	S187 and radiative	USPAT	OR	OFF	2012/09/30 19:05
S189	0	S187 and nonradiative	USPAT	OR	OFF	2012/09/30 19:05
S190	0	S187 and nonradiative	US-PGPUB	OR	OFF	2012/09/30 19:05
S191	1	S187 and radiative	US-PGPUB; USPAT	OR	OFF	2012/09/30 19:06
S192	2	((("7825543") or ("7741734")).PN.	USPAT; USOCR	OR	OFF	2012/10/01 07:01
S193	1020	(320/108).OCLS.	US-PGPUB; USPAT	OR	OFF	2012/10/01 07:16
S194	746	(320/109).OCLS.	US-PGPUB; USPAT	OR	OFF	2012/10/01 07:16
S195	67	S193 and S194	US-PGPUB; USPAT	OR	OFF	2012/10/01 07:16
S196	1	("20110018361").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/10/01 08:01
S197	1	S196 and motorized	US-PGPUB; USPAT	OR	OFF	2012/10/01 08:01
S198	1	S196 and movement	US-PGPUB; USPAT	OR	OFF	2012/10/01 08:02
S199	1	S196 and position	US-PGPUB; USPAT	OR	OFF	2012/10/01 08:04
S200	1	("20100327660").PN.	US-PGPUB; USPAT;	OR	OFF	2012/10/01 09:41

			USOCR			
S201	1	S200 and optimize	US-PGPUB; USPAT	OR	OFF	2012/10/01 09:41
S202	1	S200 and optimizing	US-PGPUB; USPAT	OR	OFF	2012/10/01 09:43
S203	1	S200 and optimiz\$	US-PGPUB; USPAT	OR	OFF	2012/10/01 09:44
S204	1	("20110074218").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/10/01 17:14
S205	3	((("20100123354") or ("20100123353") or ("20090267710")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/11/23 11:14
S206	3	S205 and resonator	US-PGPUB; USPAT	OR	OFF	2012/11/23 11:19
S207	60	"7741734"	US-PGPUB; USPAT	OR	OFF	2012/11/23 12:01
S208	1	("7741734").PN.	USPAT; USOCR	OR	OFF	2012/11/23 12:01
S209	1	("7741734").PN.	USPAT; USOCR	OR	OFF	2012/11/26 19:58
S210	0	S209 and storing	USPAT	OR	OFF	2012/11/26 19:58
S211	0	S209 and store	USPAT	OR	OFF	2012/11/26 19:58
S212	0	S209 and store	USPAT	OR	ON	2012/11/26 20:05
S213	1	S209 and energy	USPAT	OR	ON	2012/11/26 20:05
S214	1	S209 and stored	USPAT	OR	ON	2012/11/26 20:07
S215	1	S209 and intrinsic	USPAT	OR	ON	2012/11/26 20:12
S216	2	((("6960968") or ("7069064")).PN.	USPAT; USOCR	OR	OFF	2012/12/10 15:46
S217	1802	(307/104).OCLS.	US-PGPUB; USPAT	OR	OFF	2012/12/10 22:53

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S150	0	((resonator or resonant or resonance) same intrinsic same loss same characteristic same size).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10 11:55
S151	0	((resonator or resonant or resonance) and intrinsic and loss and characteristic and size).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10 11:56
S152	15	((resonator or resonant or resonance) and intrinsic and loss and characteristic and size)	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10 11:57
S153	0	((resonator or resonant or resonance) same characteristic same size).clm.	US- PGPUB;	OR	ON	2012/09/10 11:59

			USPAT; UPAD			
S154	147	((resonator or resonant or resonance) same characteristic same size).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10: 12:03
S156	10	(resonator same (resonance or resonant) same frequency same intrinsic same loss same transfer same rate).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10: 13:42
S158	1	(resonator same (resonance or resonant) same frequency same intrinsic same loss same "near" same field same q same factor).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/10: 14:50
S182	10	(resonator same (resonance or resonant) same frequency same intrinsic same loss same transfer same rate).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/09/21: 20:55
S218	1	(resonator same (resonance or resonant) same frequency same intrinsic same loss same high same (q or quality)).clm.	US- PGPUB; USPAT; UPAD	OR	ON	2012/12/10: 23:01

12/ 17/ 2012 7:22:52 AM

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<i>Index of Claims</i> 	Application/Control No. 12649635	Applicant(s)/Patent Under Reexamination JOANNOPOULOS ET AL.
	Examiner FRITZ M FLEMING	Art Unit 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	12/17/2012									
	1	✓									
	2	✓									
	3	✓									
	4	✓									
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	34	✓									
	35	✓									
	36	✓									

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : John D. Joannopoulos et al. Art Unit : 2836
Serial No. : 12/649,635 Examiner : Fritz Fleming
Filed : December 30, 2009 Conf. No. : 5891
Title : WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-
Q RESONATORS

Mail Stop Amendment

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

AMENDMENT IN REPLY TO ACTION OF DECEMBER 21, 2012

Please amend the above-identified application as follows:

Amendments to the Specification:

Please add the following new paragraph after the paragraph ending at page 5, paragraph number [0033]:

--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.--

Please replace the paragraph beginning at page 12, paragraph number [0052] 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.--

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 first resonator having a resonant frequency ω_1 and an intrinsic loss rate Γ_1 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$ with a quality factor, Q_1 , greater than 100, and configured to be coupled to an energy source to generate, generating an oscillating near field region; and
a second resonator having a resonant frequency ω_2 and an intrinsic loss rate Γ_2 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_2 = \omega_2 / (2\Gamma_2)$ with a quality factor, Q_2 , greater than 100, optionally coupled to an energy drain, and configured to move moving freely within the near field region of the first resonator,
wherein the first resonator and the second resonator are configured to be coupled to transfer electromagnetic energy from said first resonator to said second resonator when the first resonator is coupled to the energy source as the second resonator moves freely within the near field region.
2. (Original) The system of claim 1, wherein near field of the near field region is a magnetic field.
3. (Original) The system of claim 1, wherein near field of the near field region is an electromagnetic field.
4. (Canceled)

5. (Currently Amended) A method, comprising:

providing a first resonator having a resonant frequency ω_1 and an intrinsic loss rate Γ_1 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$ ~~with a quality factor, Q_1 ,~~ greater than 100, coupled to an energy source, generating an oscillating near field region; and

providing a second resonator having a resonant frequency ω_2 and an intrinsic loss rate Γ_2 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_2 = \omega_2 / (2\Gamma_2)$, ~~with a quality factor, Q_2 ,~~ greater than 100, ~~optionally coupled to an energy drain,~~ and moving freely within the near field region of the first resonator,

wherein the first resonator and the second resonator are coupled to transfer electromagnetic energy from said first resonator to said second resonator as the second resonator moves freely within the near field region.

6. (Original) The method of claim 5, wherein near field of the near field region is a magnetic field.

7. (Original) The method of claim 5, wherein near field of the near field region is an electromagnetic field.

8. (Canceled)

9. (Currently Amended) A system, comprising:

a first resonator having a resonant frequency ω_1 and an intrinsic loss rate Γ_1 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$, ~~with a quality factor, Q_1 , and configured to be coupled to an energy source to generate,~~ generating a near field region comprising an oscillating magnetic field; and

a second resonator having a resonant frequency ω_2 and an intrinsic loss rate Γ_2 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_2 = \omega_2 / (2\Gamma_2)$, with a quality factor, Q_2 optionally coupled to an energy drain, and configured to move moving freely within the near field region of the first resonator,

wherein the first resonator and the second resonator are configured to be coupled to wirelessly transfer electromagnetic energy from said first resonator to said second resonator when the first resonator is coupled to the energy source as the second resonator moves freely within the near field region,

wherein $\sqrt{Q_1 Q_2} > 100$.

10. (Previously Presented) The system of claim 9, where $Q_1 > 100$ and $Q_2 > 100$.
11. (Currently Amended) The system of claim 9, further comprising ~~the~~ an energy drain coupled to the second resonator.
12. (Previously Presented) The system of claim 11, wherein the energy drain comprises a robot, vehicle, computer, cell phone, or a portable electronic device.
13. (Previously Presented) The system of claim 9, further comprising a third resonator, optionally coupled to an energy drain, located at a variable distance from the first resonator, and wherein the first resonator and the third resonator are coupled to wirelessly transfer electromagnetic energy from the first resonator to the third resonator.
14. (Previously Presented) The system of claim 9, further comprising a third resonator, optionally coupled to an external power supply, located at a variable distance from the second resonator, and wherein the third resonator and the second resonator are coupled to wirelessly transfer electromagnetic energy from the third resonator to the second resonator.

15. (Previously Presented) The system of claim 9, wherein at least one of the resonators is a tunable resonator.

16. (Previously Presented) The system of claim 9, wherein the energy transfer in the near-field region occurs over a range of distances that includes 5 cm.

17. (Previously Presented) The system of claim 9, wherein the energy transfer in the near-field region occurs over a range of distances that includes 10 cm.

18. (Previously Presented) The system of claim 9, wherein the energy transfer in the near-field region occurs over a range of distances that includes 30 cm.

19. (Previously Presented) The system of claim 9, wherein the efficiency of the wireless energy transfer is at least 20% over a range of distances in the near-field region.

20. (Previously Presented) The system of claim 9, further comprising a feedback mechanism coupled to at least one of the resonators to correct for detuning.

21. (Previously Presented) The system of claim 9, further comprising the energy drain coupled to the second resonator, and wherein the power supply 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 first resonator and the second resonator.

22. (Previously Presented) The system of claim 9, wherein the first 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 first resonator and the second resonator.

23. (Currently Amended) A method, comprising:

providing a first resonator having a resonant frequency ω_1 and an intrinsic loss rate Γ_1 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$, with a quality factor, Q_1 , coupled to an energy source, generating a near field region comprising an oscillating magnetic field; and

providing a second resonator having a resonant frequency ω_1 and an intrinsic loss rate Γ_1 , and capable of storing electromagnetic energy with an intrinsic quality factor $Q_1 = \omega_1 / (2\Gamma_1)$, with a quality factor, Q_2 , ~~optionally coupled to an energy drain~~, and moving freely within the near field region of the first resonator,

wherein the first resonator and the second resonator are coupled to wirelessly transfer electromagnetic energy from said first resonator to said second resonator as the second resonator moves freely within the near field region,

wherein $\sqrt{Q_1 Q_2} > 100$.

24. (Previously Presented) The method of claim 23, where $Q_1 > 100$ and $Q_2 > 100$.

25. (Currently Amended) The method of claim 23, wherein ~~the~~ an energy drain is coupled to the second resonator.

26. (Previously Presented) The method of claim 25, wherein the energy drain comprises a robot, vehicle, computer, cell phone, or a portable electronic device.

27. (Previously Presented) The method of claim 23, wherein a third resonator is optionally coupled to an energy drain and is located at a variable distance from the first resonator, and further comprising wirelessly transferring electromagnetic energy from the first resonator to the third resonator.

28. (Previously Presented) The method of claim 23, wherein a third resonator is optionally coupled to an external power supply and is located at a variable distance from the second resonator, and further comprising wirelessly transferring electromagnetic energy from the third resonator to the second resonator.

29. (Previously Presented) The method system of claim 23, wherein at least one of the resonators is a tunable resonator.

30. (Previously Presented) The method of claim 23, wherein the energy transfer in the near-field region occurs over a range of distances that includes 5 cm.

31. (Previously Presented) The method of claim 23, wherein the energy transfer in the near-field region occurs over a range of distances that includes 10 cm.

32. (Previously Presented) The method of claim 23, wherein the energy transfer in the near-field region occurs over a range of distances that includes 30 cm.

33. (Previously Presented) The method of claim 23, wherein the efficiency of the wireless energy transfer is at least 20% over a range of distances in the near-field region.

34. (Previously Presented) The method of claim 23, wherein a feedback mechanism is coupled to at least one of the resonators to correct for detuning.

35. (Previously Presented) The method of claim 23, wherein the energy drain is coupled to the second resonator, and wherein the power supply and energy drain are driven to increase the ratio of useful-to-lost power for varying wireless energy transfer rates κ between the first resonator and the second resonator.

36. (Previously Presented) The method of claim 23, wherein the first 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 first resonator and the second resonator.

37. (New) The system of claim 9, further comprising the energy source configured to be coupled to the first resonator and an energy drain configured to be coupled to the second resonator to provide useful power to the energy drain, and wherein the energy source is configured to provide energy to the first resonator at a rate that varies with a rate of wireless energy transfer κ between the first resonator and the second resonator.

38. (New) The system of claim 37, wherein the energy source is configured to provide energy to the first resonator at a rate that substantially minimizes the energy stored in the first resonator and the second resonator.

39. (New) The system of claim 37, wherein the energy source is configured to provide energy to the first resonator at a rate that substantially maximizes a ratio of the useful power to lost power from the energy source to the energy drain.

40. (New) The system of claim 9, where $Q_1 > 200$ and $Q_2 > 200$.

41. (New) The method of claim 23, wherein an energy drain is coupled to the second resonator to provide useful power to the energy drain, and the method further comprises providing energy to the first resonator at a rate that varies with a rate of wireless energy transfer κ between the first resonator and the second resonator.

42. (New) The method of claim 41, wherein the energy source provides energy to the first resonator at a rate that substantially minimizes the energy stored in the first resonator and the second resonator.

43. (New) The method of claim 41, wherein the energy source provides energy to the first resonator at a rate that substantially maximizes a ratio of the useful power to lost power from the energy source to the energy drain.

44. (New) The method of claim 23, where $Q_1 > 200$ and $Q_2 > 200$.

Applicant : John D. Joannopoulos et al.
Serial No. : 12/649,635
Filed : December 30, 2009
Page : 11 of 15

Attorney's Docket No.: 01997-0359015 / MIT Case No.
11757

Amendments to the Drawings:

The attached new sheet of drawings includes a new Fig. 7 to show the feedback mechanism described in original paragraph [0052].

Attachments following last page of this Amendment:

New Sheet (1 page)

REMARKS

Claim Status

Claims 1-44 are pending. Claims 1, 5, 9, and 23 are independent claims. Claims 37-44 are new dependent claims.

Examiner Interview and Prior Art Rejections

Applicants thank Examiner Fleming for taking the time to discuss this application by telephone with Applicants' representative Marc Wefers on January 24, 2013. During the interview the double patenting and prior art rejections were discussed.

