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CLAIMS

[Claim(s)]
[Claim 1]
It is a non-contact charge dexterous planar magnetic element used as structure which embedded a spiral type plane coil under one side of a magnetic layer,
A non-contact charge dexterous planar magnetic element which arranges two or more plane coils in series on the same plane, and is characterized by things.
[Claim 2]
The aforementioned magnetic layer comprises ferrite magnetic powder,
A planar magnetic element for the noncontact chargers according to claim 1, wherein volume density of ferrite magnetic powder in the aforementioned magnetic layer is more than 25vol %.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
About the planar magnetic element mounted on a noncontact charger, the present invention suppresses local generation of heat of especially this planar magnetic element, and attains large slimming down and the improvement in charging efficiency.
[0002]
[Description of the Prior Art]
With the spread of information technologies in recent years, the miniaturization of a cellular phone, an electronic information terminal, etc., slimming down, and a weight saving proceed quickly, and the power supply of a rechargeable battery drive like a Li-ion cell or a nickel hydoride battery is increasingly used abundantly.
However, a portable device is reserved near the human body in many cases, reliability has a possibility of producing a problem, in the form which the contact for charge exposed, and the charging system of the noncontact type is demanded.
[0003]
although mainly used for the apparatus of places equipped with a water supply, such as a shaver and an electric toothbrush, as a non-contact charging system so far — these days, it is a description, for example to JP,H2000-78763,A -- like -- a cellular phone and PHS etc. — it is increasingly used also for a portable electronic device.
The example of a card shape non-contact feeder system can be especially given as a thin thing (1162 (2000), Kanai et al.: Kanai et al.: IEEE APEC Record, pp.1157- Institute of Electrical Engineers of Japan a mug references, such as NETIKUSU study group MAG-00-150).
[0004]
As a magnetic cell in such a non-contact charging system (non-contact feeder system), the structure which coiled copper wire about, or air cored coil structure has been conventionally adopted on a ferrite plate or an amorphous thin belt.
However, there was a problem which is described below in the magnetic cell of these former on structure.
(1) Coil thickness is about 1 mm, and since the dimension is as large as several centimeter angle, an occupation area and volume inhibit the miniaturization of apparatus, and slimming down largely.
(2) In order that the magnetic flux from the power transmission side may cross the inside of a coil, the loss by the eddy current generated within a receiving coil is large.
[0005]
By the way, as an ultra-thin type coil, the plane type magnetic cell using the ferrite magnetic film formed by print processes or the sheet method is known ([Refer to / etc / JP,H11-26239,A]).
By printing and calcinating first the magnetic paste which mixed the binder with ferrite powder on a Si substrate, a this plane type magnetic cell forms the ferrite magnetic film of high resistance, and then is, After forming a coil pattern by the plating method etc. on this film, a magnetic film is further formed on it and it is manufactured. And it has succeeded in inhibiting a

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coil loss effectively as well as slimming down.
[0006]
[Problem to be solved by the invention]
However, in the magnetic cell of this structure, since the magnetic body is arranged on both sides of a coil, extraction of the magnetic flux to outside and incorporation of the magnetic flux from the outside cannot say that it is sufficient, and the magnetic flux between carrier power transmission coils does not cross a sufficient mutual coil. Therefore, capability sufficient as an object for noncontact chargers could not be exerted, and the present invention was not able to apply as a target non-contact charge dexterous planar magnetic element.
[0007]
About the planar magnetic element mounted on a noncontact charger, the present invention enables the further miniaturization and slimming down, and provides the planar magnetic element for noncontact chargers which realizes good charging efficiency.
In the planar magnetic element mounted on the above-mentioned noncontact charger, the present invention suppresses local generation of heat, and realizes improvement in one step of efficiency.
[0008]
[Means for solving problem]
While the inventors repeat research intensively that the above-mentioned purpose should be attained, embedding a spiral type plane coil under one side of a magnetic layer and forming a planar magnetic element It found out that the desired end was further attained advantageously by carrying out the split shape of the plane coil concerned to plurality, and carrying out a series connection.,
[0009]
That is, the present invention is a non-contact charge dexterous planar magnetic element used as the structure which embedded the spiral type plane coil under one side of a magnetic layer, and solved the aforementioned problem by the non-contact charge dexterous planar magnetic element which arranges two or more plane coils in series on the same plane, and is characterized by things.
The aforementioned magnetic layer comprises ferrite magnetic powder, and the present invention makes it preferable for the volume density of the ferrite magnetic powder in the aforementioned magnetic layer to be more than 25vol %.
[0010]
[Mode for carrying out the invention]
Based on Fig.1 and Fig.2, it describes about an embodiment with a preferable non-contact charge dexterous planar magnetic element of the present invention.
As a plane coil, although there is form, such as spiral shape and the shape of a meander, an inductance can be enlarged and it is preferable in the present invention to consider it as spiral shape.
[0011]
The planar magnetic element 1 of Fig.1 has arranged the two spiral type plane coils 3 in series on one side of the magnetic layer 2, and it arranges them so that the direction of winding of the plane coil 3 may serve as reverse. the magnetic connection between the coil wires which were adjacent to by carrying out like this -- **** -- it hears -- it can carry out and is especially preferable.
The four plane coils 3 are arranged on one side of the magnetic layer 2, and it may be made to constitute the planar magnetic element 1, as shown in Fig.2. In this case, between the predetermined terminals of a plane coil is connected with the wiring 5 like a graphic display, and it makes with a series connection.
[0012]
Thus, the plane coil 3 formed in the planar magnetic element 1 is divided, it can form and arrange, the turn number of a coil can be divided by connecting in series, and it becomes possible to distribute local generation of heat which is concentrated on a coil and generated. The coil wire in one coil can be shortened and direct current resistance can be reduced. While

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being surrounded by the coil of the plane coil, it becomes possible to take the area of a window largely, and the magnetic flux which crosses the inside of a coil relatively can be reduced, generation of heat is suppressed, and power receiving efficiency can be improved.
[0013]
On the other hand, if it has composition which formed only one spiral type plane coil in one side of the magnetic layer 2 as shown in Fig.3 for comparison, generation of heat will concentrate on one coil, and the length of the coil wire in a plane coil will become long, and direct current resistance will increase. While being surrounded by the coil, area of a window cannot be taken largely, either.
As ferrite magnetic powder in a magnetic layer, a NiZn ferrite is made preferable. In order to be filled up with ferrite magnetic resin and to form a magnetic layer between the coil wires of a plane coil, there are methods, such as stenciling with screen printing, and the mixture of ferrite magnetic powder and a resin binder can be attained easily.
[0014]
As the planar magnetic element of the present invention is shown in Fig.4, the plane coil 3 is formed in the nonmagnetic substrate 7, for example, a Si substrate, an alumina substrate, etc. via the insulating resin layer 6, and it is made to perform non-contact charge by arranging so that this nonmagnetic substrate 7 side may become the power transmission equipment 10 side.
The plane coil 3 is formed on the ferrite substrate 8, and it is filled up with the magnetic layer 2 and may be made to form between coil wires, as shown in Fig.5. In this case, the film of the surface of the plane coil 3 is carried out by the insulating resin layer 6.
[0015]
The power transmission equipment 10 is good also as a winding coil, as the same plane coil as the planar magnetic element of the present invention may be adopted and it is shown in Fig.4 and Fig.5.It can be suitably chosen by power transmission conditions etc. which system is adopted. However, the power transmission side coil makes it preferable to consider it as the arrangement made to correspond to the arrangement which opposes to the plane coil in the planar magnetic element by the side of power receiving, as shown in Fig.4 and Fig.5.
[0016]
To the next, A magnetic layer comprises ferrite magnetic powder and describes about the point which makes it preferable to make volume density of the ferrite magnetic powder in the aforementioned magnetic layer more than 25vol %.
It is to make volume density of ferrite magnetic powder more than 25vol % as it is less than 25vol %, The coupling coefficient k shown in the magnetic combination between the power transmission coil by the side of a battery charger and the receiving coil by the side of an equipment body, i.e., a following formula, becomes small, It is because sufficient charging characteristic is not acquired.
[0017]
$k=M/(L_1 \times L_2)^{1/2}$
It is here and is M:mutual inductance (H).
L_1: The self-inductance (H) of a power transmission coil
L_2: The self-inductance (H) of a receiving coil
Such a magnetic layer can fix and form the ferrite magnetic powder of desired composition with binders, such as an epoxy resin.
[0018]
In the whole magnetic cell, this volume density does not necessarily need to be the same and the magnetic body of 1 type or 2 type or more of volume density can be used for it according to places, such as between a magnetic layer, an inside window, and a coil wire.
In the present invention, it is the thickness of a magnetic layer 5-500 It is preferable to consider it as micrometer degree. For example, although the thickness of a suitable magnetic layer can be adjusted with adjustment of the volume density of ferrite magnetic powder, if this thickness is less than 5 micrometers, the incorporation effect of the magnetic flux from the power

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transmission side will become scarce, and on the other hand, it is 500. It is because a magnetic cell will become thick and will inhibit slimming down of apparatus, if micrometer is exceeded.
[0019]
Planar magnetic element of the present invention, Although you may use it as it is in the state which has formed the coil, in order to protect the surface, As shown in Fig.5, it is advantageous to cover the insulating resin layer 6 which is a protective coating which is nonmagnetic [of insulating resin, such as an epoxy resin and polyimide resin, glass, etc.], and is from an electrical insulator on a coil making side. As shown in Fig.4, it adds to the insulating resin layer 6 concerned, It is effective to cover with the nonmagnetic thin plate-like nonmagnetic substrates 7, such as ceramics, silicon, etc., such as alumina, when securing strength.
[0020]
[Working example]
The typical manufacturing method of the planar magnetic element of the present invention is described. Specific numerical values, such as a dimension of a description to the following, illustrate typical composition.
A numerical value is not limited at all.