It was agreed that, pending a further prior art search by the Examiner, the clarifying amendments above would overcome the prior art rejections because they are similar to those made in related applications 12/415,667, 12/639,966, and 12/639,967 that overcame substantially the same prior art. For example, whereas the amendment in the '667 application recites that each resonator is "capable of storing electromagnetic energy with a *high* intrinsic quality factor" (emphasis added), the claims in the present application omit the adjective "high" and instead expressly recite a lower bound for the intrinsic quality factors Q_1 and Q_2 . Specifically, independent claims 1 and 5 require Q_1 and Q_2 to be each greater than 100, and independent claims 9 and 23 require $\sqrt{Q_1 Q_2} > 100$. The claims distinguish the cited prior art for at least the reasons that they recite multiple resonators, each of which is high-Q, and which facilitate wireless power transfer as more specifically claimed in remaining limitations.

During the interview, Applicants also provided documents showing the acclaim Applicants' invention has received in both academic and popular press. We 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)**

Double Patent Rejections

The double patent rejections were also discussed during the telephone interview. It was explained that the pending claims in application no. 12/649,904 are not presently identical to

those in the present application. Specifically, the amendment filed on October 9, 2012 in the '904 application explained that the earlier submission of identical claims was an inadvertent error and provided new claims which were not taken into account in the present Office Action. Accordingly, we submit that the statutory double patenting rejection is now moot because the present claims and those in the '904 application are no longer identical.

As to the provisional obviousness-type double patent rejection over related application nos. 12/649,777 and 12/649,852 and 12/649,813, while we do not necessarily concede the merits of the rejections, Applicants will submit a Terminal Disclaimer upon an indication that the claims are otherwise allowable and assuming that the Examiner maintains the obviousness-type double patent rejection in view the amendments being made here and contemporaneously in the related '777, '852, and '813 applications. Applicants note that a Terminal Disclaimer has already been submitted in all of these related applications with respect to the originally filed parent application, application no. 11/481,077, which issued as U.S. Patent No. 7,741,734. We ask the Examiner to contact Applicants' representative Marc Wefers by telephone, rather than by further form action, if he requires the Terminal Disclaimer, so that we can expedite the submission of the Terminal Disclaimer and issuance of the present application.

New Drawing

The specification has been amended and a new drawing submitted to address the drawing objection. The amendment and new drawing are supported by the disclosure in at least original paragraph [0052] from the specification.

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

Applicant : John D. Joannopoulos et al.
Serial No. : 12/649,635
Filed : December 30, 2009
Page : 15 of 15

Attorney's Docket No.: 01997-0359015 / MIT Case No.
11757

The fees in the amount of \$372.00 for excess claim fees 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: January 25, 2013

/Marc M. Wefers Reg. No. 56,842/

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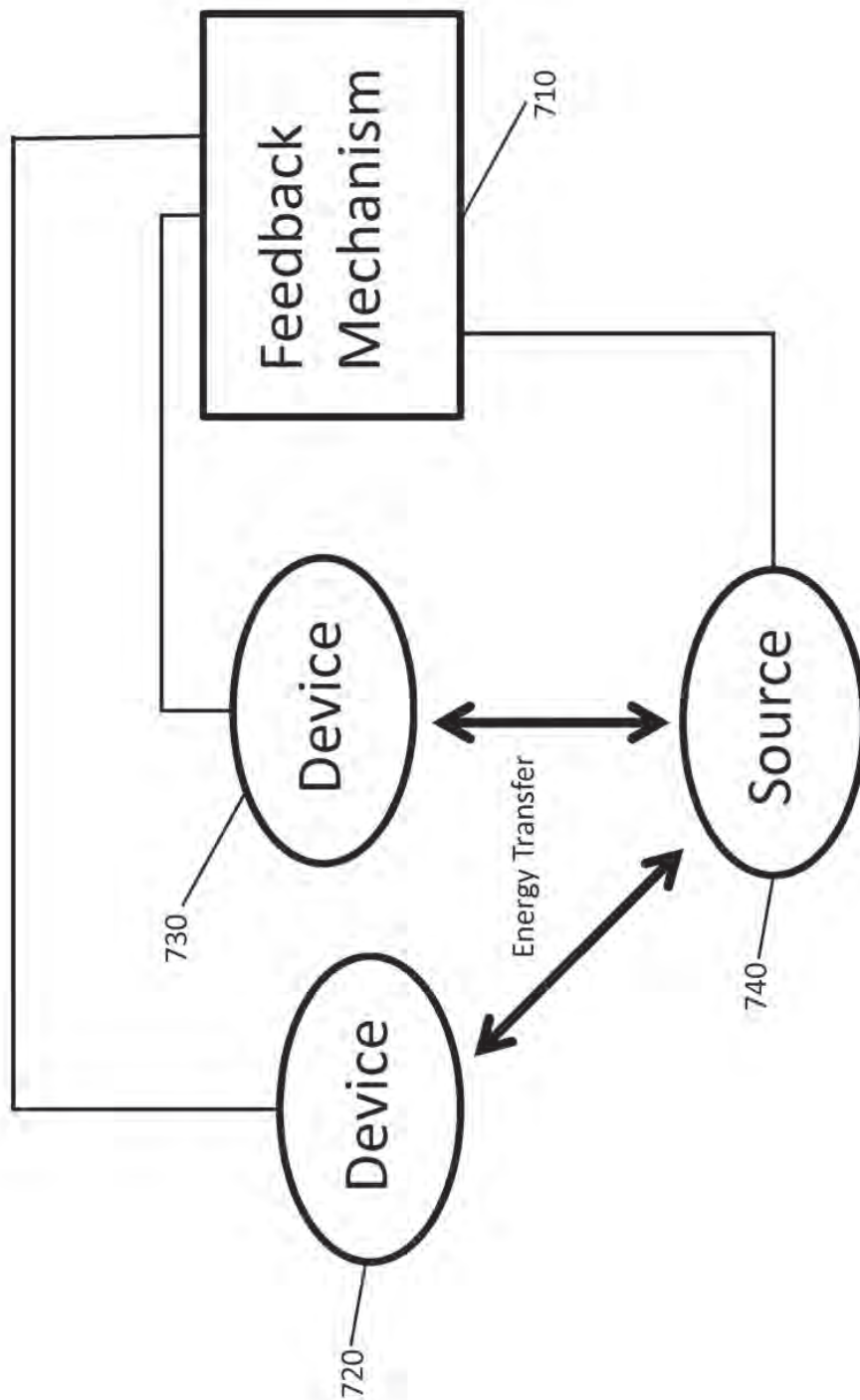


FIG. 7

Electronic Patent Application Fee Transmittal				
Application Number:		12649635		
Filing Date:		30-Dec-2009		
Title of Invention:		WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-Q RESONATORS		
First Named Inventor/Applicant Name:		John D. Joannopoulos		
Filer:		Marc M. Wefers/Cheryl Forrest		
Attorney Docket Number:		01997-0359015 / 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	6	62	372
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 (\$)				552

Electronic Acknowledgement Receipt	
EFS ID:	14791523
Application Number:	12649635
International Application Number:	
Confirmation Number:	5891
Title of Invention:	WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-Q RESONATORS
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:	01997-0359015 / MIT 11757
Receipt Date:	25-JAN-2013
Filing Date:	30-DEC-2009
Time Stamp:	12:43:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

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Payment was successfully received in RAM	\$552
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	Multipart Description/PDF files in .zip description				
	Document Description	Start	End		
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1		
	Specification	2	2		
	Claims	3	10		

	Applicant Arguments/Remarks Made in an Amendment	11	15		
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : John D. Joannopoulos et al. Art Unit : 2836
Serial No. : 12/649,635 Examiner : Fritz Fleming
Filed : December 30, 2009 Conf. No. : 5891
Title : WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-
Q RESONATORS

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: January 25, 2013

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Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 2009	Group Art Unit 2836

U.S. Patent Documents							
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Other Documents (include Author, Title, Date, and Place of Publication)		
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	3	"Automatic Recharging, From a Distance" by Anne Eisenberg, The New York Times, (see www.nytimes.com/2012/03/11/business/built-in-wireless-charging-for-electronic-devices.html?_r=0) (published on March 10, 2012)
	4	"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)
	5	"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)
	6	"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)
	7	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)
	8	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)
	9	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)
	10	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)

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Substitute Disclosure Form U.S. Department of Commerce Patent and Trademark Office Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))	Attorney Docket No. 01997-0359015	Application No. 12/649,635
	Applicant John D. Joannopoulos et al.	
	Filing Date December 30, 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	
	14	WO 95/11545	4/27/1995	WIPO	H02J	17/00	Yes	No
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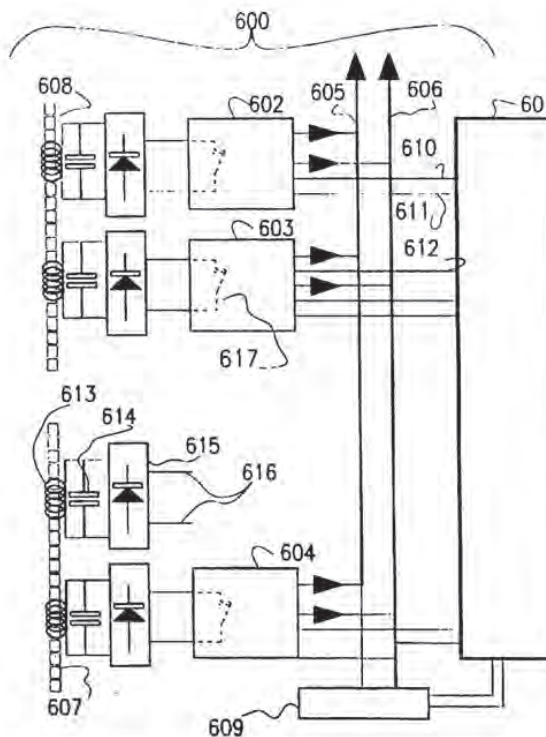


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶: H02J 17/00, 5/00, H01F 23/00, B60L 5/00, 13/00	A1	(11) International Publication Number: WO 95/11545 (43) International Publication Date: 27 April 1995 (27.04.95)
(21) International Application Number: PCT/NZ94/00115 (22) International Filing Date: 20 October 1994 (20.10.94) (30) Priority Data: 250024 21 October 1993 (21.10.93) NZ (71) Applicant (for all designated States except US): AUCKLAND UNISERVICES LIMITED [NZ/NZ]; UniServices House, 58 Symonds Street, Auckland 1001 (NZ). (72) Inventors; and (75) Inventors/Applicants (for US only): BOYS, John, Talbot [NZ/NZ]; 15A Island Bay Road, Birkdale, Auckland 1310 (NZ). GREEN, Andrew, William [NZ/NZ]; 15 McDonald Road, Papatoetoe, Auckland 1701 (NZ). (74) Agents: PIPER, James, William et al.; James W. Piper & Co., 46 Brown Street, Ponsonby, Auckland 1002 (NZ).		(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(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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- 1 -

5

INDUCTIVE POWER PICK-UP COILS

10

TECHNICAL FIELD OF THE INVENTION

15 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

20 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.

25 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:

30

(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.

35

(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.

- 2 -

5 (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.

10 (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.

15 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
20 enhance the ability of secondary windings to collect as much of the available flux as possible.

DEFINITIONS

25 **IPT** is used as 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
30 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
35 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

- 3 -

effect in the primary inductor.

5 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.

10 **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.

15 **STATEMENT OF THE INVENTION**

20 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
25 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.

30 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.

35 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.

- 5 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.

10

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.

- 15 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.

- 20 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
25 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.

30

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.

- 35 Alternatively the ferrite material of the core may be made up of modules having shapes other than rectangles.

- 5 -

5 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.

10 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.

15 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.

20 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.

25 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.

30 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.

35 Optionally both predetermined limits may be the same voltage.

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5 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.

10 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.

15 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.

20 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.

25 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.

30 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

35 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.
- 5 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.
- 10 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.
- 15 Fig 12: is an illustration of a preferred embodiment of the present invention constructed from discrete ferrite elements as seen from one end.
- 20 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.

25 INTRODUCTION

In our loosely coupled inductive power transfer (IPT) systems, we prefer to use:

- 30 (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;
- 35 that is, alternating currents having a low harmonic content, as these radiate less electromagnetic interference and dissipate less energy than do waveforms with added

- 8 -

harmonics.

5 (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 10 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 15 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 20 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 25 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 30 rise to high levels if the consumption of power from it happens to be light.

PREFERRED EMBODIMENT

35 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.

- 10 -

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 slide 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 $75 \text{ mm} \pm 25 \text{ mm}$, whereas earlier designs had preferred spacings of only $20 \text{ mm}, \pm 10 \text{ mm}$.

5

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.

10

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.

15

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.

20

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:

25

- (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.

30

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.

5 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.

10 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.

15 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
25 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
30 input 1505.

Example 2:

35 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.

- 5 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
10 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
15 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.

- 20 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
25 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
30 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
35 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.

5 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.

10 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.

25 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
5	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
10	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		

15

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.

20

25

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.

30

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.

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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
5 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
10 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
15 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
20 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.

25 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
30 615. 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.

5 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).
- 10 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).

15 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
20 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
- 25 (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 - I²C or US-232 serial channels for example. Preferably this channel is optically isolated and then it is simpler to isolate the
- 30 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
35 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.

- 5 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 if it deviates by too much, or which may guide an automatically guided vehicle along a warehouse floor.

OPTIONS

- 10 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.
- 15 Surges of power can be provided from a battery backup or a capacitor bank.

ADVANTAGES

- 20 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.

- 25 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.

- 30 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.

- 35 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

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nearby articles.

5 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 field 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 field also allows for multiple coils giving much better misalignment performance than for a vertical field.

10

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.

15 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.

20 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
5 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
10 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
15 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
20 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
25 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
30 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
35 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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5 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.

10 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.

15 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.

20 11. Inductive power pick-up means as claimed in claim 10 wherein the shaped sides are substantially optically flat.

25 12. Inductive power pick-up means as claimed in claim 7 wherein more than one pick-up coil is provided on a single core.

30 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.

35 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.

10

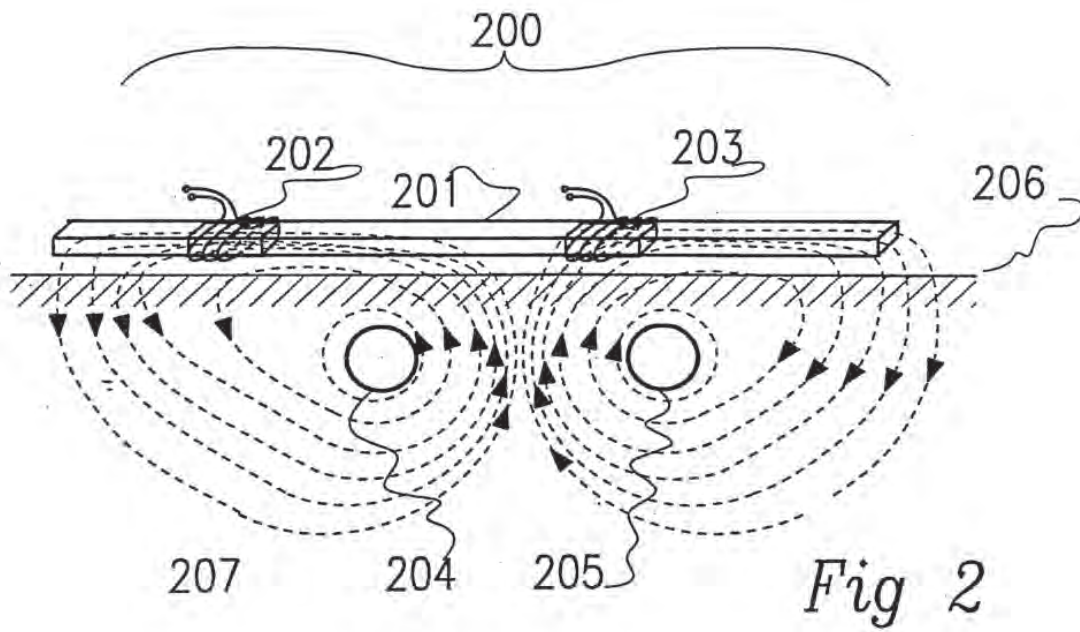
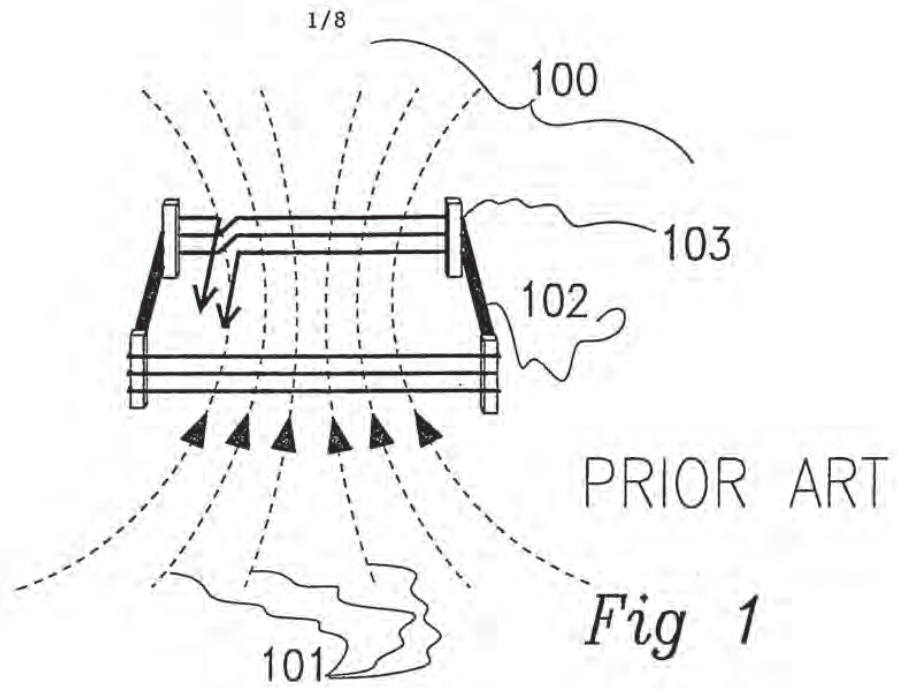
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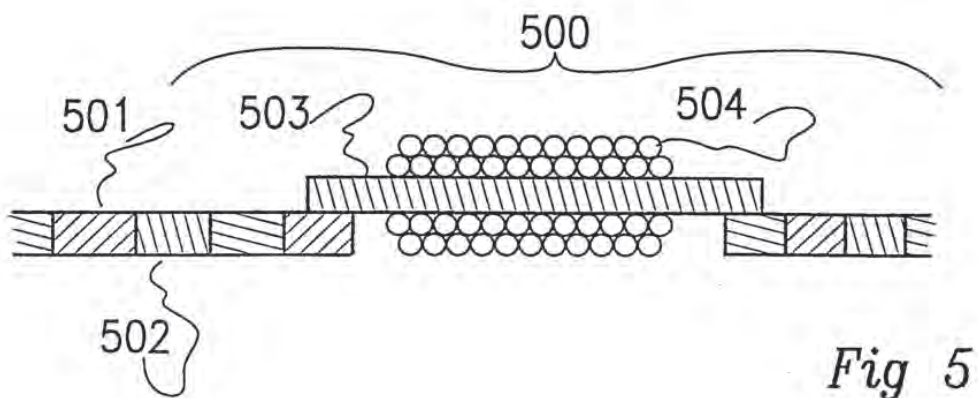
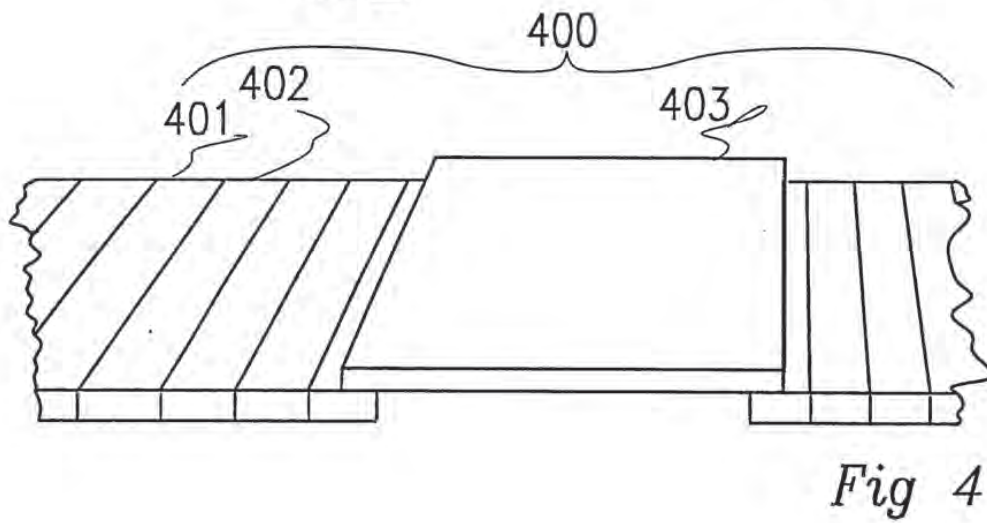
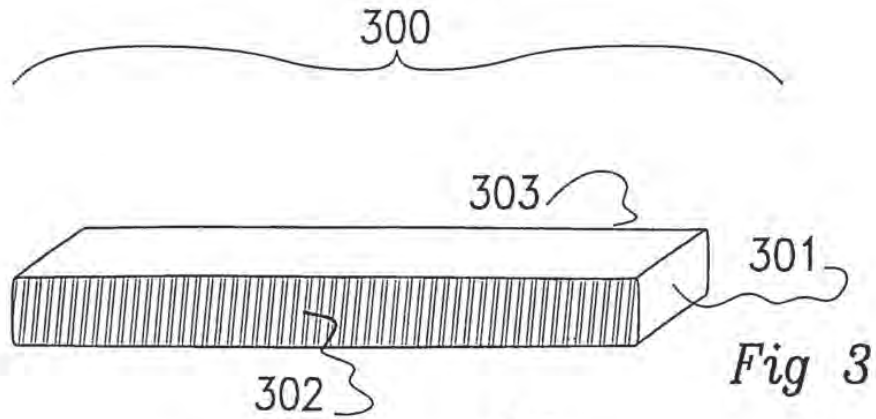
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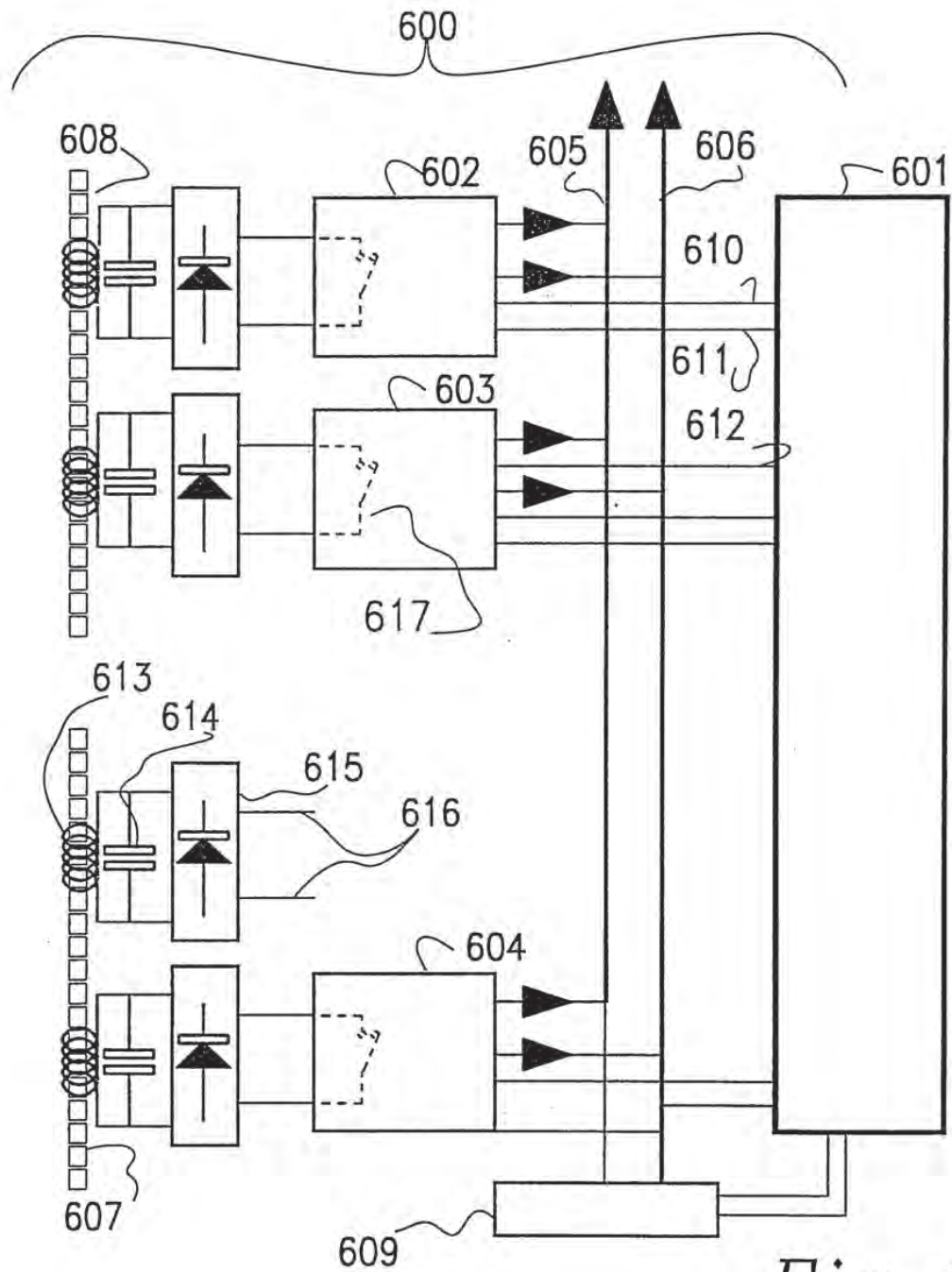