(1) Form so that it may become 40-micrometer thickness by screen-stenciling and calcinating the ferrite paste of a NiZn system on a Si substrate.
(2) Apply polyimide resin on it and it is a Cu seed layer further 0.5 Membranes are formed as micrometer thickness.
(3) On it, apply a resist, for example, expose and develop the plane coil pattern of a total of 20 turns on single-sided 10 turn and both sides, and form a resist frame.
(4) Deposit Cu with electroplating in the above-mentioned resist frame.
(5) Etching removes an unnecessary Cu seed layer after resist removing.
(6) Fill up and heat-harden between the lines of the plane coil which formed the paste to which ferrite magnetic powder was mixed with the epoxy resin with screen printing, and at an inside window.
[0021]
At the above process, the planar magnetic element of illustration is completed to Fig.4. Form Cu like the above on a ferrite substrate, and [a plane coil and nothing], The paste which mixed ferrite magnetic powder with the epoxy resin between the line and at an inside window can be made to be able to fill up and heat-harden, and, finally the planar magnetic element illustrated to Fig.5 can be completed by forming an insulating resin layer as protective covering.
[0022]
Next, the planar magnetic element (it is hereafter called the example of the present invention.) of the present invention which carried out the series connection of the two plane coils to Fig.1 and Fig.4, and formed them in them like illustration is manufactured, and it describes about the result of having performed the characterization.
For comparison, the planar magnetic element (it is hereafter called a comparative example.) used as one plane coil shown in Fig.3 is manufactured, and same characterization is carried out.
[0023]
All ferrite composition is Fe_2O_3:49 mol%, ZnO:23 mol%, and NiO:28.
It was considered as composition of mol%.
First, on the Si substrate, after printing the ferrite paste of the above-mentioned composition, it calcinated and the ferrite layer of 40-micrometer thickness was formed. It is 0.5 with the nonelectrolytic plating method after forming polyimide resin to 3-micrometer thickness with a spin coat besides. Membranes were formed on the whole surface by making Cu of micrometer thickness into a seed layer. Moreover application, exposure, and the development of the resist were performed, and the resist frame for plane coil formation of spiral shape was formed. Then, electric Cu plating was performed and etching removal of the unnecessary Cu seed layer was carried out after resist removing. The completed plane coils are a total of 30 turns on 80 micrometers in thickness, single-sided 15 turn, and both sides. Next, it was filled up with the

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epoxy resin paste which made the volume rate of ferrite magnetic powder 60vol %, and it was made to heat-harden, the magnetic layer was formed, and the planar magnetic element of the example of the present invention was completed.
[0024]
On the other hand, the planar magnetic element of the comparative example was created by the same process as the above. The plane coil of the comparative example was made into one thing of 20 turns.
The power transmission equipment side arranges and formed the power transmission coil corresponding to each plane coil. The lead was coiled around the coil and each power transmission coil formed it in the sintering ferrite core. The drive frequency of power transmission equipment set the gap between 100 kHz and a power-transmission-and-reception coil as 2 mm. Comparison of the obtained characteristic is shown in Table 1.
[0025]
[Table 1]

	誘起電圧（V）	コイル直流抵抗（Ω）	ΔT （℃）
本発明例	6	0.8	30
比較例	5	1.0	40

[0026]
Compared with the comparative example, in the example of the present invention, the induced voltage has exceeded and coil direct current resistance is small so that clearly from Table 1. The example of the present invention is small rather than the comparative example also about the temperature rise (deltaT) by generation of heat, and the effect of the present invention is clear.
[0027]
[Effect of the Invention]
According to the present invention, it can be slimmed down extremely, a non-contact charge dexterous magnetic cell with high charging efficiency can be obtained, and local generation of heat can also be suppressed now.
[Brief Description of the Drawings]
[Drawing 1]It is a ** type plan view of the non-contact charge dexterous planar magnetic element of the present invention.
[Drawing 2]It is a ** type plan view of the non-contact charge dexterous planar magnetic element of another form of the present invention.
[Drawing 3]It is a ** type plan view of the non-contact charge dexterous planar magnetic element (comparative example) constituted from one plane coil.
[Drawing 4]It is a schematic cross section of the non-contact charge dexterous planar magnetic element of the present invention, and a feeder system.
[Drawing 5]It is a schematic cross section of the non-contact charge dexterous planar magnetic element of the present invention which differs in structure, and a feeder system.
[Explanations of letters or numerals]
1, 1a, 1b Non-contact charge dexterous planar magnetic element
2 Magnetic layer

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3 Plane coil
4 Terminal
5 Wiring
6 Insulating resin layer
7 A nonmagnetic substrate (a Si substrate, an alumina substrate)
8 Ferrite substrate
10 Power transmission equipment
11 Ferrite core
12 Winding coil

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TECHNICAL FIELD

[Field of the Invention]
About the planar magnetic element mounted on a noncontact charger, the present invention suppresses local generation of heat of especially this planar magnetic element, and attains large slimming down and the improvement in charging efficiency.
[0002]

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PRIOR ART

[Description of the Prior Art]
With the spread of information technologies in recent years, the miniaturization of a cellular phone, an electronic information terminal, etc., slimming down, and a weight saving proceed quickly, and the power supply of a rechargeable battery drive like a Li-ion cell or a nickel hydoride battery is increasingly used abundantly.
However, a portable device is reserved near the human body in many cases, reliability has a possibility of producing a problem, in the form which the contact for charge exposed, and the charging system of the noncontact type is demanded.
[0003]
although mainly used for the apparatus of places equipped with a water supply, such as a shaver and an electric toothbrush, as a non-contact charging system so far -- these days, it is a description, for example to JP,H2000-78763,A -- like -- a cellular phone and PHS etc. -- it is increasingly used also for a portable electronic device.
The example of a card shape non-contact feeder system can be especially given as a thin thing (1162 (2000), Kanai et al.: Kanai et al.: IEEE APEC Record, pp.1157- Institute of Electrical Engineers of Japan a mug references, such as NETIKUSU study group MAG-00-150).
[0004]
As a magnetic cell in such a non-contact charging system (non-contact feeder system), the structure which coiled copper wire about, or air cored coil structure has been conventionally adopted on a ferrite plate or an amorphous thin belt.
However, there was a problem which is described below in the magnetic cell of these former on structure.
(1) Coil thickness is about 1 mm, and since the dimension is as large as several centimeter angle, an occupation area and volume inhibit the miniaturization of apparatus, and slimming down largely.
(2) In order that the magnetic flux from the power transmission side may cross the inside of a coil, the loss by the eddy current generated within a receiving coil is large.
[0005]
By the way, as an ultra-thin type coil, the plane type magnetic cell using the ferrite magnetic film formed by print processes or the sheet method is known ([Refer to / etc / JP,H11-26239,A]).
By printing and calcinating first the magnetic paste which mixed the binder with ferrite powder on a Si substrate, a this plane type magnetic cell forms the ferrite magnetic film of high resistance, and then is, After forming a coil pattern by the plating method etc. on this film, a magnetic film is further formed on it and it is manufactured. And it has succeeded in inhibiting a coil loss effectively as well as slimming down.
[0006]

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention]
According to the present invention, it can be slimmed down extremely, a non-contact charge dexterous magnetic cell with high charging efficiency can be obtained, and local generation of heat can also be suppressed now.

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TECHNICAL PROBLEM

[Problem to be solved by the invention]
However, in the magnetic cell of this structure, since the magnetic body is arranged on both sides of a coil, extraction of the magnetic flux to outside and incorporation of the magnetic flux from the outside cannot say that it is sufficient, and the magnetic flux between carrier power transmission coils does not cross a sufficient mutual coil. Therefore, capability sufficient as an object for noncontact chargers could not be exerted, and the present invention was not able to apply as a target non-contact charge dexterous planar magnetic element.
[0007]
About the planar magnetic element mounted on a noncontact charger, the present invention enables the further miniaturization and slimming down, and provides the planar magnetic element for noncontact chargers which realizes good charging efficiency.
In the planar magnetic element mounted on the above-mentioned noncontact charger, the present invention suppresses local generation of heat, and realizes improvement in one step of efficiency.
[0008]

[Translation done.]