Fig 6

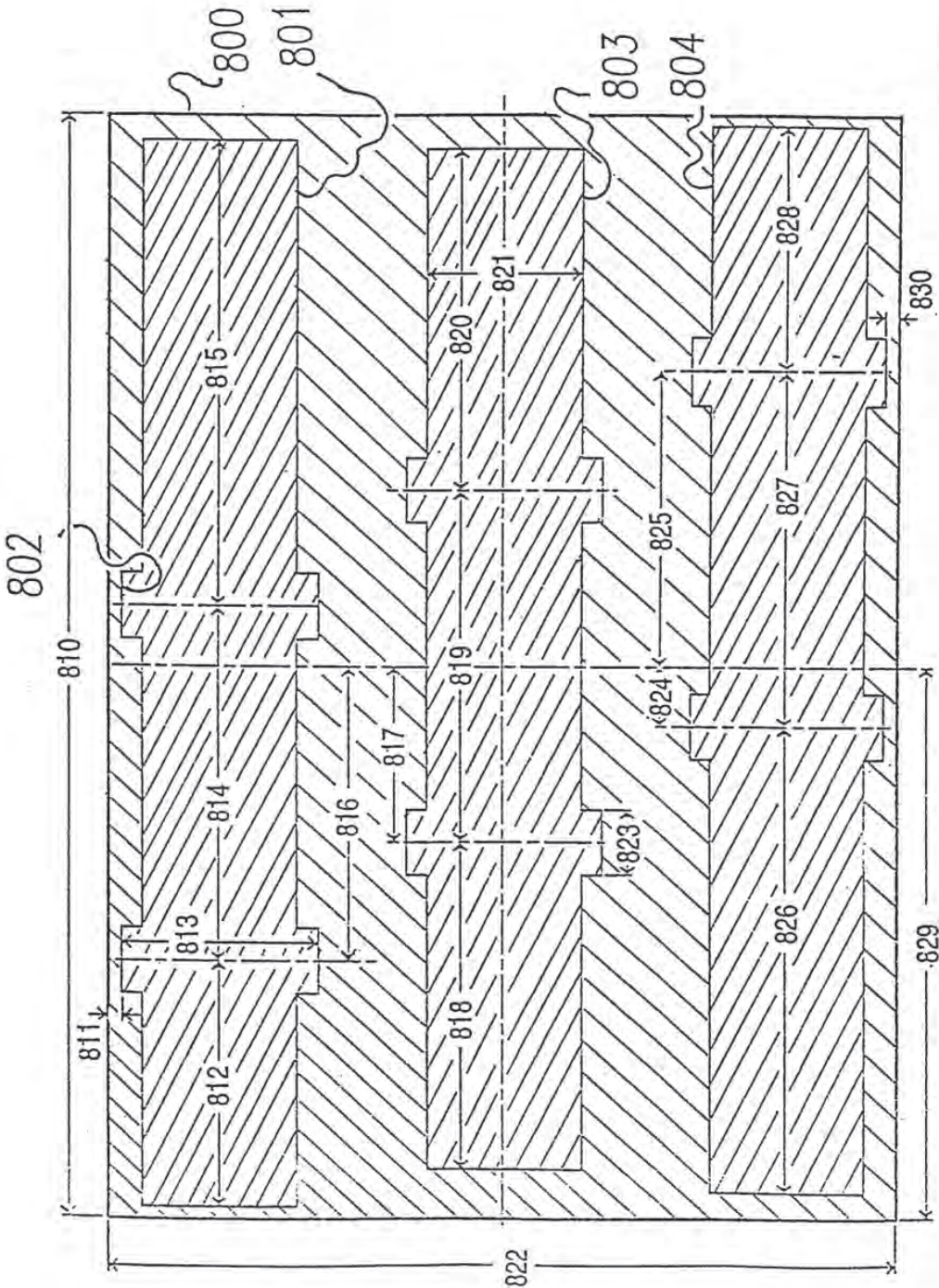
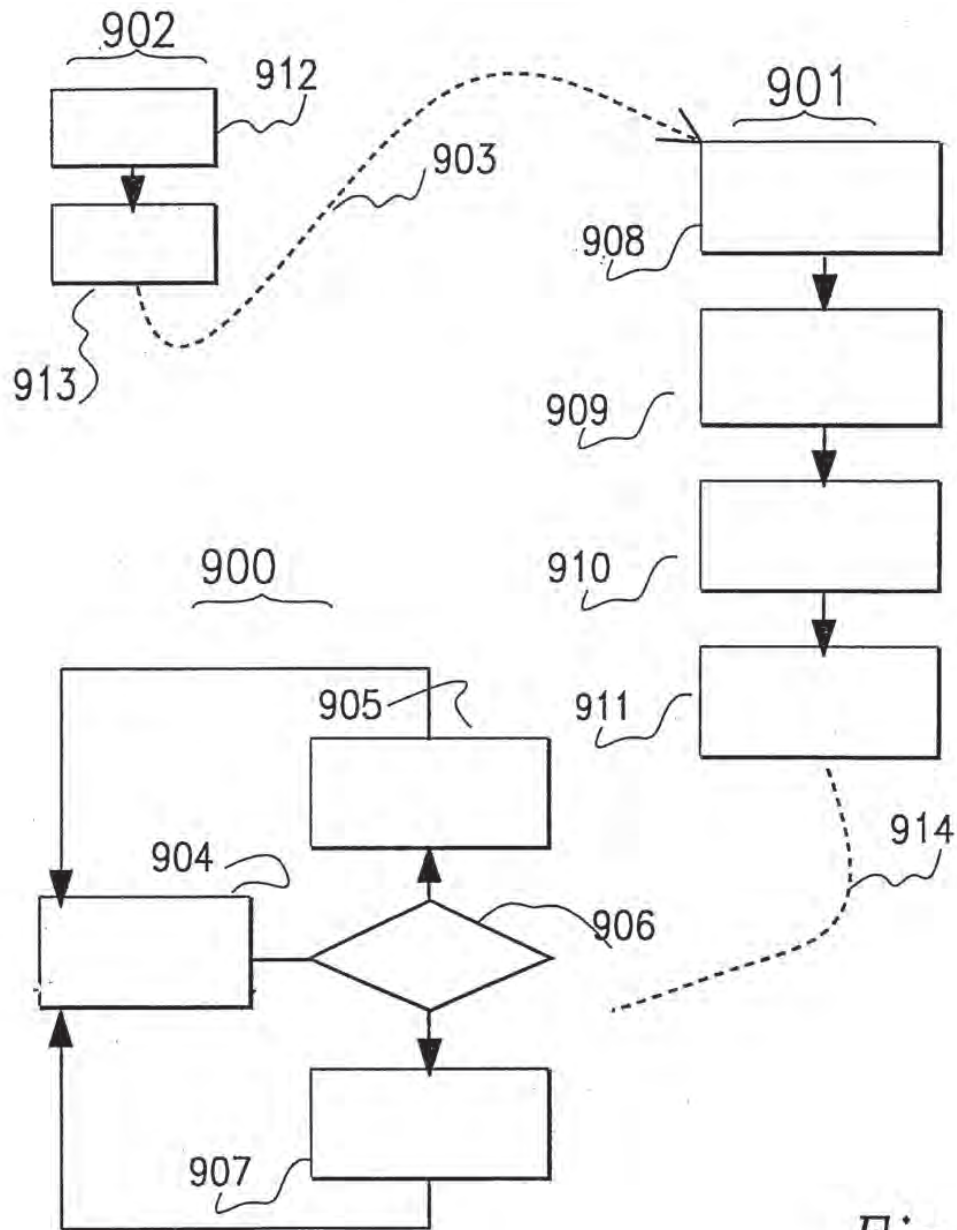
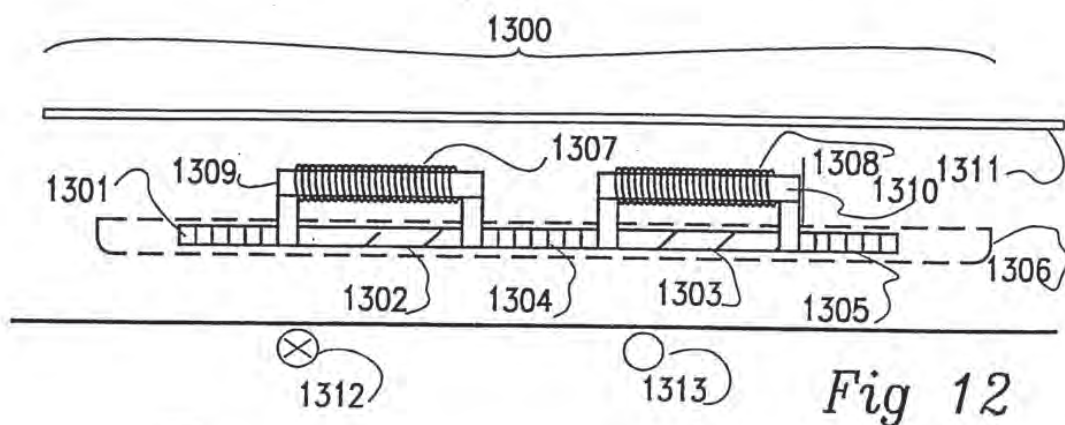
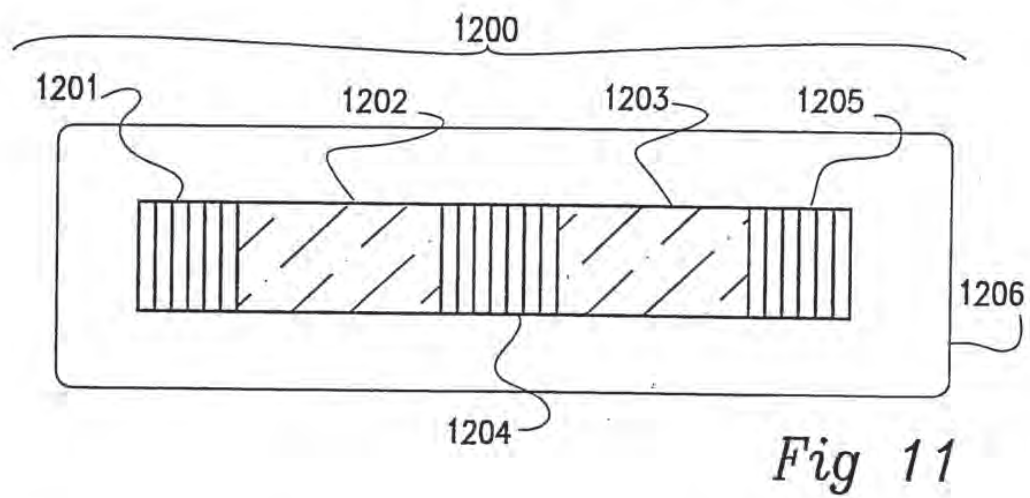
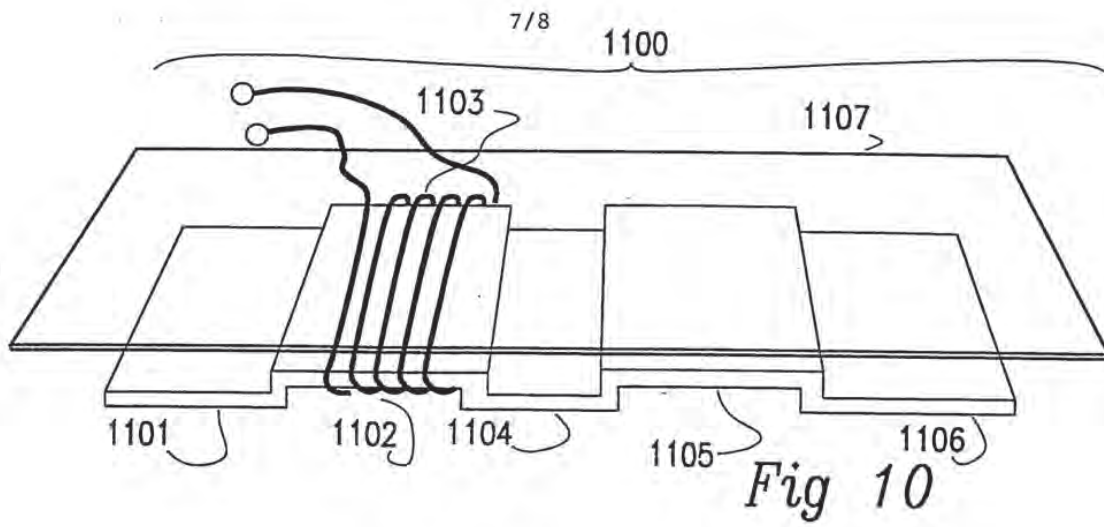


Fig 8

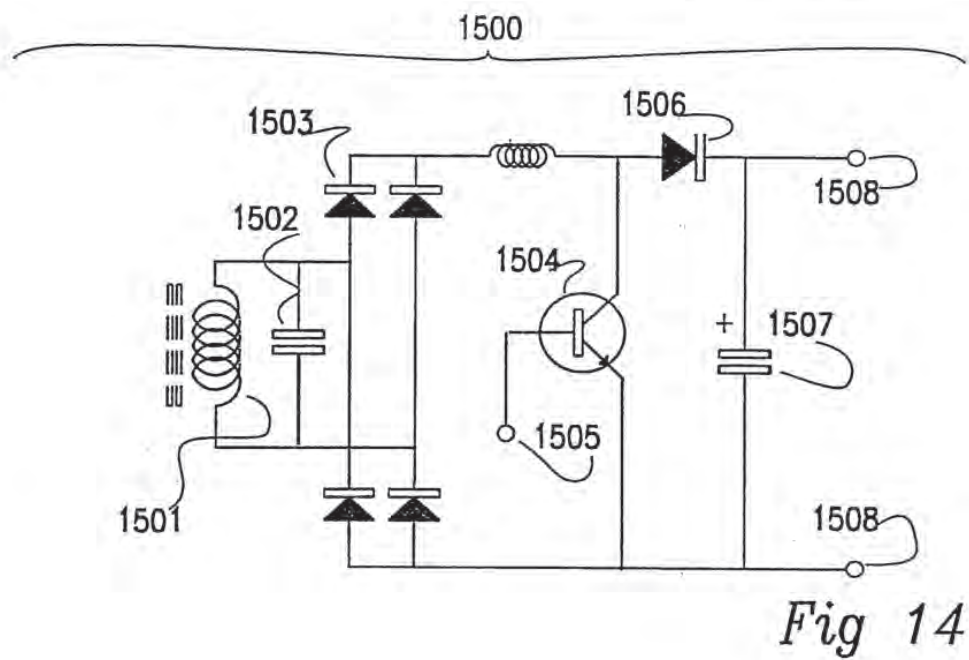
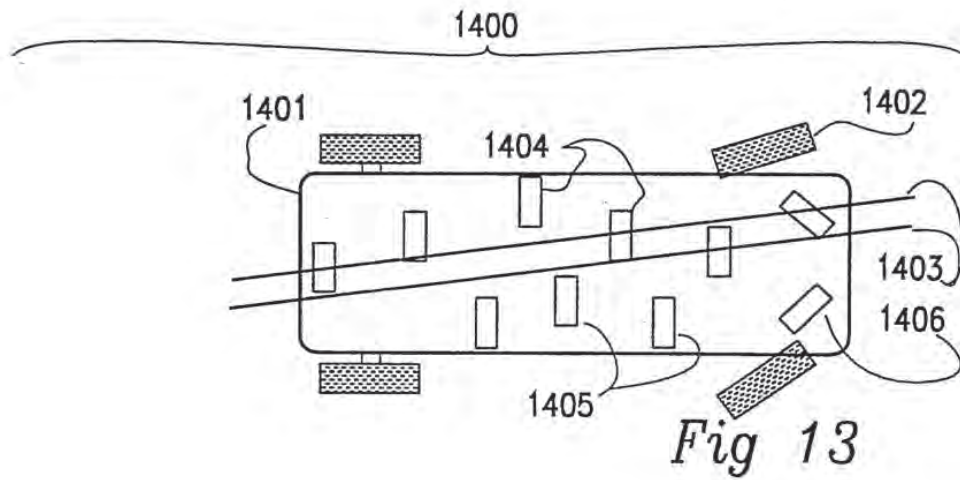
SUBSTITUTE SHEET

6/8

*Fig 9*



8/8



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) abstract	1-4																				
A	DE,A, 3915682 (Angewandte Digital Elektronik GmbH) 22 November 1990 (22.11.90) whole document	1																				
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.																						
* Special categories of cited documents : <table border="0"> <tr> <td>"A"</td> <td>document defining the general state of the art which is not considered to be of particular relevance</td> <td>"T"</td> <td>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</td> </tr> <tr> <td>"E"</td> <td>earlier document but published on or after the international filing date</td> <td>"X"</td> <td>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</td> </tr> <tr> <td>"L"</td> <td>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)</td> <td>"Y"</td> <td>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</td> </tr> <tr> <td>"O"</td> <td>document referring to an oral disclosure, use, exhibition or other means</td> <td>"&"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"P"</td> <td>document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			"A"	document defining the general state of the art which is not considered to be of particular relevance	"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	"E"	earlier document but published on or after the international filing date	"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	"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)	"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	"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family	"P"	document published prior to the international filing date but later than the priority date claimed		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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																			
"E"	earlier document but published on or after the international filing date	"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																			
"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)	"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																			
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family																			
"P"	document published prior to the international filing date but later than the priority date claimed																					
Date of the actual completion of the international search 24 February 1995 (24.02.95)		Date of mailing of the international search report 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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ 94/00115

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

Form PCT/ISA/210 (continuation of second sheet)(July 1992) copyus

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							

Electronic Patent Application Fee Transmittal				
Application Number:		12649635		
Filing Date:		30-Dec-2009		
Title of Invention:		WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-Q RESONATORS		
First Named Inventor/Applicant Name:		John D. Joannopoulos		
Filer:		Marc M. Wefers/Cheryl Forrest		
Attorney Docket Number:		01997-0359015 / 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:	15139414
Application Number:	12649635
International Application Number:	
Confirmation Number:	5891
Title of Invention:	WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-Q RESONATORS
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:	01997-0359015 / MIT 11757
Receipt Date:	07-MAR-2013
Filing Date:	30-DEC-2009
Time Stamp:	09:48:59
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	11676
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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1		359015-IDS.pdf	57517 d1b9cb263286613e02e1d9888161852c57 56bb9c	yes	2
Multipart Description/PDF files in .zip description					
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Warnings:					
Information:					
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Warnings:					
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Total Files Size (in bytes):			1586434		
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. <u>New Applications Under 35 U.S.C. 111</u> 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. <u>National Stage of an International Application under 35 U.S.C. 371</u> 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. <u>New International Application Filed with the USPTO as a Receiving Office</u> 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. : 12/649,635 Examiner : Fritz Fleming
Filed : December 30, 2009 Conf. No. : 5891
Title : WIRELESS ENERGY TRANSFER TO A MOVING DEVICE BETWEEN HIGH-
Q RESONATORS

MAIL STOP AMENDMENT

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

INFORMATION DISCLOSURE STATEMENT

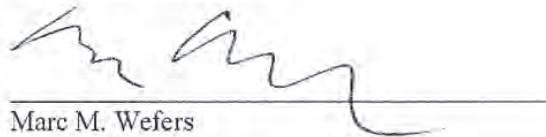
Please consider the references listed on the enclosed PTO-1449 form. Foreign patent documents and non-patent literature are enclosed; cited U.S. patents and patent application publications will be provided on request.

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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Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 01997-0359015	Application No. 12/649,635
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant John D. Joannopoulos et al.	
		Filing Date December 30, 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	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



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(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.04.2005 Bulletin 2005/14

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(30) Priority: 01.10.2003 JP 2003343616

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(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.

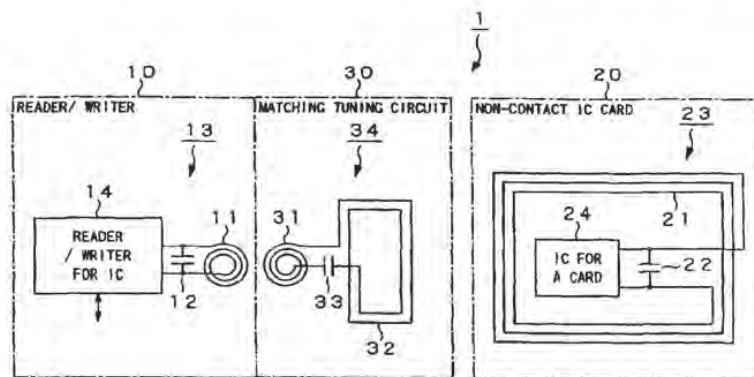


FIG. 1

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EP 1 521 206 A2

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

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 field, 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.

10 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

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 res-

onance 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

relaying device of the communication system so that the third and fourth antenna coils will be electro-magnetically coupled to the first antenna coils of the information read/write device and the second antenna coil of the non-contact information medium, respectively.

[0032] In case limitations are imposed on the space in which to mount the first antenna coil, it is sufficient that the third antenna coil is changed in shape/size so as to be electrically coupled to the first antenna coil. In case limitations are imposed that the first antenna coil has to be mounted on a metal component, such as a casing, the size of the first antenna coil or the aperture formed in the casing may be of the smallest size possible to assure the strength of the casing as well as to avoid adverse effects by the metal components.

[0033] The relaying device of the communication system of the present invention performs wireless communication of the electromagnetic coupling system with the information read/write device, no laborious processing, such as wiring, is needed, and is able to relay the wireless communication with the non-contact information medium by fitting the relaying device on a removable cover or to a door that may be opened/closed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

Fig.1 illustrates the configuration of a communication system showing the best embodiment of the present invention.

Fig.2 illustrates the configuration of a matching tuning circuit of the communication system.

Fig.3 shows an example of concrete setup of the communication system.

Fig.4 illustrates the configuration of a matching tuning circuit of the communication system.

Fig.5 shows an induction current I flowing in a matching tuning circuit of the communication system.

Fig.6 shows another example of concrete setup of the communication system.

Fig.7 shows a matching tuning circuit provided with a parallel-connected antenna coil.

Fig.8 illustrates an experiment 1 carried out for verifying the effect of the matching tuning circuit.

Fig.9 illustrates a communication range XY in the experiment 1.

Fig. 10 shows the results of an experiment on a communication range Z in the experiment 1.

Fig.11 shows the results of an experiment on the communication range XY in the experiment 1.

Fig. 12 illustrates an experiment 2 carried out for verifying the effect of the matching tuning circuit.

Fig. 13 illustrates an iron plate used in the experiment 2.

Fig. 14 shows the communication range XY in the experiment 2.

Fig. 15 shows the results of an experiment on the communication range Z in the experiment 2.

Fig.16 shows the results of an experiment on the communication range Z in the experiment 2.

Fig. 17A shows an example of an antenna coil of a non-contact IC card and Fig.17B shows an example of an antenna coil for a reader/writer.

Fig. 18 shows the magnetic flux passed through the antenna coil of the non-contact IC card.

Fig.19 shows an example of concrete setup of a reader/writer of a communication system shown as a prior art.

Fig.20 shows the magnetic flux passed through an antenna coil of a non-contact IC card when an antenna coil of the reader/writer is mounted on a metal chassis.

Fig.21 shows an example of mounting the antenna coil of the reader/writer of the communication system of the prior art as a relay antenna.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] Referring now to the drawings, the best embodiments of a relay apparatus and a communication system of the present invention are explained in detail.

[0036] Referring first to Fig. 1, a communication system 1 as the best embodiment for carrying out the present invention is explained.

[0037] The communication system 1, shown in Fig.1, is an RFID (Radio Frequency Identification), by the electromagnetic coupling system, provided with a reader/writer 10, a non-contact IC card 20, and a matching tuning circuit 30.

[0038] In this communication system 1, the non-contact IC card 20, as a non-contact information medium, receives electrical waves, transmitted from the reader/writer 10 through the matching tuning circuit 30, to obtain the power by electromagnetic induction, and has data communication with the reader/writer 10, with use of the electrical waves, through the matching tuning circuit 30.

[0039] The reader/writer 10 includes a parallel resonance circuit 13, comprised of a serial connection of an antenna coil 11, as an inductor, and a tuning capacitor 12. A reader/writer for IC 14 is connected in parallel with this parallel resonance circuit 13. The reader/writer 10 is tuned to a frequency f_c in the vicinity of, for example, 13.56MHz, as the a.c. voltage is applied to the parallel resonance circuit 13, under control by the reader/writer for IC 14.

[0040] The reader/writer 10 has wireless communication with the non-contact IC card 20, using the electrical waves, which have modulated a carrier having this frequency f_c as the carrier frequency. Although the carrier frequency is the frequency f_c , in the following explanation, the carrier frequency f_c is not limited to 13.56MHz.

[0041] The reader/writer for IC 14 is provided with an

interfacing circuit, not shown, and is connected to and controlled by a CPU (central processing unit) of a counterpart device, having loaded thereon the reader/writer 10.

[0042] The reader/writer for IC 14 controls the operation in sending data from the reader/writer 10 to the non-contact IC card 20 and in receiving data sent from the non-contact IC card 20.

[0043] In data transmission, the reader/writer for IC 14 modulates the carrier wave of the carrier frequency f_c with data being transmitted to generate transmission signals. As the data modulating system, ASK (amplitude shift keying), PWM (pulse width modulation) or the PSK (phase shift keying), for example, may be used.

[0044] The transmission signals, generated on modulation, are sent to the antenna coil 11 to generate a magnetic field. The magnetic field, generated in the antenna coil 11, is changed in keeping with the transmission signals, such that data carried by the carrier wave with the carrier frequency f_c is transmitted, as changes in the magnetic flux, to an antenna coil 31 of the matching tuning circuit 30, electro-magnetically coupled to the antenna coil 11.

[0045] In data receipt, the reader/writer for IC 14 demodulates the data, transmitted from the non-contact IC card 20 through the matching tuning circuit 30 and received as changes in the magnetic flux by the antenna coil 11. On receipt of the data by the antenna coil 11 from the non-contact IC card 20, the induced current is generated in the antenna coil 11 as a result of changes in the magnetic flux in the antenna coil 31 of the matching tuning circuit 30 electro-magnetically coupled with the antenna coil 11.

[0046] As the induced current, generated in the antenna coil 11, is changed with the magnetic flux, the data carried by the carrier wave with the carrier frequency f_c is transmitted to the antenna coil 11 as changes in the induced current.

[0047] The reader/writer for IC 14 demodulates this induced current to acquire data transmitted from the non-contact IC card 20.

[0048] The non-contact IC card 20 includes a parallel resonance circuit 23, which is a serial connection of an antenna coil 21, as an inductor, and a tuning capacitor 22. An IC for a card 24 is connected in parallel with this parallel resonance circuit 23.

[0049] The antenna coil 21 receives the electrical waves, transmitted from the reader/writer 10 through the matching tuning circuit 30, as changes in the magnetic flux. In the parallel resonance circuit 23, there is generated the induced electromotive force operating in a direction of obstructing changes in the magnetic flux of the electrical waves received by the antenna coil 11. By this induced electromotive force, the parallel resonance circuit 23 is tuned in the vicinity of the frequency $f_c = 13.56$ MHz.

[0050] The IC for a card 24, connected in parallel with the parallel resonance circuit 23, is operated with this

induced electromotive force as the operating power. The IC for a card 24, supplied with the operating power, controls the operation in receiving data sent from the reader/writer 10 and in transmitting data to the reader/writer 10.

[0051] In data receipt, the IC for a card 24 demodulates the electrical waves, transmitted from the reader/writer 10 through the matching tuning circuit 30 and received as changes in the magnetic flux in the antenna coil 21.

[0052] In data transmission, the IC for a card 24 modulates the carrier wave, with the carrier frequency f_c , with data to be transmitted, to generate transmission signals. The IC for a card 24 changes the load of the antenna coil 21, responsive to data to be transmitted, to modulate the carrier wave, by way of load modulation.

[0053] The transmission signals, generated on modulation, are sent to the antenna coil 21 to generate a magnetic field. As the magnetic field, generated in the antenna coil 21, is changed with the transmission signals, the data carried by the carrier wave, with the carrier frequency f_c , is transmitted, as changes in the magnetic flux, to an antenna coil 32 of the matching tuning circuit 30, electro-magnetically coupled with the antenna coil 21.

[0054] The matching tuning circuit 30 includes a parallel resonance circuit 34, comprised of a series connection of an antenna coil 31, as a first inductor, an antenna coil 32, as a second inductor, and a tuning capacitor 33.

[0055] Specifically, the matching tuning circuit 30 is comprised of the antenna coils 31, 32, arranged on a substrate 35, so as to be connected in series with the tuning capacitor 33.

[0056] The antenna coil 31 is electro-magnetically coupled, in a non-contact fashion, with the antenna coil 11, forming the parallel resonance circuit 13 in the reader/writer 10, and is shaped for communicating with the reader/writer 10.

[0057] The antenna coil 31 may be of any suitable shape, on the condition that it may communicate with the reader/writer 10. For example, the antenna coil 31 may be of an elliptical or a square shape, to say nothing of the circular shape shown in Fig. 1.

[0058] The antenna coil 31 does not have to be of the same shape as the antenna coil 11, on the condition that the antenna coil 31 is able to communicate with the reader/writer 10. However, in case the antenna coil 31 is approximately of the same shape and of the same size as the antenna coil 11, the electro-magnetic coupling may be stronger to achieve stable and highly efficient data communication.

[0059] On the other hand, the antenna coil 32 is electro-magnetically coupled, in a non-contact fashion, with the antenna coil 21 on the non-contact IC card 20, forming the parallel resonance circuit 23, such as to communicate with the non-contact IC card 20.

[0060] The antenna coil 32 may be of any suitable shape, on the condition that it may communicate with the reader/writer 10. For example, the antenna coil 31

may be of an elliptical or a circular shape, to say nothing of the square shape shown in Fig.1.

[0061] The antenna coil 32 is desirably larger in size than the antenna coil 21, provided to the non-contact IC card 20, since then a sufficient amount of the magnetic flux can be passed through the antenna coil 21 even in case the center of the antenna coil 21 is offset from the center of the antenna coil 32.

[0062] For example, in case the non-contact information medium is a non-contact IC card, and is used as a commutation ticket for railway or bus, the non-contact IC card cannot be placed at a constant fixed position at all times with respect to the antenna coil 32 of the matching tuning circuit 30 for data communication. Thus, in such case, the antenna coil 32 is larger in size than the antenna coil of the non-contact IC card to assure more reliable data communication.

[0063] For example, if the non-contact information medium is a non-contact IC tag affixed to a toner cartridge of a printer, as a consumable commodity, and is to have data communication with the reader/writer 10 mounted to a preset inner chassis in a printer casing, in order to manage the residual toner quantity, the non-contact IC tag may be placed in a fixed position relative to the antenna coil 32 of the matching tuning circuit 30 for data communication. Thus, in such a case, more efficient data communication may be had with the antenna coil 32 sized to be approximately equal to the size of the antenna coil of the non-contact IC tag.

[0064] If the antenna coil 32 is slightly smaller in size than the antenna coil 21, communication may be had by adjusting the output of the reader/writer 10.