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MEANS

[Means for solving problem]
While the inventors repeat research intensively that the above-mentioned purpose should be attained, embedding a spiral type plane coil under one side of a magnetic layer and forming a planar magnetic element It found out that the desired end was further attained advantageously by carrying out the split shape of the plane coil concerned to plurality, and carrying out a series connection.,
[0009]
That is, the present invention is a non-contact charge dexterous planar magnetic element used as the structure which embedded the spiral type plane coil under one side of a magnetic layer, and solved the aforementioned problem by the non-contact charge dexterous planar magnetic element which arranges two or more plane coils in series on the same plane, and is characterized by things.
The aforementioned magnetic layer comprises ferrite magnetic powder, and the present invention makes it preferable for the volume density of the ferrite magnetic powder in the aforementioned magnetic layer to be more than 25vol %.
[0010]
[Mode for carrying out the invention]
Based on Fig.1 and Fig.2, it describes about an embodiment with a preferable non-contact charge dexterous planar magnetic element of the present invention.
As a plane coil, although there is form, such as spiral shape and the shape of a meander, an inductance can be enlarged and it is preferable in the present invention to consider it as spiral shape.
[0011]
The planar magnetic element 1 of Fig.1 has arranged the two spiral type plane coils 3 in series on one side of the magnetic layer 2, and it arranges them so that the direction of winding of the plane coil 3 may serve as reverse. the magnetic connection between the coil wires which were adjacent to by carrying out like this -- **** -- it hears -- it can carry out and is especially preferable.
The four plane coils 3 are arranged on one side of the magnetic layer 2, and it may be made to constitute the planar magnetic element 1, as shown in Fig.2. In this case, between the predetermined terminals of a plane coil is connected with the wiring 5 like a graphic display, and it makes with a series connection.
[0012]
Thus, the plane coil 3 formed in the planar magnetic element 1 is divided, it can form and arrange, the turn number of a coil can be divided by connecting in series, and it becomes possible to distribute local generation of heat which is concentrated on a coil and generated. The coil wire in one coil can be shortened and direct current resistance can be reduced. While being surrounded by the coil of the plane coil, it becomes possible to take the area of a window largely, and the magnetic flux which crosses the inside of a coil relatively can be reduced, generation of heat is suppressed, and power receiving efficiency can be improved.
[0013]

On the other hand, if it has composition which formed only one spiral type plane coil in one side of the magnetic layer 2 as shown in Fig.3 for comparison, generation of heat will concentrate on one coil, and the length of the coil wire in a plane coil will become long, and direct current resistance will increase. While being surrounded by the coil, area of a window cannot be taken largely, either.
As ferrite magnetic powder in a magnetic layer, a NiZn ferrite is made preferable. In order to be filled up with ferrite magnetic resin and to form a magnetic layer between the coil wires of a plane coil, there are methods, such as stenciling with screen printing, and the mixture of ferrite magnetic powder and a resin binder can be attained easily.
[0014]
As the planar magnetic element of the present invention is shown in Fig.4, the plane coil 3 is formed in the nonmagnetic substrate 7, for example, a Si substrate, an alumina substrate, etc. via the insulating resin layer 6, and it is made to perform non-contact charge by arranging so that this nonmagnetic substrate 7 side may become the power transmission equipment 10 side.
The plane coil 3 is formed on the ferrite substrate 8, and it is filled up with the magnetic layer 2 and may be made to form between coil wires, as shown in Fig.5. In this case, the film of the surface of the plane coil 3 is carried out by the insulating resin layer 6.
[0015]
The power transmission equipment 10 is good also as a winding coil, as the same plane coil as the planar magnetic element of the present invention may be adopted and it is shown in Fig.4 and Fig.5.It can be suitably chosen by power transmission conditions etc. which system is adopted. However, the power transmission side coil makes it preferable to consider it as the arrangement made to correspond to the arrangement which opposes to the plane coil in the planar magnetic element by the side of power receiving, as shown in Fig.4 and Fig.5.
[0016]
To the next, A magnetic layer comprises ferrite magnetic powder and describes about the point which makes it preferable to make volume density of the ferrite magnetic powder in the aforementioned magnetic layer more than 25vol %.
It is to make volume density of ferrite magnetic powder more than 25vol % as it is less than 25vol %, The coupling coefficient k shown in the magnetic combination between the power transmission coil by the side of a battery charger and the receiving coil by the side of an equipment body, i.e., a following formula, becomes small, It is because sufficient charging characteristic is not acquired.
[0017]
$k=M/(L_1 \times L_2)^{1/2}$
It is here and is M:mutual inductance (H).
L_1: The self-inductance (H) of a power transmission coil
L_2: The self-inductance (H) of a receiving coil
Such a magnetic layer can fix and form the ferrite magnetic powder of desired composition with binders, such as an epoxy resin.
[0018]
In the whole magnetic cell, this volume density does not necessarily need to be the same and the magnetic body of 1 type or 2 type or more of volume density can be used for it according to places, such as between a magnetic layer, an inside window, and a coil wire.
In the present invention, it is the thickness of a magnetic layer 5-500 It is preferable to consider it as micrometer degree. For example, although the thickness of a suitable magnetic layer can be adjusted with adjustment of the volume density of ferrite magnetic powder, if this thickness is less than 5 micrometers, the incorporation effect of the magnetic flux from the power transmission side will become scarce, and on the other hand, it is 500. It is because a magnetic cell will become thick and will inhibit slimming down of apparatus, if micrometer is exceeded.
[0019]
Planar magnetic element of the present invention, Although you may use it as it is in the state

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which has formed the coil, in order to protect the surface, As shown in Fig.5, it is advantageous to cover the insulating resin layer 6 which is a protective coating which is nonmagnetic [of insulating resin, such as an epoxy resin and polyimide resin, glass, etc.], and is from an electrical insulator on a coil making side. As shown in Fig.4, it adds to the insulating resin layer 6 concerned, It is effective to cover with the nonmagnetic thin plate-like nonmagnetic substrates 7, such as ceramics, silicon, etc., such as alumina, when securing strength.
[0020]

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EXAMPLE

[Working example]
The typical manufacturing method of the planar magnetic element of the present invention is described. Specific numerical values, such as a dimension of a description to the following, illustrate typical composition.
A numerical value is not limited at all.

(1) Form so that it may become 40-micrometer thickness by screen-stenciling and calcinating the ferrite paste of a NiZn system on a Si substrate.
(2) Apply polyimide resin on it and it is a Cu seed layer further 0.5 Membranes are formed as micrometer thickness.
(3) On it, apply a resist, for example, expose and develop the plane coil pattern of a total of 20 turns on single-sided 10 turn and both sides, and form a resist frame.
(4) Deposit Cu with electroplating in the above-mentioned resist frame.
(5) Etching removes an unnecessary Cu seed layer after resist removing.
(6) Fill up and heat-harden between the lines of the plane coil which formed the paste to which ferrite magnetic powder was mixed with the epoxy resin with screen printing, and at an inside window.
[0021]
At the above process, the planar magnetic element of illustration is completed to Fig.4. Form Cu like the above on a ferrite substrate, and [a plane coil and nothing], The paste which mixed ferrite magnetic powder with the epoxy resin between the line and at an inside window can be made to be able to fill up and heat-harden, and, finally the planar magnetic element illustrated to Fig.5 can be completed by forming an insulating resin layer as protective covering.
[0022]
Next, the planar magnetic element (it is hereafter called the example of the present invention.) of the present invention which carried out the series connection of the two plane coils to Fig.1 and Fig.4, and formed them in them like illustration is manufactured, and it describes about the result of having performed the characterization.
For comparison, the planar magnetic element (it is hereafter called a comparative example.) used as one plane coil shown in Fig.3 is manufactured, and same characterization is carried out.
[0023]
All ferrite composition is Fe_2O_3:49 mol%, ZnO:23 mol%, and NiO:28.
It was considered as composition of mol%.
First, on the Si substrate, after printing the ferrite paste of the above-mentioned composition, it calcinated and the ferrite layer of 40-micrometer thickness was formed. It is 0.5 with the nonelectrolytic plating method after forming polyimide resin to 3-micrometer thickness with a spin coat besides. Membranes were formed on the whole surface by making Cu of micrometer thickness into a seed layer. Moreover application, exposure, and the development of the resist were performed, and the resist frame for plane coil formation of spiral shape was formed. Then, electric Cu plating was performed and etching removal of the unnecessary Cu seed layer was carried out after resist removing. The completed plane coils are a total of 30 turns on 80

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micrometers in thickness, single-sided 15 turn, and both sides. Next, it was filled up with the epoxy resin paste which made the volume rate of ferrite magnetic powder 60vol %, and it was made to heat-harden, the magnetic layer was formed, and the planar magnetic element of the example of the present invention was completed.

[0024]

On the other hand, the planar magnetic element of the comparative example was created by the same process as the above. The plane coil of the comparative example was made into one thing of 20 turns.

The power transmission equipment side arranges and formed the power transmission coil corresponding to each plane coil. The lead was coiled around the coil and each power transmission coil formed it in the sintering ferrite core. The drive frequency of power transmission equipment set the gap between 100 kHz and a power-transmission-and-reception coil as 2 mm. Comparison of the obtained characteristic is shown in Table 1.

[0025]

[Table 1]

	誘起電圧（V）	ｺｲﾙ直流抵抗（Ω）	ΔT （℃）
本発明例	6	0.8	30
比較例	5	1.0	40

[0026]

Compared with the comparative example, in the example of the present invention, the induced voltage has exceeded and coil direct current resistance is small so that clearly from Table 1. The example of the present invention is small rather than the comparative example also about the temperature rise (deltaT) by generation of heat, and the effect of the present invention is clear.

[0027]

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a ** type plan view of the non-contact charge dexterous planar magnetic element of the present invention.
[Drawing 2]It is a ** type plan view of the non-contact charge dexterous planar magnetic element of another form of the present invention.
[Drawing 3]It is a ** type plan view of the non-contact charge dexterous planar magnetic element (comparative example) constituted from one plane coil.
[Drawing 4]It is a schematic cross section of the non-contact charge dexterous planar magnetic element of the present invention, and a feeder system.
[Drawing 5]It is a schematic cross section of the non-contact charge dexterous planar magnetic element of the present invention which differs in structure, and a feeder system.
[Explanations of letters or numerals]
1, 1a, 1b Non-contact charge dexterous planar magnetic element
2 Magnetic layer
3 Plane coil
4 Terminal
5 Wiring
6 Insulating resin layer
7 A nonmagnetic substrate (a Si substrate, an alumina substrate)
8 Ferrite substrate
10 Power transmission equipment
11 Ferrite core
12 Winding coil

[Translation done.]

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* NOTICES *

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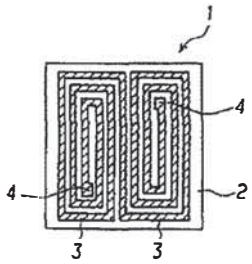
damages caused by the use of this translation.