[0065] The antenna coil 32 does not have to be of the same size and shape as the antenna coil 21, on the condition that the antenna coil 32 is able to communicate with the non-contact IC card 20, as discussed above. However, if the antenna coil 32 is of the same size and shape as the antenna coil 21, the electro-magnetic coupling becomes stronger to realize more efficient stable data communication.

[0066] That is, the size as well as the shape of the antenna coils 31, 32 of the matching tuning circuit 30 is limited to a more or less extent by the shape of the antenna coil 11 of the reader/writer 10 and by the shape of the antenna coil 21 of the non-contact IC card 20, respectively, for the realization of the efficient stable wireless communication.

[0067] With the communication system 1, shown as the best embodiment for carrying out the present invention, the non-contact IC card 20 is used as the non-contact information medium. Hence, in the following explanation, it is assumed that the shape and the size of the antenna coil 32 are approximately the same as those of the antenna coil 21 of the non-contact IC card 20, and also that the shape and the size of the antenna coil 31 are approximately the same as those of the antenna coil 11 of the reader/writer 10.

[0068] Since the antenna coils 31, 32 are connected

in series with each other so that these coils are wound in the same direction, the antenna coils 31, 32 may be deemed to be an inductor having a combined inductance $L = L_1 + L_2$, where L_1 is the inductance of the antenna coil 31 and L_2 is the inductance of the antenna coil 32. Consequently, the parallel resonance circuit 34 may be deemed to be a resonance circuit comprised of a series connection of an inductor having a combined inductance L and the tuning capacitor 33.

[0069] Referring to Fig.3, a concrete setup example of the reader/writer 10 and the matching tuning circuit 30 is shown and, based on this setup example, the operating principle of the matching tuning circuit 30 is explained.

[0070] It is assumed that the reader/writer 10, provided on a substrate 15, is mounted on the back side of a metal chassis 50, as a casing of an apparatus on which to mount the reader/writer 10. The metal chassis 50, on which the reader/writer 10 is mounted in this manner, has an aperture 50A in a location which is to be register with the mounting position of the antenna coil 11 of the reader/writer 10.

[0071] The opening area of the aperture 50A is selected to be such that the strength of the metal chassis 50 is not impaired and such that there is no risk of leakage of the electromagnetic noise produced by e.g. an electronic circuit within the metal chassis 50. The shape and the size of the antenna coil 11 of the reader/writer 10 are selected so that the antenna coil will be housed within this aperture 50A.

[0072] Since the antenna coil 31 of the matching tuning circuit 30 is shaped so that the antenna coil 31 is electro-magnetically coupled with the antenna coil 11 in a non-contact fashion and so that the antenna coil 31 may communicate with the reader/writer 10, the shape of the antenna coil 31 is determined to a more or less extent if once the shape of the antenna coil 11 is determined.

[0073] On the other hand, the matching tuning circuit 30 is mounted for facing the reader/writer 10, mounted on the metal chassis 50, with the metal chassis 50 in-between. The matching tuning circuit 30 is mounted at this time so that the antenna coil 31 overlies the aperture 50A formed in the metal chassis 50. By so doing, the antenna coil 11 of the reader/writer 10 and the antenna coil 31 of the matching tuning circuit 30 may be electro-magnetically coupled to each other in a non-contact fashion.

[0074] Since the reader/writer 10 mounted to the metal chassis 50 and the matching tuning circuit 30 may have wireless communication by the antenna coils 11, 31 being electromagnetically coupled to each other in a non-contact fashion, no physical connection between the reader/writer 10 and the matching tuning circuit 30 is needed and hence the matching tuning circuit 30 may be mounted in position by a simplified technique of directly bonding the substrate 30 to the metal chassis 50 with e.g. a double-sided adhesive tape.

[0075] The matching tuning circuit 30, mounted to the metal chassis 50 operates as follows, by the electrical waves, transmitted from the reader/writer 10.

[0076] The antenna coil 31 of the parallel resonance circuit 34 of the matching tuning circuit 30 is traversed by a magnetic flux A, generated by a magnetic field, generated in turn by the antenna coil 11 of the reader/writer 10, for electromagnetically coupling the antenna coils 11, 31 to each other.

[0077] The induced electromotive force is generated in the parallel resonance circuit 34 by the magnetic flux A traversing the antenna coil 31, so that the induced current I by the induced electromotive force flows through the entire circuit. The parallel resonance circuit 34 is tuned by the induced electromotive force in the vicinity of the frequency $f_c = 13.56$ MHz.

[0078] When the induced current I flows through the antenna coil 32, a magnetic field is generated in the coil 32.

[0079] At this time, the non-contact IC card 20 may be moved to the vicinity of the matching tuning circuit 30. Thus, the magnetic flux B, generated by the magnetic field, generated in turn in the antenna coil 32, is passed through the inside of the antenna coil 21, as shown in Fig. 4. This electro-magnetically couples the antenna coils 32, 21 to each other.

[0080] When the magnetic flux B traverses the antenna coil 21 of the non-contact IC card 20 in this manner, the non-contact IC card 20 is activated so that the reader/writer 10 and the non-contact IC card 20 are now able to have wireless communication with each other through the matching tuning circuit 30.

[0081] Referring to the cross-sectional view of Fig. 6, another setup example of the reader/writer 10 and the matching tuning circuit 30 is hereinafter explained.

[0082] Referring to Fig. 6, the reader/writer 10 is mounted on the back-side surface of a metal chassis 51, as a casing of a device, adapted for being loaded with the reader/writer 10, so that the antenna coil 11 will be in register with an aperture 51A of the metal chassis 51.

[0083] On the front side surface of the metal chassis 51, having the reader/writer 10 mounted thereon, there is provided a metal component 52, such as a screw, such that the matching tuning circuit 30 cannot directly be mounted thereon, as shown in Fig. 6.

[0084] Thus, the matching tuning circuit 30 is mounted in position by bonding the substrate 35 of the matching tuning circuit 30 on the back side surface of a resin cover 53 overlying the aperture 51A of the metal chassis 51.

[0085] The matching tuning circuit 30 is bonded to the back-side surface of the resin cover 53, so that, when the resin cover 53 is mounted to the metal chassis 51, the antenna coil 31 of the matching tuning circuit 30 is in register with the antenna coil 11 of the reader/writer 10.

[0086] The cover 53, to which is bonded the matching

tuning circuit 30, is formed of non-magnetic resin, in order to cause no loss of the magnetic flux by the magnetic field generated in the antenna coil 32 of the matching tuning circuit 30. The substrate 35 of the matching tuning circuit 30 is of an extremely thin thickness, and is e. g. a flexible substrate, so as not to affect the magnetic field generated in the antenna coil 32.

[0087] A shield plate 54 may also be provided in order to prevent the effect of the electromagnetic noise generated in the device designed for carrying the reader/writer 10. The shield plate 54 needs only to be mounted to overlie the antenna coil 11. At this time, caution should be exercised so that the shield plate 54 is kept aloof from the reader/writer 10 in order to prevent the function of the antenna coil 11 from being impaired.

[0088] The matching tuning circuit 30, mounted to the resin cover 53, may also be mounted to the inner side of a rotatable door, provided to e. g. a casing of the device loaded with the reader/writer 10, in a manner not shown, for saving the spacing.

[0089] Thus, there is no necessity for providing the wiring for the matching tuning circuit 30, in order for the matching tuning circuit 30 to communicate with the reader/writer 10, and the matching tuning circuit 30 may be separated from the reader/writer 10 and mounted freely to any place within the sphere of electro-magnetic coupling. The result is the communication system 1 with an extremely high degree of mounting freedom.

[0090] In the matching tuning circuit 30 of the above-described communication system 1, the antenna coils 31, 32 are connected in series with each other. In the communication system 1, a matching tuning circuit 40, in which a parallel resonance circuit 41 is made up by a parallel connection of the antenna coils 31, 32 and the tuning capacitor 33, as shown in Fig. 7, may be used in place of the matching tuning circuit 30. The case of using the matching tuning circuit 40 is not explained in detail because the operation of the communication system 1 gives the identical effect in case the matching tuning circuit 40 is used in place of the matching tuning circuit 30.

[0091] Meanwhile, the tuning capacitor 33 is connected in series with both the antenna coils 31, 32, as shown in Fig. 7.

[Embodiment]

[0092] By way of an embodiment, the results of an experiment, conducted for measuring the effect by the matching tuning circuit 30, are shown.

[0093] In the experiment, the area which allows for communication for the case of using the matching tuning circuit 30 and that for the case of not using the matching tuning circuit 30, in the wireless communication between the reader/writer 10 and the non-contact IC card 20, were measured and compared to each other.

[0094] The same experiment was conducted as an iron plate having an aperture of the same shape as the antenna coil 11 of the reader/writer 10 was interposed

between the reader/writer 10 and the non-contact IC card 20, in order to verify the effect by the matching tuning circuit 30 under the actual assumed use condition of the matching tuning circuit 30, as shown in Figs.3 and 6.

(Experiment 1)

[0095] In an experiment 1, measurement was made of the area which allows for communication, in case the reader/writer 10 and the non-contact IC card 20 were arranged in a free space devoid of an obstacle, and the reader/writer 10 was activated in this state, and of the area which allows for communication, in case the matching tuning circuit 30 was interposed between the reader/writer 10 and the non-contact IC card 20, and the reader/writer 10 was activated in this state, as shown in Fig.8.

[0096] The antenna coil 11 of the reader/writer 10 was circular in shape, with a diameter on the order of 25 mm. The antenna coil 31 of the matching tuning circuit 30 was of approximately the same shape. The non-contact IC card 20 used was of the size of 54 mm in length, 85.6 mm in width and 0.76 mm in thickness, as provided for in the ISO (International Organization for Standardization). The antenna coil 21, enclosed in the non-contact IC card 20, was wound to approximate the size of the non-contact IC card 20. The antenna coil 32 of the matching tuning circuit 30 was approximately of the same shape as the antenna coil 21.

[0097] The area which allows for communication, and which is to be measured, is now explained. The area which allows for communication, and which is now to be measured, is defined by a distance for communication Z, representing the distance which allows for communication, in case the non-contact IC card 20 is moved vertically relative to the reader/writer 10, and by a distance for communication XY, representing the distance which allows for communication, in case the non-contact IC card 20 is moved horizontally relative to the reader/writer 10.

[0098] Specifically, the distance for communication Z is a distance up to which the communication is possible when the center of the antenna coil 11 of the reader/writer 10, placed horizontally, is confounded with the center of the major plane surface of the non-contact IC card 20, and when the non-contact IC card 20 is moved in the vertical direction, as it is kept parallel to the antenna coil 11.

[0099] The distance for communication XY is a distance up to which the communication is possible when the non-contact IC card 20, placed horizontally at a preset distance with respect to the antenna coil 11 of the reader/writer 10, is optionally moved along the X-axis direction and along the Y-axis direction within the X-Y coordinate plane shown in Fig.9. This distance for communication may be found by measuring the trajectory of the center point of the non-contact IC card 20.

[0100] This distance for communication Z and the dis-

tance for communication XY, thus measured, may be used as indexes for the effect of the matching tuning circuit 30.

[0101] First, Fig. 10 shows the results of measurement of the distance for communication Z without the matching tuning circuit 30 and the results of measurement of the distance for communication Z with the matching tuning circuit 30 placed in position. Meanwhile, since the matching tuning circuit 30 is mounted at a distance of 10 mm from the antenna coil 11 of the non-contact IC card 10, the distance for communication for the case the matching tuning circuit 30 is placed in position was measured from the position of the intervening matching tuning circuit 30.

[0102] The distance for communication Z without the matching tuning circuit 30 was 10 to 25 mm, as shown in Fig. 10. The same distance Z with the matching tuning circuit 30 interposed in position was 20 to 75 mm. Thus, it may be seen that, by placing the matching tuning circuit 30 between the reader/writer 10 and the non-contact IC card 20, the distance for communication Z is approximately tripled.

[0103] If, in case the matching tuning circuit 30 is placed in position, the non-contact IC card 20 is at a distance of 10 to 20 mm from the antenna coil 11, the communication becomes infeasible because the non-contact IC card 20 and the matching tuning circuit 30 interfere with each other and become unstable in operation. This inconvenience may be overcome by strictly matching the resonance frequency of the non-contact IC card 20 to that of the matching tuning circuit 30 or by significantly separating the two resonance frequencies from each other.

[0104] Fig. 11 shows the results of measurement of the distance for communication XY without the matching tuning circuit 30 and the results of measurement of the distance for communication XY with the matching tuning circuit 30 placed in position.

[0105] In case the matching tuning circuit 30 is not used, the distance for communication XY was measured at a location separated in the vertical direction by 10 mm from the center of the antenna coil 11 of the reader/writer 10. In case the matching tuning circuit 30 is used, the distance for communication XY was measured at a location separated 10 mm in the vertical direction from the center of the antenna coil 32 of the matching tuning circuit 30.

[0106] Meanwhile, the location of insertion of the matching tuning circuit 30 is 10 mm away from the reader/writer 10, as set forth above.

[0107] In the absence of the matching tuning circuit 30, the distance for communication XY is such that $-30 \leq X \text{ (mm)} \leq 30$ and $-15 \leq Y \text{ (mm)} \leq 15$, as shown in Fig. 11. That is, the distance for communication XY is defined to be the inside of an ellipsis, with a long axis of 60 mm and a short axis of 30 mm, as indicated by a broken line.

[0108] In case the matching tuning circuit 30 is placed in position, the distance for communication XY is such

that $-50 \leq X \text{ (mm)} \leq 50$ and $-40 \leq Y \text{ (mm)} \leq 40$, as shown in Fig. 11. That is, in Fig. 11, the distance for communication XY is defined to be the inside of an ellipsis, with a long axis of 100 mm and a short axis of 80 mm, as indicated by a solid line.

[0109] Thus, it may be seen that, by placing the matching tuning circuit 30 between the reader/writer 10 and the non-contact IC card 20, the distance for communication XY is quadrupled.

(Experiment 2)

[0110] In the experiment 2, the reader/writer 10 was bonded to an iron plate 60, which iron plate, stuck to the reader/writer 10, was placed so as to prove an obstacle between the reader/writer 10 and the non-contact IC card 20 to approximate the actual use state, as shown in Fig. 12. The distance for communication Z and the distance for communication XY were measured for the case in which the matching tuning circuit 30 was used and for the case in which the matching tuning circuit 30 was not used.