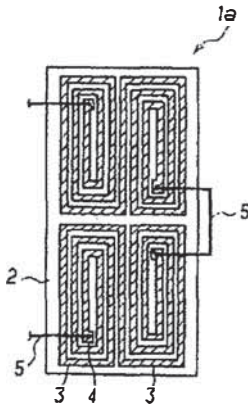
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 2]



[Drawing 3]

Momentum Dynamics Corporation
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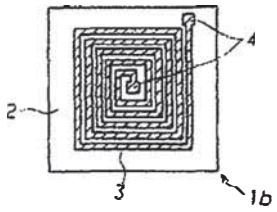
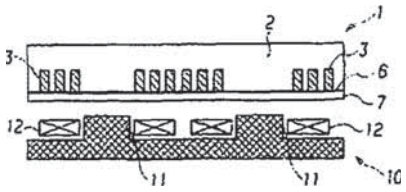
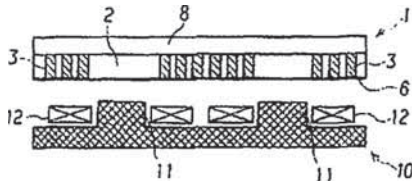


[Drawing 4]



[Drawing 5]



[Translation done.]

2/12/2013

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/451,436	Filing Date 01/13/2010	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	x $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	x $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	12/12/2013	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 35	Minus	** 36	= 0	x $80 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***5	= 0	x $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/CHRISTINE MOLLISH/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

14443 7590 02/04/2014
The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149

EXAMINER	
NGUYEN, TUYEN T	
ART UNIT	PAPER NUMBER
2837	

DATE MAILED: 02/04/2014

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/451,436	01/13/2010	John Talbot Boys	6081/81072	4685

TITLE OF INVENTION: MULTI POWER SOURCED ELECTRIC VEHICLE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/05/2014

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

14443 7590 02/04/2014
The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/451,436	01/13/2010	John Talbot Boys	6081/81072	4685

TITLE OF INVENTION: MULTI POWER SOURCED ELECTRIC VEHICLE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/05/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, TUYEN T	2837	336-08400C

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Page 522

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/451,436	01/13/2010	John Talbot Boys	6081/81072	4685

14443 7590 02/04/2014

The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149

EXAMINER	
NGUYEN, TUYEN T	

ART UNIT	PAPER NUMBER
2837	

DATE MAILED: 02/04/2014

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 357 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 357 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 12/451,436	Applicant(s) BOYS ET AL.	
	Examiner TUYEN NGUYEN	Art Unit 2837	AIA (First Inventor to File) Status No

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

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *RCE filed 12/12/2013.*
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ 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.
3. ☒ The allowed claim(s) is/are *72-83 and 93-115.* As a result of the allowed claim(s), 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 .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   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)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 12/12/2013
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date ____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other ____.

/TUYEN NGUYEN/
Primary Examiner, Art Unit 2837

Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination	
12/451,436	BOYS ET AL.	
Examiner	**Art Unit**	
TUYEN NGUYEN	2837	

SEARCHED			
Class	Subclass	Date	Examiner
336	84R, 84C, 200, 212, 232	1/25/2014	TN

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
same as above		1/25/2014	TN

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR

OPAP AKIMA-13
DEC 12 2013
PATENT & TRADEMARK OFFICE

Dkt. 1172/69068

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of : John Talbot BOYS et al.

Serial No. : 12/451,436 Examiner: Tuyen T. Nguyen

Date Filed : January 13, 2010 GAU: 2832

For : MULTI POWER SOURCED ELECTRIC VEHICLE

273 Walt Whitman Rd.
Suite 327
Huntington Station, NY 11746

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

INFORMATION DISCLOSURE STATEMENT

The information listed in the attached form PTO-1449 is brought to the attention of the Examiner. In accordance with 37 C.F.R. §1.92(a)(2)(ii), copies of U.S. Patents listed herein need not be provided.

It is respectfully requested that the information cited in annexed Form PTO-1449 be considered by the Examiner in connection with the above-identified patent application, and that such art be made of record in said application.

I hereby certify that this paper is being deposited this date with the U.S. Postal Service as first class mail addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

December 9, 2013
Richard F. Jaworski Date
Reg. No. 33,515

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /TN/

The citation of the listed items is not a representation that they constitute a complete or exhaustive listing of the relevant art or that these items are prior art. The items listed are submitted in good faith, but are not intended to substitute for the Examiner's search. It is hoped, however, that in addition to apprising the Examiner of the particular items, they will assist in identifying fields of search and in making as full and complete a search as possible.

The filing of this Information Disclosure Statement is not an admission that the information cited herein is, or is considered to be, material to patentability as defined in 37 C.F.R. §1.56(b).

This Information Disclosure Statement is being submitted along with a Request for Reconsideration.

It is believed that no fee is required for consideration of the present Information Disclosure Statement. However, if a fee is deemed to be required, the Office is authorized to charge any fees to Deposit Account 50-5504.

Early and favorable consideration of the case is respectfully requested.

Respectfully submitted,

RICHARD F. JAWORSKI
Registration No. 33,515
Attorney for Applicant
Customer No. 14443
The Law Office of Richard F. Jaworski, PC
Tel. (631) 659-3608

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /TN/

Form PTO-1449 — U.S. Department of Commerce, Patent and Trademark Office

OPAP AKIMA-13 DEC 12 2013 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION BY APPLICANT
(Use several sheets if necessary)

Atty. Docket No.	Serial No.
1172/69068	12/451,436
Applicant	
John Talbot BOYS et al.	
Filing Date	**Group**
January 13, 2010	2832

U.S. PATENT DOCUMENTS

Examiner Initial		Document Number	Date	Name	Class	Subclass	Filing Date if Appropriate
/TN/	AA	4 8 7 3 6 7 7	Oct. 10, 1989	Sakamoto et al.			
/TN/	AB	6 5 0 1 3 6 4	Dec. 31, 2002	Hui et al.			
/TN/	AC	6 9 0 6 4 9 5	Jun. 14, 2005	Cheng et al.			
	AD						
	AE						
	AF						
	AG						
	AH						
	AI						
	AJ						
	AK						
	AL						
	AM						
	AN						
	AO						
	AP						

FOREIGN PATENT DOCUMENTS

		Document Number	Date	Country	Class	Subclass	Translation Yes	Translation No
/TN/	AQ	WO 2008/051611	May 2, 2008	WIPO				
/TN/	AR	2002-345365	Nov. 29, 2002	Japan			X	
/TN/	AS	2000-207025	July 18, 2000	Japan			X	
/TN/	AT	6-86321	Dec. 13, 1994	Japan			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

	AU	
	AV	
	AW	
	AX	

EXAMINER	/Tuyen Nguyen/	DATE CONSIDERED	01/27/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609: Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /TN/

Form PTO-1449 — U.S. Department of Commerce, Patent and Trademark Office

OPAP AKIMA-13 DEC 1 2 2013 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION BY APPLICANT
(Use several sheets if necessary)

Atty. Docket No.	Serial No.
1172/69068	12/451,436
Applicant	
John Talbot BOYS et al.	
Filing Date	**Group**
January 13, 2010	2832

U.S. PATENT DOCUMENTS

Examiner Initial		Document Number	Date	Name	Class	Subclass	Filing Date if Appropriate
	AA						
	AB						
	AC						
	AD						
	AE						
	AF						
	AG						
	AH						
	AI						
	AJ						
	AK						
	AL						
	AM						
	AN						
	AO						
	AP						

FOREIGN PATENT DOCUMENTS

		Document Number	Date	Country	Class	Subclass	Translation Yes	Translation No
/TN/	AQ	6-662062	Sept. 16, 1994	Japan			X	
/TN/	AR	11-097262	Apr. 9, 1999	Japan			X	
/TN/	AS	2004-47701	Feb. 12, 2004	Japan			X	
	AT							

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

	AU	
	AV	
	AW	
	AX	

EXAMINER /Tuyen Nguyen/ DATE CONSIDERED 01/27/2014

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /TN/

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	12/451,436	BOYS ET AL.	
	Examiner	Art Unit	
	TUYEN NGUYEN	2837	

ISSUE CLASSIFICATION

ORIGINAL			CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)							
336	84C									
INTERNATIONAL CLASSIFICATION										
H 0 1 F	27/32									
	/									
	/									
	/									
	/									

none (Assistant Examiner) (Date)	/Tuyen Nguyen/ Primary Examiner 1/25/2014 (Primary Examiner) (Date)	Total Claims Allowed: 35
(Legal Instruments Examiner) (Date)		O.G. Print Claim(s): 1 / O.G. Print Fig.: 3

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

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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	5		35		65	15	95		125		155		185
	6		36		66	16	96		126		156		186
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 4685

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/451,436	01/13/2010 RULE	336	2837	6081/81072

APPLICANTS

INVENTORS

John Talbot Boys, Auckland, NEW ZEALAND;
Grant Anthony Covic, Auckland, NEW ZEALAND;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/NZ2008/000103 05/09/2008

**** FOREIGN APPLICATIONS ***************************

NEW ZEALAND 555128 05/10/2007
NEW ZEALAND 556646 07/20/2007

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

01/26/2010

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☑ Yes ☐ No	NEW ZEALAND	5	21	5

35 USC 119(a-d) conditions met ☑ Yes ☐ No ☐ Met after Allowance

Verified and Acknowledged /TUYEN T NGUYEN/ Examiner's Signature /TN/ Initials

ADDRESS

The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149
UNITED STATES

TITLE

MULTI POWER SOURCED ELECTRIC VEHICLE

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
2502	No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

14443 7590 02/04/2014
The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149

OPAP AKMAR 23 MAY 07 2014 PATENT & TRADEMARK OFFICE

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Richard F. Jaworski	(Depositor's name)
	(Signature)
May 5, 2014	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/451,436	01/13/2010	John Talbot Boys	6081/81072	4685

TITLE OF INVENTION: MULTI POWER SOURCED ELECTRIC VEHICLE

05/07/2014 CCHAU2 00000015 12451436
01 FC:1501 960.00 OP

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/05/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, TUYEN T	2837	336-08400C

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Law Office of Richard F. Jaworski, PC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Auckland Uniservices Ltd.
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Auckland New Zealand

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☑ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☑ Payment by credit card. Form PTO-2038 is attached.
☑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-5504 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date May 5, 2014
Typed or printed name Richard F. Jaworski Registration No. 33,515

PTOL-85 Part B (10-13) Approved for use through 10/31/2013 OMB 0651-0033 U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Form PTO-1449 — U.S. Department of Commerce, Patent and Trademark Office

OPAP APR 15 2013 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION BY APPLICANT
(Use several sheets if necessary)

Atty. Docket No.	Serial No.
1172/69068	12/451,436
Applicant	
John Talbot BOYS et al.	
Filing Date	**Group**
January 13, 2010	2832

U.S. PATENT DOCUMENTS

Examiner Initial		Document Number	Date	Name	Class	Subclass	Filing Date if Appropriate
/TN/	AA	5 4 6 9 0 3 6	Nov. 21, 1995	Eto			
	AB						
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	AH						
	AI						
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	AL						
	AM						
	AN						
	AO						
	AP						

FOREIGN PATENT DOCUMENTS

		Document Number	Date	Country	Class	Subclass	Translation Yes	Translation No
/TN/	AQ	JP 06 - 27 73 5 8	Oct. 4, 1994	Japan			Abst.	
/TN/	AR	JP 20 02 - 23 15 45	Aug. 16, 2002	Japan			Abst.	
/TN/	AS	JP 8 - 23 83 2 6	Sept. 17, 1996	Japan			Abst.	
/TN/	AT	JP T2 00 7- 50 54 80	~~no date~~ 03/2007	Japan				

Change(s) applied to document, /D.S.D.N/ 10/1/2013

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

	AU	Notice of Reasons for Rejection in corresponding Japanese application p2010-507347 (Original and English Translation)
	AV	
	AW	
	AX	

EXAMINER	DATE CONSIDERED
/Tuyen Nguyen/	8/12/2013

***EXAMINER**: Initial if reference considered, whether or not citation is in conformance with MPEP 609: Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /TN/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/451,436	06/10/2014	8749334	6081/81072	4685

14443 7590 05/21/2014

The Law Office of Richard F. Jaworski, PC
273 Walt Whitman Road
Suite 327
Huntington Station, NY 11746-4149

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 782 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

John Talbot Boys, Auckland, NEW ZEALAND;
Grant Anthony Covic, Auckland, NEW ZEALAND;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

OPAP
NOV 17 2014
PATENT & TRADEMARK OFFICE

Dkt. 1172/69068

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of : John Talbot BOYS et al.

U.S. Patent No. : 8,749,334

Serial No. : 12/451,436

Date Filed : January 13, 2010

For : MULTI POWER SOURCED ELECTRIC VEHICLE

273 Walt Whitman Rd.
Suite 327
Huntington Station, NY 11746

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

INFORMATION DISCLOSURE STATEMENT

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The cited documents were both third party submissions in a corresponding Japanese patent application. In addition, document WO 03/105308 was recently cited by the EPO in an extended European Search Report.

The above-noted application having issued as a patent, it is respectfully requested that the information cited in annexed Form PTO-1449 be placed in the file wrapper of the above-identified application.

I hereby certify that this paper is being deposited this date with the U.S. Postal Service as first class mail addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

NOV. 14, 2014
Richard F. Jaworski Date
Reg. No. 33,515

Form PTO-1449	U.S. Department of Commerce Patent and Trademark Office	Atty. Docket No. 1172/69068	Serial No. 12/451,436
		Applicant John Talbot BOYS et al.	
	INFORMATION DISCLOSURE CITATION BY APPLICANT (Use several sheets if necessary)	Filing Date January 13, 2010	Group

U.S. PATENT DOCUMENTS

Examiner Initial		Document Number	Date	Name	Class	Subclass	Filing Date if Appropriate
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	AC						
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	AN						
	AO						
	AP						

OPAP
NOV 17 2014
PATENT & TRADEMARK OFFICE

FOREIGN PATENT DOCUMENTS

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							Yes	No
	AQ	JP 2006-425191	Feb. 9, 2006	Japan			X	
	AR	WO 03/105308	Dec. 18, 2003	WIPO				
	AS							
	AT							

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

	AU	
	AV	
	AW	
	AX	

EXAMINER	DATE CONSIDERED

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Respectfully submitted,

RICHARD F. JAWORSKI
Registration No. 33,515
Attorney for Applicant
Customer No. 14443
The Law Office of Richard F. Jaworski, PC
Tel. (631) 659-3608

【書類名】 刊行物等提出書
【あて先】 特許庁長官殿
【事件の表示】
【出願番号】 特願2010-507347
【提出者】
【住所又は居所】 省略
【氏名又は名称】 省略
【提出する刊行物等】 文献１：特開２００６－４２５１９号公報、文献２：国際公開２００３／１０５３０８号公報
【提出物件の目録】
【物件名】 特開２００６－４２５１９号公報 1
【物件名】 国際公開２００３／１０５３０８号公報 1

JP 2006-42519 A 2006.2.9

(19)日本国特許庁(JP) (12)公開特許公報(A) (11)特許出願公開番号
特開2006-42519
(P2006-42519A)
(43)公開日 平成18年2月9日(2006.2.9)

(51)Int.Cl.'	F I		テーマコード(参考)
H02J 17/00	H02J 17/00	B	5G003
H02J 7/00	H02J 7/00	301 D	

【添付書類】
12 199

審査請求 未請求 請求項の数 10 OL (全12頁)

(21)出願番号 特願2004-219904(P2004-219904)
(22)出願日 平成16年7月28日(2004.7.28)

(71)出願人 000002369
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東京都新宿区西新宿2丁目4番1号
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(74)代理人 100075579
弁理士 内藤 嘉昭
(74)代理人 100103850
弁理士 崔 秀▲てつ▼
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長野県諏訪市大和3丁目3番5号 セイコーエプソン株式会社内
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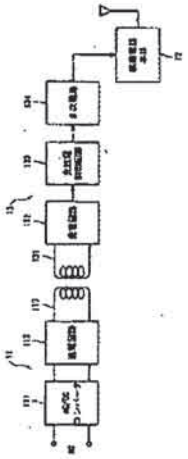
長野県諏訪市大和3丁目3番5号 セイコーエプソン株式会社内

Fターム(参考) 5G003 AA01 BA01 FA03 GB08

【裏面有】

(54)【発明の名称】非接触電力伝送装置

(57)【要約】
【課題】非接触電力伝送に使用される送電コイルと受電コイルの薄型化を図る際に、そのコイルからの不要輻射を抑制し、かつ、電力伝送の効率化を図ること。
【解決手段】この発明は、送電装置１１と受電装置１３からなり、動作時に、送電コイル１１３と受電コイル１３１とが電磁的に結合することにより、非接触で電力伝送を行うようになっている。両コイル１１３、１３１は、渦巻き状であってその平面が対向するようになっている平面コイルからなる。さらに、その両平面コイルは、両者が対向する面の反対側の面に、両コイルの発生する磁界による不要輻射を抑える磁性シートが、その面全体を覆うようにそれぞれ設けられている。
【選択図】 図１



【特許請求の範囲】
【請求項１】
第１コイルを含む送電装置と、第２コイルおよび２次電池を含む受電装置とを備え、
前記送電装置は、前記第１コイルが前記第２コイルと電磁結合するときに、前記第１コイルに供給する交流を生成する送電手段を有し、
前記受電装置は、前記第２コイルが前記第１コイルと電磁結合するときに、前記第２コイルに誘起される交流を直流に変換し、この変換された直流により前記２次電池の充電を行う受電手段を有し、
さらに、前記第１コイルおよび前記第２コイルは、渦巻き状であってその平面が対向するようになっている第１平面コイルおよび第２平面コイルからなり、
かつ、前記第１平面コイルおよび前記第２平面コイルは、その両者が対向する面の反対側の面に、磁性シートをそれぞれ設けたことを特徴とする非接触電力伝送装置。
【請求項２】
前記第１平面コイルおよび前記第２平面コイルに設けた各磁性シートの外側面に、さらに、金属シートをそれぞれ重ねて設けたことを特徴とする請求項１に記載の非接触電力伝送装置。
【請求項３】
前記受電装置を構成する前記第２コイル、前記受電手段、および前記２次電池のうち、少なくとも前記第２コイルと前記２次電池を一体化したことを特徴とする請求項１または請求項２に記載の非接触電力伝送装置。
【請求項４】
前記受電装置を構成する前記第２コイル、前記受電手段、および前記２次電池のうち、少なくとも前記第２コイルと前記２次電池は、所定のケース内に収容し又は固形化するようにしたことを特徴とする請求項１または請求項２に記載の非接触電力伝送装置。
【請求項５】
前記受電装置は、携帯電話に搭載させたことを特徴とする請求項１乃至請求項４のうちのいずれか１の請求項に記載の非接触電力伝送装置。
【請求項６】
第１コイルを含む送電装置と、第２コイルおよび第１の２次電池を含む送電・受電兼用装置と、第３コイルおよび第２の２次電池を含む受電装置とを備え、
前記送電装置は、
前記第１コイルが前記第２コイルまたは前記第３コイルと電磁結合するときに、前記第１コイルに供給する交流を生成する送電手段を有し、
前記送電・受電兼用装置は、
前記第２コイルが前記第３コイルと電磁結合するときに、前記第１の２次電池を電源として用いて前記第２コイルに供給する交流を生成する送電手段と、
前記第２コイルが前記第１コイルと電磁結合するときに、その第２コイルに誘起される交流を直流に変換し、この変換された直流により前記第１の２次電池の充電を行う受電手段とを有し、
前記受電装置は、
前記第３コイルが前記第１コイルまたは前記第２コイルと電磁結合するときに、その第３コイルに誘起される交流を直流に変換し、この変換された直流により前記第２の２次電池の充電を行う受電手段を有し、
さらに、前記第１コイル、前記第２コイル、および前記第３コイルは、渦巻き状であってその平面が相互に対向するようになっている第１平面コイル、第２平面コイル、および第３平面コイルからなり、
かつ、前記第１平面コイル、第２平面コイル、および前記第３平面コイルは、それぞれ対向する面の反対側の面に、磁性シートを設けたことを特徴とする非接触電力伝送装置。
【請求項７】
前記第１平面コイル、前記第２平面コイル、および前記第３平面コイルに設けた各磁性