[0111] In the iron plate 60, there is bored an aperture 60A of approximately the same shape as that of the antenna coil 1 of the reader/writer 10. When the reader/writer 10 is stuck to the iron plate 60, attention is to be paid so that the aperture 60A is in register with the antenna coil 11.

[0112] In the experiment 2, the reader/writer 10, non-contact IC card 20 and the matching tuning circuit 30 used are to be exactly the same as those used in the experiment 1. In using the matching tuning circuit 30, a spacer 61 is interposed between the iron plate 60 and the matching tuning circuit 30, and the separation between the antenna coil 11 of the reader/writer 10 and the matching tuning circuit 30 is set to 5 mm, as shown in Fig. 12.

[0113] The measured results of the distance for communication Z, shown in Fig. 12, and those for the distance for communication XY, shown in Fig. 14, are shown below. First, Fig. 15 shows the measured results of the distance for communication Z, in the absence of the matching tuning circuit 30, and those of the distance for communication Z with the matching tuning circuit 30 placed in position. Meanwhile, since the matching tuning circuit 30 in the experiment 2 is placed at a separation of 5 mm from the antenna coil 11 of the reader/writer 10, the distance for communication Z was measured from the position of the matching tuning circuit 30.

[0114] In the absence of the matching tuning circuit 30, the communication disabled state was invited, in which communication is disabled under the influence of the iron plate 60, as shown in Fig. 15. The distance for communication Z, in case the matching tuning circuit 30 was placed in position, was 5 to 35 mm.

[0115] Thus, by introducing the matching tuning circuit 30 between the reader/writer 10 non-contact IC card 20, the wireless communication by the reader/writer 10

and the non-contact IC card 20 may be improved from the communication disabled state to a practically satisfactory state.

[0116] Fig. 16 shows the measured results of the distance for communication XY in the absence of the matching tuning circuit 30 and those of the same distance with the matching tuning circuit 30 placed in position.

[0117] In the absence of the matching tuning circuit 30, the distance for communication XY was measured at a position 5mm spaced apart in the vertical direction from the center of the antenna coil 11 of the reader/writer 10 and, in case the matching tuning circuit 30 was placed in position, the same distance XY was measured at a location 5 mm spaced apart from the center of the antenna coil 32 of the matching tuning circuit 30.

[0118] It is noted that the matching tuning circuit 30 is introduced at a position 5 mm spaced apart from the antenna coil 11 of the reader/writer 10, as noted previously.

[0119] In case the matching tuning circuit 30 is not used, the communication is disabled, as shown in Fig. 16. The distance for communication XY is such that $-35 \leq X \text{ (mm)} \leq 35$ and $-20 \leq Y \text{ (mm)} \leq 20$. That is, as shown in Fig. 16, the distance for communication XY is defined to be the inside of an ellipsis, with a long axis of 70 mm and a short axis of 40 mm, as indicated by a solid line in Fig. 16.

[0120] Thus, it may be seen that, by placing the matching tuning circuit 30 between the reader/writer 10 and the non-contact IC card 20, the wireless communication by the reader/writer 10 and the non-contact IC card 20 may be improved from the communication disabled state to a practically satisfactory state.

Claims

1. 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, said relaying apparatus comprising
 - a first antenna coil electro-magnetically coupled to an antenna coil of said information read/write device;
 - a second antenna coil, connected in series with said first antenna coil and electro-magnetically coupled with an antenna coil of said non-contact information medium; and
 - a tuning capacitor connected in series with said first antenna coil and with said second antenna coil;
- said first antenna coil, second antenna coil and the tuning capacitor forming a resonance circuit resonated at the resonance frequency which is the same as the resonance frequency of a resonance circuit of said read/write device and the resonance

frequency of a resonance circuit of said non-contact information medium

2. The relaying apparatus according to claim 1 wherein said first antenna coil is of approximately same size and shape as those of the antenna coil of said read/write device, and wherein
 said second antenna coil is of approximately same size and shape as those of the antenna coil of said non-contact information medium.
3. 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, said relaying apparatus comprising
 - a first antenna coil electro-magnetically coupled to an antenna coil of said information read/write device;
 - a second antenna coil, connected in parallel with said first antenna coil and electro-magnetically coupled with an antenna coil of said non-contact information medium; and
 - a tuning capacitor connected in series with said first antenna coil and with said second antenna coil connected parallel to said first antenna coil;
 - said first antenna coil, second antenna coil and the tuning capacitor forming a resonance circuit resonated at the resonance frequency which is the same as the resonance frequency of a resonance circuit of said read/write device and the resonance frequency of a resonance circuit of said non-contact information medium
4. The relaying apparatus according to claim 3 wherein said first antenna coil is of approximately same size and shape as those of the antenna coil of said read/write device, and wherein
 said second antenna coil is of approximately same size and shape as those of the antenna coil of said non-contact information medium.
5. A communication system for wireless communication of the electro-magnetic coupling system, mediated by a carrier wave of a preset frequency, said communication system comprising
 - 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 said first antenna coil, said information read/write device having wireless communication with a circuit electro-magnetically coupled to said first antenna coil, with the resonance frequency of said first resonance circuit as said frequency of said carrier wave;
 - 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 said second antenna coil, said second resonance circuit resonating with a resonance frequency which is the same as the resonance frequency of said first resonance circuit and having wireless communication with a circuit electro-magnetically coupled to said second antenna coil; and

a relaying device including a third resonance circuit, made up by a third antenna coil, electro-magnetically coupled to said first antenna coil of said information write device, a fourth antenna coil connected in series with said third coil and electro-magnetically coupled with the antenna coil of said non-contact information medium, and a third tuning capacitor connected in series with said third and fourth antenna coils, said third relaying circuit resonating with the same resonance frequency as the resonance frequency of said first resonance circuit and said second resonance circuit, said relaying device relaying the wireless communication between said information read/write device and said non-contact information medium

6. The communication system according to claim 5 wherein
 said third antenna coil of said relaying device is approximately of the same size and shape as said first antenna coil of said information read/write device; and wherein
 said second antenna coil of said relaying device is approximately of the same size and shape as said second antenna coil of said non-contact information medium.
7. A communication system for wireless communication of the electro-magnetic coupling system, mediated by a carrier wave of a preset frequency, said communication system comprising
 - 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 said first antenna coil, said information read/write device having wireless communication with a circuit electro-magnetically coupled to said first antenna coil, with the resonance frequency of said first resonance circuit as said frequency of said carrier wave;
 - 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 said second antenna coil, said second resonance circuit resonating with a resonance frequency which is the same as the resonance frequency of said first resonance circuit and having wireless communication with a circuit electro-magnetically coupled to said second antenna coil; and

a relaying device including a third resonance circuit, made up by a third antenna coil, electromagnetically coupled to said first antenna coil of said information write device, a fourth antenna coil connected in series with said third coil and electromagnetically coupled with the antenna coil of said non-contact information medium, and a third tuning capacitor connected in series with each of said third and fourth antenna coils, said third relaying circuit resonating with the same resonance frequency as the resonance frequency of said first resonance circuit and said second resonance circuit; said relaying device relaying the wireless communication between said information read/write device and said non-contact information medium.

8. The communication system according to claim 7 wherein

said third antenna coil of said relaying device is approximately of the same size and shape as said first antenna coil of said information read/write device; and wherein

said second antenna coil of said relaying device is approximately of the same size and shape as said second antenna coil of said non-contact information medium.

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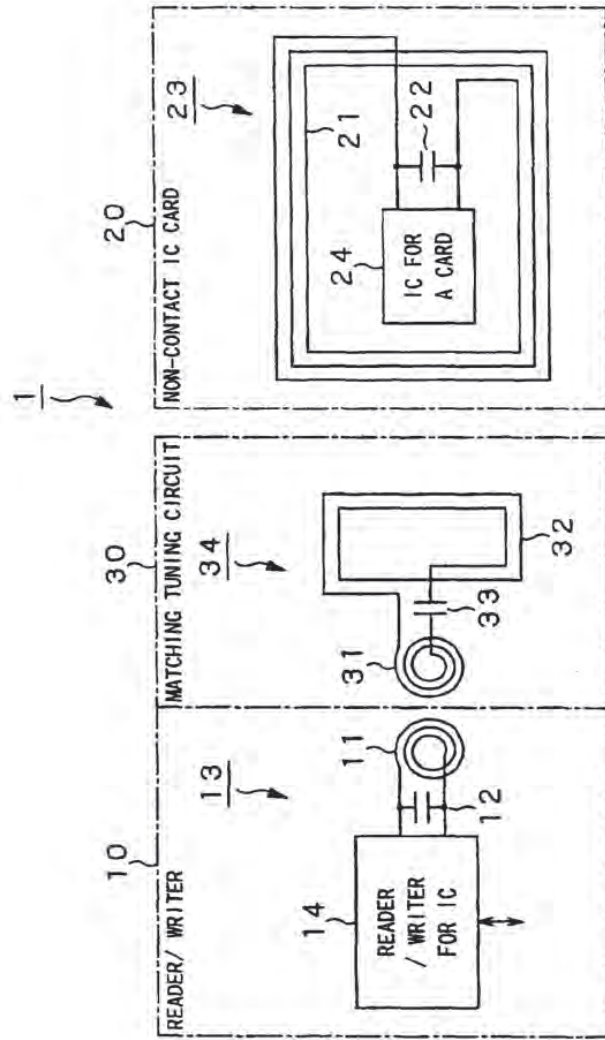