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シートの外側面に、さらに、金属シートをそれぞれ重ねて設けたことを特徴とする請求項６に記載の非接触電力伝送装置。

【請求項８】

前記送電・受電兼用装置を構成する前記第２コイル、前記送電手段、前記受電手段、および前記第１の２次電池のうち、少なくとも前記第２コイルと前記第１の２次電池を一体化し、

かつ、前記受電装置を構成する前記第３コイル、前記受電手段、および前記第２の２次電池のうち、少なくとも前記第３コイルと前記第２の２次電池を一体化したことを特徴とする請求項６または請求項７に記載の非接触電力伝送装置。

【請求項９】

前記送電・受電兼用装置を構成する前記第２コイル、前記送電手段、前記受電手段、および前記第１の２次電池のうち、少なくとも前記第２コイルと前記第１の２次電池は、所定のケース内に収容し又は固形化するようにし、

かつ、前記受電装置を構成する前記第３コイル、前記受電手段、および前記第２の２次電池のうち、少なくとも前記第３コイルと前記第２の２次電池は、所定のケース内に収容し又は固形化するようにしたことを特徴とする請求項６または請求項７に記載の非接触電力伝送装置。

【請求項１０】

前記送電・受電兼用装置および前記受電装置は、それぞれ携帯電話に搭載させたことを特徴とする請求項６乃至請求項９のうちのいずれか１の請求項に記載の非接触電力伝送装置。

【発明の詳細な説明】

【技術分野】

【０００１】

本発明は、例えば携帯電話のような携帯端末と充電器との間などで、非接触電力伝送を行うことができる非接触電力伝送装置に関するものである。

【背景技術】

【０００２】

従来、この種の非接触電力伝送装置としては、携帯用通信機の本体底部の形状に関係なく、充電部の送電コイルと被充電部の受電コイルとの間の電磁誘導による非接触電力伝送の効率向上を図るようにしたものが知られている（例えば、特許文献１、特許文献２を参照）。

そして、送電コイルは送電コイル用コアに巻かれ、受電コイルは受電コイル用コアに巻かれている。また、送電コイル用コアと受電コイル用コアとはいずれも棒状体で構成され、使用時には、その両コアの端面同士が対向するようになっている。

【特許文献１】特開平１０－４６３９号公報

【特許文献２】特開平１０－１４１２４号公報

【発明の開示】

【発明が解決しようとする課題】

【０００３】

ところで、従来の非接触電力伝送装置に使用される送電コイルと受電コイルは、いずれもコアに巻かれている。この場合には、コイルから発生する磁界はその殆どがコアに集中するため、磁界による不要な輻射はごくわずかであり、不要輻射を抑える対策が特に必要ではない。しかし、コイルから発生する磁界をコアに集中させるためには、上記のように、使用時にその両コアの端面同時を対向するような構造にする必要がある。

【０００４】

このため、従来のように、送電コイルと受電コイルとを異なるコアに巻いて使用する場合には、両コイルの形態や構造に制約があるので、薄型化や平面化を図るのが困難であるという不具合がある。

そこで、送電コイルと受電コイルの薄型化を実現するには、その両コイルの平面化を図

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ることが考えられるが、それを平面化した場合にはコアの使用ができないので、コイルから発生する磁界による不要輻射の抑制、および電力伝送の効率化を図る必要がある。

【０００５】

本発明の目的は、上記の点に鑑み、非接触電力伝送に使用される送電コイルと受電コイルの平面化を図る際に、そのコイルからの不要輻射の抑制、および電力伝送の効率化を図ることができる非接触電力伝送装置を提供することにある。

【課題を解決するための手段】

【０００６】

上記の課題を解決し本発明の目的を達成するために、各発明は、以下のような構成からなる。

すなわち、第１の発明は、第１コイルを含む送電装置と、第２コイルおよび２次電池を含む受電装置とを備え、前記送電装置は、前記第１コイルが前記第２コイルと電磁結合するときに、前記第１コイルに供給する交流を生成する送電手段を有し、前記受電装置は、前記第２コイルが前記第１コイルと電磁結合するときに、前記第２コイルに誘起される交流を直流に変換し、この変換された直流により前記２次電池の充電を行う受電手段を有し、さらに、前記第１コイルおよび前記第２コイルは、渦巻き状であってその平面が対向するようになっている第１平面コイルおよび第２平面コイルからなり、かつ、前記第１平面コイルおよび前記第２平面コイルは、その両者が対向する面の反対側の面に、磁性シートをそれぞれ設けるようにした。

【０００７】

第２の発明は、第１の発明において、前記第１平面コイルおよび前記第２平面コイルに設けた各磁性シートの外側面に、さらに、金属シートをそれぞれ重ねて設けるようにした。

第３の発明は、第１または第２の発明において、前記受電装置を構成する前記第２コイル、前記受電手段、および前記２次電池のうち、少なくとも前記第２コイルと前記２次電池を一体化した。

【０００８】

第４の発明は、第１または第２の発明において、前記受電装置を構成する前記第２コイル、前記受電手段、および前記２次電池のうち、少なくとも前記第２コイルと前記２次電池は、所定のケース内に収容し又は固形化するようにした。

第５の発明は、第１乃至第４のうちのいずれかの発明において、前記受電装置は、携帯電話に搭載させるようにした。

【０００９】

第６の発明は、第１コイルを含む送電装置と、第２コイルおよび第１の２次電池を含む送電・受電兼用装置と、第３コイルおよび第２の２次電池を含む受電装置とを備え、前記送電装置は、前記第１コイルが前記第２コイルまたは前記第３コイルと電磁結合するときに、前記第１コイルに供給する交流を生成する送電手段を有し、前記送電・受電兼用装置は、前記第２コイルが前記第３コイルと電磁結合するときに、前記第１の２次電池を電源として用いて前記第２コイルに供給する交流を生成する送電手段と、前記第２コイルが前記第１コイルと電磁結合するときに、その第２コイルに誘起される交流を直流に変換し、この変換された直流により前記第１の２次電池の充電を行う受電手段とを有し、前記受電装置は、前記第３コイルが前記第１コイルまたは前記第２コイルと電磁結合するときに、その第３コイルに誘起される交流を直流に変換し、この変換された直流により前記第２の２次電池の充電を行う受電手段を有し、さらに、前記第１コイル、前記第２コイル、および前記第３コイルは、渦巻き状であってその平面が相互に対向するようになっている第１平面コイル、第２平面コイル、および第３平面コイルからなり、かつ、前記第１平面コイル、第２平面コイル、および前記第３平面コイルは、それぞれ対向する面の反対側の面に、磁性シートを設けるようにした。

【００１０】

第７の発明は、第６の発明において、前記第１平面コイル、前記第２平面コイル、およ

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び前記第３平面コイルに設けた各磁性シートの外側面に、さらに、金属シートをそれぞれ重ねて設けるようにした。

第８の発明は、第６または第７の発明において、前記送電・受電兼用装置を構成する前記第２コイル、前記送電手段、前記受電手段、および前記第１の２次電池のうち、少なくとも前記第２コイルと前記第１の２次電池を一体化し、かつ、前記受電装置を構成する前記第３コイル、前記受電手段、および前記第２の２次電池のうち、少なくとも前記第３コイルと前記第２の２次電池を一体化した。

【００１１】

第９の発明は、第６または第７の発明において、前記送電・受電兼用装置を構成する前記第２コイル、前記送電手段、前記受電手段、および前記第１の２次電池のうち、少なくとも前記第２コイルと前記第１の２次電池は、所定のケース内に収容し又は固形化するようにし、かつ、前記受電装置を構成する前記第３コイル、前記受電手段、および前記第２の２次電池のうち、少なくとも前記第３コイルと前記第２の２次電池は、所定のケース内に収容し又は固形化するようにした。

【００１２】

第１０の発明は、第６乃至第９のうちのいずれかの発明において、前記送電・受電兼用装置および前記受電装置は、それぞれ携帯電話に搭載させるようにした。

以上のような構成からなる本発明によれば、非接触電力伝送に使用される送電用コイルや受電用コイルなどが平面コイルからなり、使用の際には、それらは変圧器を形成するが、両コイルが発生する磁界等による不要輻射を抑制でき、かつ、電力伝送の効率化が図れる。

【発明を実施するための最良の形態】

【００１３】

以下、本発明の実施形態について、図面を参照して説明する。

【００１４】

(第１実施形態)

本発明の非接触電力伝送装置の第１実施形態の構成について、図１を参照しながら説明する。

この第１実施形態に係る非接触電力伝送装置は、例えば携帯電話に適用したものであり、図１に示すように、充電器として機能する送電装置１１と、携帯電話本体１２の電源となる２次電池を含む受電装置１３とを備えている。

【００１５】

送電装置１１と受電装置１３とは、電磁的に結合することにより、後述のように非接触で電力伝送を行う非接触電力伝送装置を形成するようになっている。

送電装置１１は、図１に示すように、ＡＣ／ＤＣコンバータ１１１と、送電回路１１２と、送電コイル１１３とを備えている。

ＡＣ／ＤＣコンバータ１１１は、例えば家庭に供給される１００〔Ｖ〕の交流電圧を所定の直流電圧に変換するものであり、その変換された直流電圧を送電回路１１２に供給するようになっている。送電回路１１２は、ＡＣ／ＤＣコンバータ１１１からの直流電圧を使用して所定の周波数の交流電圧を生成する回路であり、この生成した交流電圧を送電コイル１１３に供給するようになっている。

【００１６】

受電装置１３は、図１に示すように、受電コイル１３１と、受電回路１３２と、充放電制御回路１３３と、２次電池１３４とを備えている。

この受電装置１３は、構成要素である受電コイル１３１、受電回路１３２、充放電制御回路１３３、および２次電池１３４を、一体に１つの容器に収容させたり、または熱硬化性の合成樹脂などを用いて一体にモジュール化（固形化）させ、受電装置モジュール（電池パック）として形成するようにした。

【００１７】

受電コイル１３１は、送電装置１１の送電コイル１１３と接近させて使用する場合には

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、その両コイル１３１、１１３が、電磁結合して両者の間で変圧器を形成するようになっている。電磁結合により受電コイル１３１に誘起される交流電圧は、受電回路１３２に供給されるようになっている。

受電回路１３２は、受電コイル１３１に誘起される交流電圧を整流して直流電圧を出力する回路である。受電回路１３２から出力される直流電圧は、充放電制御回路１３３を介して２次電池１３４に供給され、２次電池１３４を充電するようになっている。

【００１８】

充放電制御回路１３３は、受電回路１３２からの出力により２次電池１３４を充電する場合にはその充電の制御を行い、２次電池１３４で負荷である携帯電話本体１２を動作させる場合には放電の制御を行う回路である。

２次電池１３４は、例えばリチウムイオン電池のように、放電後に充電により繰り返して使用できる電池である。

【００１９】

次に、送電装置１１の送電コイル１１３、および受電装置１３の受電コイル１３１の具体的な構造について、図２および図３を参照して説明する。

送電コイル１１３は、図２示すように、平面渦巻き型コイル１１３ａと、磁性シート１１３ｂと、金属シート１１３ｃとからなる。そして、図３に示すように、平面渦巻き型コイル１１３ａの外面側に、その外面側全体を覆うように、磁性シート１１３ｂと金属シート１１３ｃとが重ねた状態で設けられている。

【００２０】

従って、送電コイル１１３の構成要素は、図３に示すように、平面渦巻き型コイル１１３ａ、磁性シート１１３ｂ、および金属シート１１３ｃの順序で大きくなるように構成され、これらは接着剤などの適宜手段で一体に密着、または固定されている。

また、受電コイル１３１は、図２に示すように、平面渦巻き型コイル１３１ａと、磁性シート１３１ｂと、金属シート１３１ｃとからなる。そして、図３に示すように、平面渦巻き型コイル１３１ａの外面側に、その外面側全体を覆うように、磁性シート１３１ｂと金属シート１３１ｃとが重ねた状態で設けられている。

【００２１】

従って、受電コイル１３１の構成要素は、図３に示すように、平面渦巻き型コイル１３１ａ、磁性シート１３１ｂ、および金属シート１３１ｃの順序で大きくなるように構成され、これらは接着剤などの適宜手段で一体に密着または固定されている。

さらに、送電コイル１１３側の平面渦巻き型コイル１１３ａと、受電コイル１３１側の平面渦巻き型コイル１３１ａとは、使用時には、図３に示すようにその内面側同士が対向して変圧器を形成するようになっている。このため、使用時には、磁性シート１１３ｂ、１３１ｂは、平面渦巻き型コイル１１３ａ、１３１ａが発生する磁界による不要輻射を抑制でき、金属シート１１３ｃ、１３１ｃは、平面渦巻き型コイル１１３ａ、１３１ａが発生する電界による不要輻射を抑制できるようになっている。

【００２２】

ここで、平面渦巻き型コイル１１３ａ，１３１ａは、単線または撚り線のような絶縁された電線からなり、その電線を図２および図３に示すように同一平面内で渦巻き状に巻いたものである。

また、磁性シート１１３ｂ，１３１ｂは、板状またはシート状の磁性材料からなり、けい素鋼板、アモルファス金属の磁性シートなどが使用される。

【００２３】

さらに、金属シート１１３ｃ，１３１ｃは、板状またはシート状の金属材料からなり、アルミニウムなどが使用される。

次に、図１～図３に示すような構成からなる送電装置１１と受電装置１３とを、充電器のケースと携帯電話のケースにそれぞれ組み込んだ場合の具体例について、図４を参照して説明する。

【００２４】

【裏面有】

図１に示す送電装置１１を構成する各要素は、図４に示す充電器のケース２１内に組み込まれ、図１に示す受電装置１３を構成する各要素は、図４に示す携帯電話のケース３１内に組み込まれている。

充電器のケース２１は、図４に示すように、その上部側に、携帯電話の充電時に携帯電話のケース３１が収容される携帯電話収容部２１１を備えている。また、充電器のケース２１は、その携帯電話収容部２１１の下部側に送電コイル収納部２１２を備え、その送電コイル収納部２１２内に、図３に示す送電コイル１１３が例えば密封された状態で収納されている。さらに、充電器のケース２１内には、送電装置１１のＡＣ／ＤＣコンバータ１１１や送電回路１１２などの構成部品を搭載した回路基板２２が収容されている。

【００２５】

携帯電話のケース３１は、図４に示すように、その下部側に、図１に示す受電装置１３をモジュール化した受電装置モジュール３２を収容する収容部３１１と、その受電装置モジュール３２の交換の際にその収容部３１１の開閉を行う蓋３１２と、を備えている。

ここで、受電装置モジュール３２は、上記のように、受電装置１３を構成する、受電コイル１３１、受電回路１３２、充放電制御回路１３３、および２次電池１３４を、一体に１つの容器に収容し、または熱硬化性の合成樹脂などを用いて一体にモジュール化したものである。

【００２６】

図４に示す受電装置モジュール３２は、同図に示すように、例えば薄型の直方形のケース３２１内に受電回路１３２、充放電制御回路１３３、および２次電池１３４が収納され、かつそのケース３２１の下面に受電コイル１３１がケース３２１に一体に取り付けられている。

また、携帯電話のケース３１内には、携帯電話本体１２を構成する各種の電子回路の構成部品を搭載した回路基板３３が収容されている。

【００２７】

次に、このような構成からなる第１実施形態の動作例について、図１および図３を参照して説明する。

受電装置１３の２次電池１３４を、送電装置１１を用いて充電する場合について説明する。この場合には、受電装置１３の受電コイル１３１を送電装置１１の送電コイル１１３に接近させて、両コイル１３１、１１３を電磁結合する状態にさせる。このときには、送電コイル１１３と受電コイル１３１とは、例えば図３または図４に示す状態になる。

【００２８】

このように、送電コイル１１３と受電コイル１３１が電磁結合されると、受電装置１３の２次電池１３４は、送電装置１１による充電が開始される。この充電時には、受電回路１３２により２次電池１３４の充電が行われる。

この充電時には、送電コイル１１３と受電コイル１３１には磁界や電界が発生し、その不要輻射がある。しかし、図３に示すように、磁性シート１１３ｂ、１３１ｂは、平面渦巻き型コイル１１３ａ、１３１ａが発生する磁界による不要輻射を抑制し、金属シート１１３ｃ、１３１ｃは、平面渦巻き型コイル１１３ａ、１３１ａが発生する電界による不要輻射を抑制する。

【００２９】

充放電制御回路１３３は、２次電池１３４の充電状態を監視し、その充電が終了すると、受電回路１３２による２次電池１３４の充電を停止させる。

このようにして、２次電池１３４に充電が終了した場合には、受電装置１３の受電コイル１３１を送電装置１１の送電コイル１１３から離し、これにより、携帯電話本体１２は、その充電された２次電池１３４を電源として使用できる。

【００３０】

以上説明したように、この第１実施形態では、非接触電力伝送に使用される送電コイル１１３および受電コイル１３１が平面コイルからなり、使用の際には、それらは変圧器を形成するが、両コイルからの磁界や電界による不要輻射を抑制でき、かつ効率的な電力伝

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送ができる。

【００３１】

（第２実施形態）

本発明の非接触電力伝送装置の第２実施形態の構成について、図５を参照しながら説明する。

【００３２】

この第２実施形態に係る非接触電力伝送装置は、例えば携帯電話に適用したものであり、図５に示すように、充電器として機能する送電装置１１と、携帯電話本体１２の電源となる２次電池を含む受電装置１３と、充電器として機能するとともに携帯電話本体１５の電源となる２次電池を含む送電・受電兼用装置１４とを備えている。