FIG.1

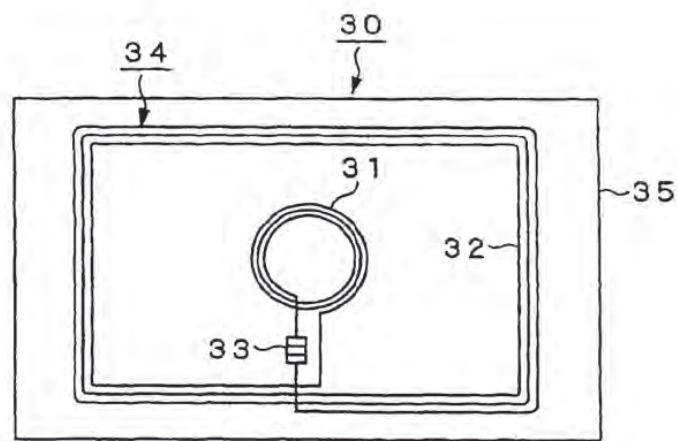


FIG.2

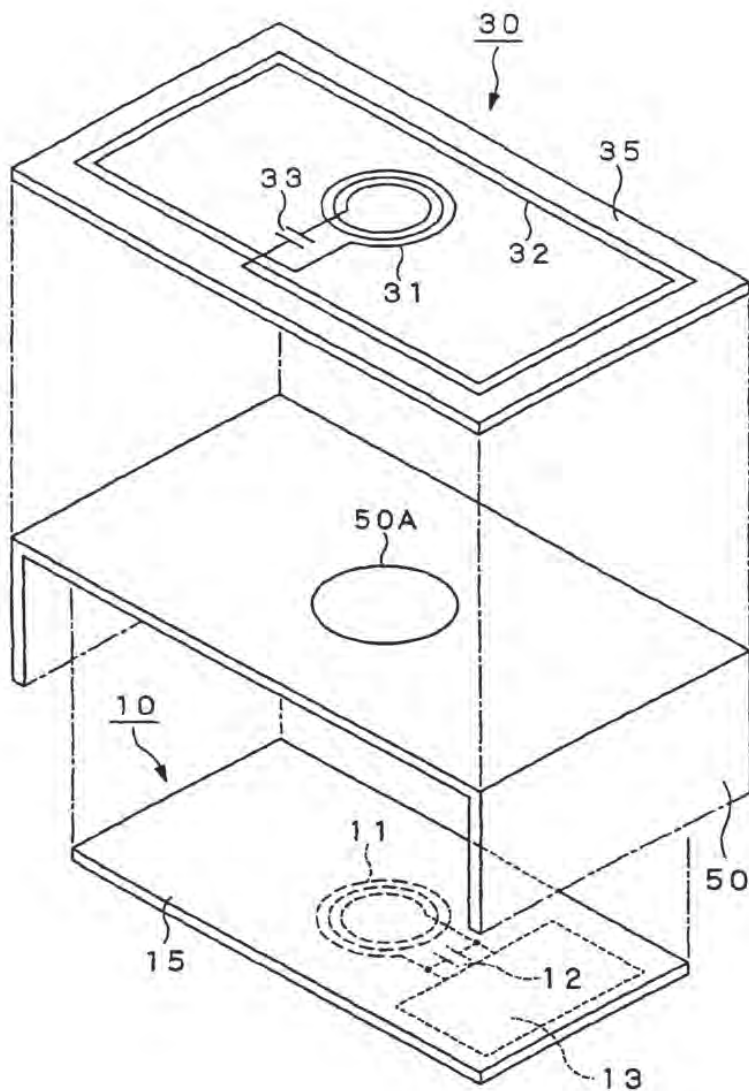


FIG.3

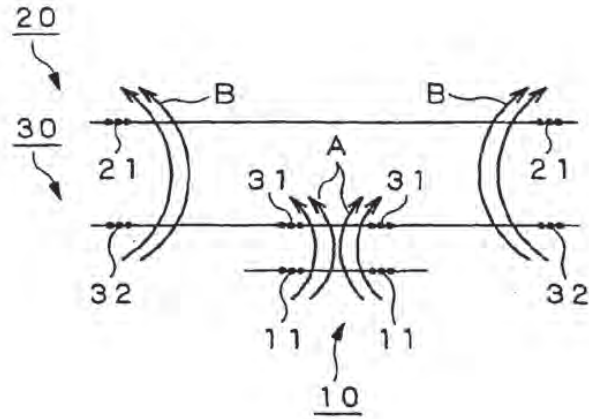


FIG. 4

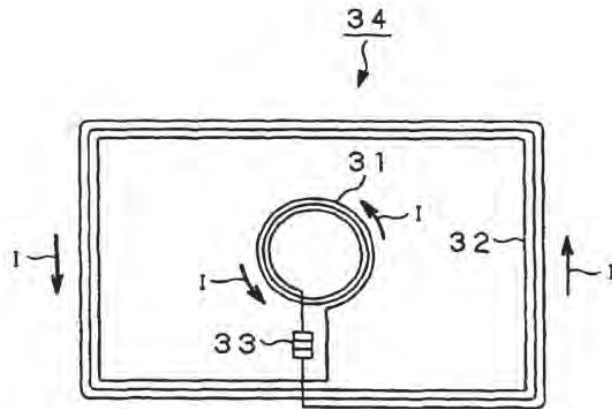


FIG. 5

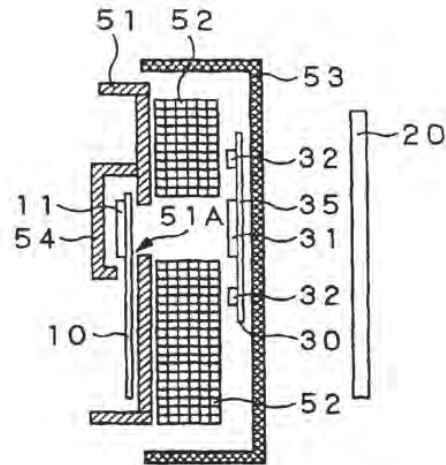


FIG. 6

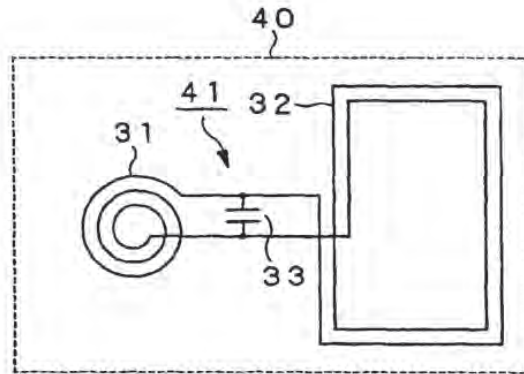


FIG. 7

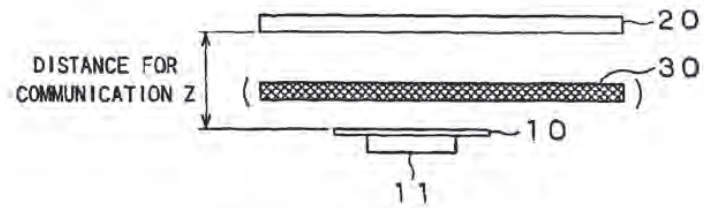


FIG. 8

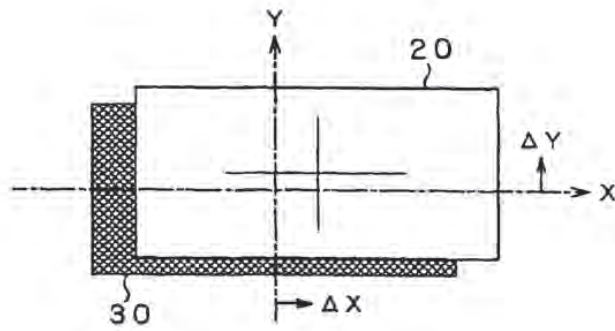


FIG. 9

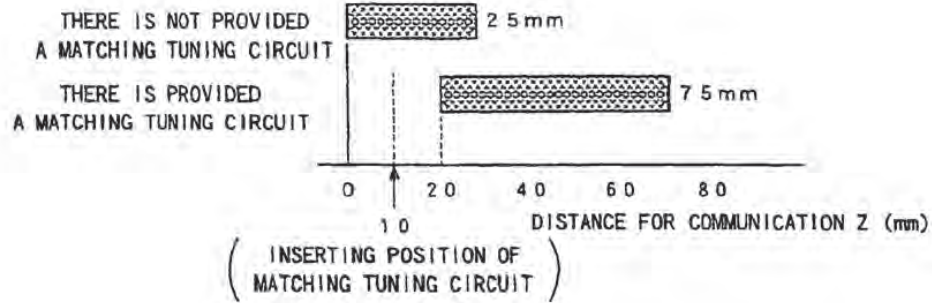


FIG. 10

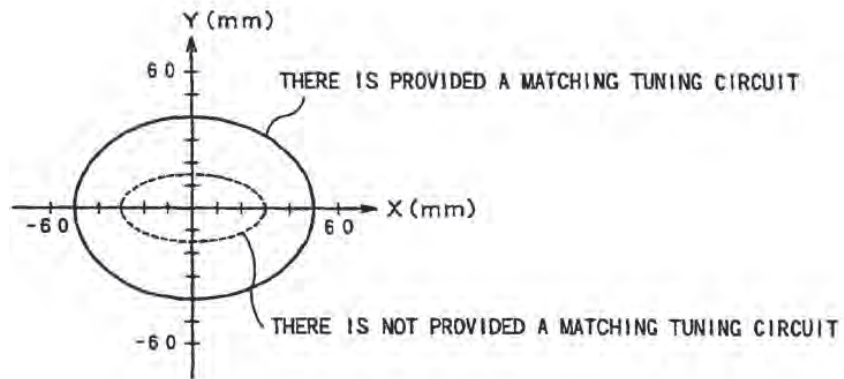


FIG. 11

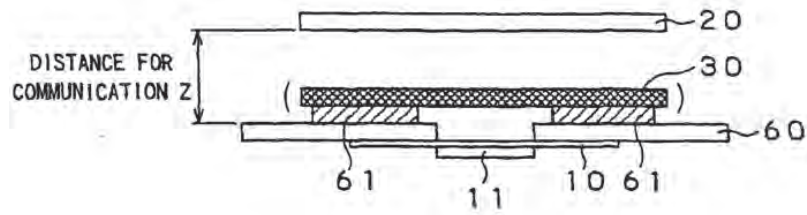


FIG. 12

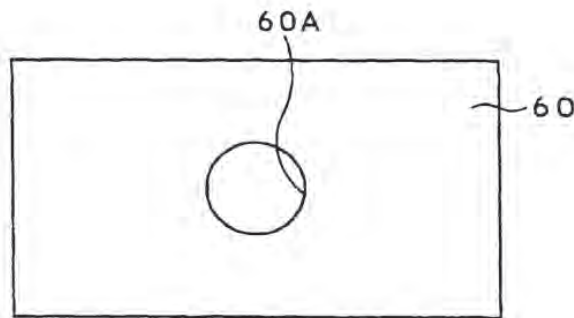


FIG. 13

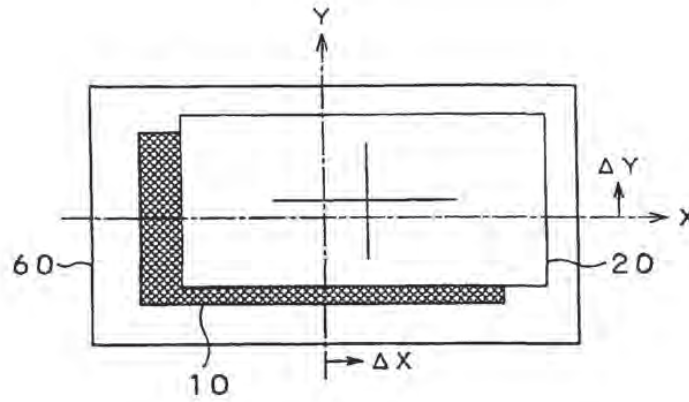


FIG. 14

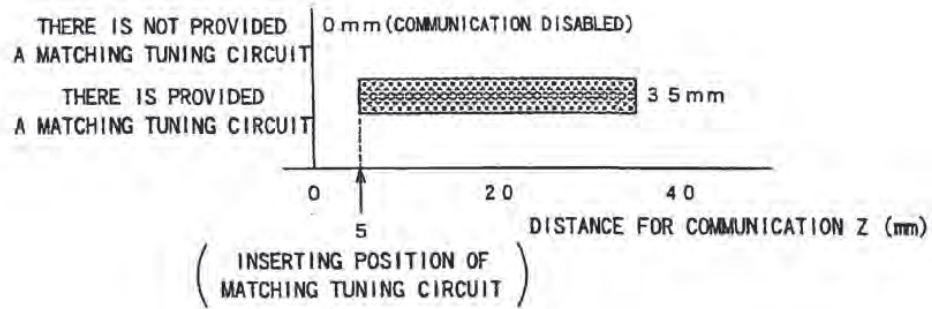


FIG. 15

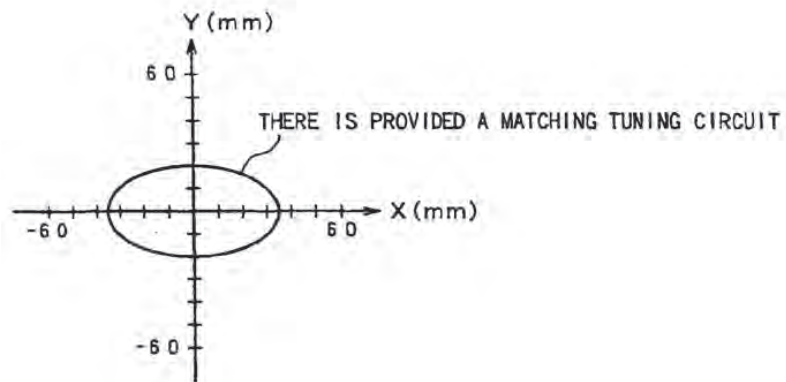


FIG. 16

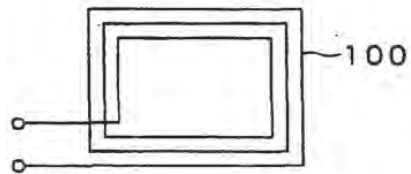


FIG. 17A



FIG. 17B

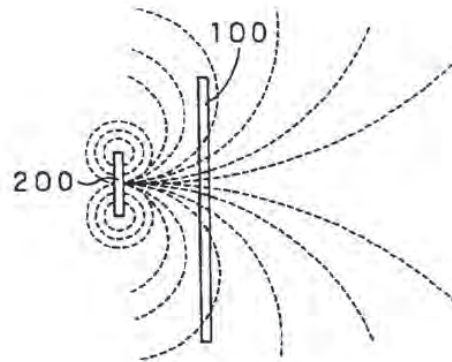


FIG. 18

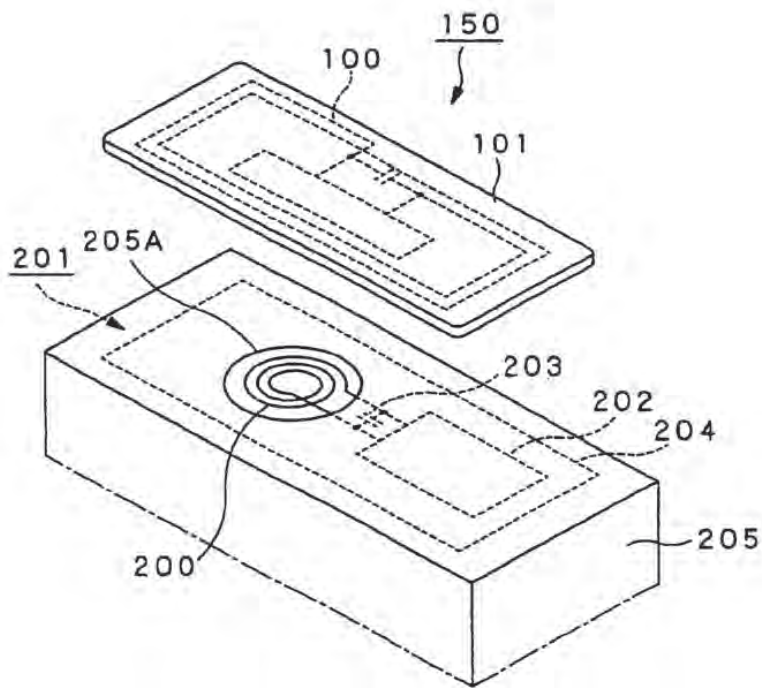


FIG. 19

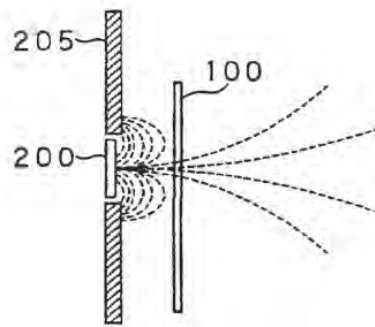


FIG. 20

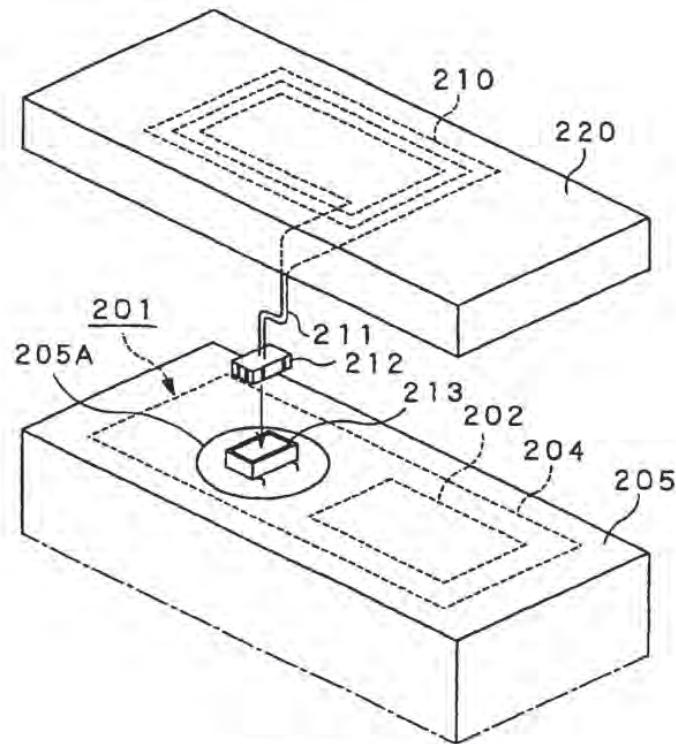


FIG. 21



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(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.

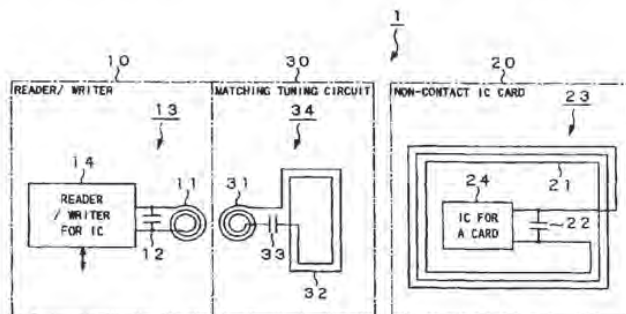


FIG. 1

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