そして、送電装置１１は、送電・受電兼用装置１４または受電装置１３と電磁的に結合することにより非接触電力伝送装置をそれぞれ形成し、送電・受電兼用装置１４と結合した場合にはそれに含まれる２電池を充電でき、受電装置１３と結合した場合にはそれに含まれる２次電池を充電できるようになっている。また、送電・受電兼用装置１４は、受電装置１３と電磁的に結合することにより非接触電力伝送装置を形成し、このときには受電装置１３に含まれる２電池を充電できるようになっている。

【００３３】

次に、この第２実施形態の各部の具体的な構成について、図５を参照して説明する。

送電装置１１および受電装置１３は、図１に示す送電装置１１および受電装置１３と同様に構成されるので、同一の構成要素には同一符号を付して、ここではその構成の説明は省略する。

送電・受電兼用装置１４は、図５に示すように、送電回路１４１と、受電回路１４２と、２次電池１４３と、充放電制御回路１４４と、送電・受電コイル１４５と、切り換えスイッチＳＷ１～ＳＷ３と、設定器１４６と、制御回路１４７と、表示器１４８とを備えている。

【００３４】

この送電・受電兼用装置１４は、構成要素である送電回路１４１、受電回路１４２、２次電池１４３、充放電制御回路１４４、送電・受電コイル１４５、切り換えスイッチＳＷ１～ＳＷ３、設定器１４６、制御回路１４７、および表示器１４８のうち、設定器１４６および表示器１４８を除く他の各構成要素を、一体に１つの容器に収容させたり、または熱硬化性の合成樹脂などを用いて一体にモジュール化（固形化）させ、送電・受電兼用装置モジュールとして形成するようにした。

【００３５】

ここで、その送電・受電兼用装置モジュールは、図１に示す受電装置１３をモジュール化した受電装置モジュールと基本的に同様のものであり、例えば図４に示す受電装置モジュール３２と同様に形成される。

送電回路１４１は、動作時に、２次電池１４３から供給される直流電圧を使用して所定の周波数の交流電圧を生成し、この生成した交流電圧を送電・受電コイル１４５に供給する回路である。受電回路１４２は、送電・受電コイル１４５が送電装置１１の送電コイル１１３と電磁結合して送電装置１１から電力が送電される場合に、送電・受電コイル１４５に誘起される交流電圧を整流して直流電圧を生成する回路、すなわち交流－直流変換回路である。受電回路１４２で生成される直流電圧は、充放電制御回路１４４を介して２次電池１４３に供給され、２次電池１４３を充電するようになっている。

【００３６】

２次電池１４３は、例えばリチウムイオン電池のように、放電後に充電により繰り返して使用できる電池である。充放電制御回路１４４は、受電回路１４２により２次電池１４３を充電する場合にはその充電の制御（監視）を行い、２次電池１４３で送電回路１４１や負荷である携帯電話本体１５を動作させる場合には放電の制御（監視）を行う回路である。

【００３７】

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送電・受電コイル１４５は、送電装置１１の送電コイル１１３と接近させて使用する場合には、その両コイル１４５、１１３は、電磁結合して両者の間で変圧器を形成するようになっている。また、送電・受電コイル１４５は、受電装置１３の受電コイル１３１と接近させて使用する場合には、その両コイル１４５、１３１は、電磁結合して両者の間で変圧器を形成するようになっている。すなわち、送電コイル１１３、送電・受電コイル１４５、および受電コイル１３１は、相互に電磁結合でき、かつ相互に分離できるようになっている。

【００３８】

切り換えスイッチＳＷ１，ＳＷ２は、送電・受電コイル１４５と、送電回路１４１または受電回路１４２との選択的な接続を行うものである。また、切り換えスイッチＳＷ３は、２次電池１４３と、送電回路１４１または受電回路１４２との選択的な接続を行うものである。これらの切り換えスイッチＳＷ１～ＳＷ３の各接点は、通常は、例えば図示のように受電回路１４２側に接続されている。

【００３９】

設定器１４６は、使用者が、送電回路１４１または受電回路１４２の使用を選択的に設定するものであり、その設定データが制御回路１４７に入力されるようになっている。制御回路１４７は、その設定器１４６からの設定データに従って、その動作状態を表示器１４８を表示させるとともに、切り換えスイッチＳＷ１～ＳＷ３の接点の切り換えを制御する回路である。表示器１４８は、液晶表示器などからなり、上記のように所定の情報が表示されるようになっている。

【００４０】

次に、図５に示す送電コイル１１３、受電コイル１３１、および送電・受電コイル１４５の具体的な構成について、図３を参照して説明する。

図５に示す送電コイル１１３および受電コイル１３１は、図３に示す第１実施形態の送電コイル１１３および受電コイル１３１と同様に構成される。また、図５に示す送電・受電コイル１４５は、例えば図３に示す送電コイル１１３または受電コイル１３１と同様に構成される。

【００４１】

このような構成により、図５に示す送電コイル１１３、送電・受電コイル１４５、および受電コイル１３１は、使用時に、そのうちの２つのコイルが相互に電磁結合して変圧器を形成し、その際に各コイルで生成される電界や磁界による不要輻射を抑制して効率的な電力伝送ができる。

次に、このような構成からなる第２実施形態の動作例について、図５を参照して説明する。

【００４２】

ここで、第２実施形態では、第１実施形態の場合と同様に、受電装置１３の２次電池１３４を送電装置１１で充電する場合があるが、この場合はすでに説明済みであるので、以下では他の場合の動作について説明する。

まず、携帯電話本体１５に搭載される送電・受電兼用装置１４の２次電池１４３を、送電装置１１を用いて充電する場合について説明する。この場合には、送電・受電兼用装置１４の送電・受電コイル１４５を送電装置１１の送電コイル１１３に接近させて、両コイル１４５、１１３が電磁結合する状態にさせる。

【００４３】

この状態で、設定器１４６により、送電装置１１を用いて２次電池１４３の充電を行う旨の設定を行うと、その設定データが制御回路１４７に入力される。制御回路１４７は、その設定データに従い、その旨の表示を表示器１４８に表示させるとともに、切り換えスイッチＳＷ１～ＳＷ３の接点を、図５に示す位置、すなわち、受電回路１４２側に接続させる。

【００４４】

この結果、送電・受電兼用装置１４の２次電池１４３は、送電装置１１による充電が開

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始される。この充電時には、受電回路１４２により２次電池１４３の充電が行われる。
また、この充電時には、送電コイル１１３と送電・受電コイル１４５により磁界や電界が生成され、その不要輻射がある。しかし、このときには、送電コイル１１３と送電・受電コイル１４５とは、上記のように図３に示す送電コイル１１３および受電コイル１３１と同様に構成される。このため、送電コイル１１３と送電・受電コイル１４５は、図３に示す送電コイル１１３および受電コイル１３１と同様に、コイルが発生する磁界や電界による不要輻射を抑制できる。

【００４５】

充放電制御回路１４４は、２次電池１４３の充電状態を監視し、その充電が終了すると、受電回路１４２による２次電池１４３の充電を停止させる。
次に、携帯電話本体１２に搭載される受電装置１３の２次電池１３４が使用不能となり、その２次電池１３４の充電を、携帯電話本体１５に搭載される送電・受電兼用装置１４を用いて充電する場合について説明する。

【００４６】

この場合には、受電装置１３の受電コイル１３１を送電・受電兼用装置１４の送電・受電コイル１４５に接近させて、両コイル１３１、１４５が電磁結合する状態にさせる。この状態で、送電・受電兼用装置１４により２次電池１３４を充電させる旨の設定を設定器１４６で行うと、その設定データが制御回路１４７に入力される。制御回路１４７は、その設定データに従い、その旨の表示を表示器１４８に表示させるとともに、切り換えスイッチＳＷ１～ＳＷ３の接点を、図に示す位置とは反対の位置、すなわち、送電回路１４１側に切り換える。

【００４７】

この結果、受電装置１３の２次電池１３４は、送電・受電兼用装置１４による充電が開始される。この充電時には、受電回路１３２により２次電池１３４の充電が行われる。
また、この充電時には、受電コイル１３１と送電・受電コイル１４５により磁界や電界が生成され、その不要輻射がある。しかし、このときには、受電コイル１３１と送電・受電コイル１４５とは、上記のように図３に示す送電コイル１１３および受電コイル１３１と同様に構成される。このため、、受電コイル１３１と送電・受電コイル１４５は、図３に示す送電コイル１１３および受電コイル１３１と同様に、コイルが発生する磁界や電界による不要輻射を抑制できる。

【００４８】

充放電制御回路１３３は、２次電池１３４の充電状態を監視し、その充電が終了すると、受電回路１３２による２次電池１３４の充電を停止させる。
以上説明したように、この第２実施形態では、非接触電力伝送に使用される送電コイル１１３、送電・受電コイル１４５、および受電コイル１３１が平面コイルからり、使用の際には、そのうちの２つのコイルにより変圧器が形成されるが、その変圧器を形成するコイルからの磁界や電界による不要輻射を抑制でき、かつ、電力伝送の効率化を図ることができる。

【００４９】

また、この第２実施形態では、充電器として機能するとともに２次電池１４３を含む送電・受電兼用装置１４を携帯電話本体１５に搭載し、２次電池１３４を含む受電装置１３を携帯電話本体１２に搭載するようした。
このため、第２実施形態によれば、受電装置１３を搭載する携帯電話が使用不能になっても、送電・受電兼用装置１４を搭載する携帯電話を使用して受電装置１３の２次電池１３４を充電できるので、非常に便宜である。

【００５０】

さらに、第２実施形態の送電・受電兼用装置１４では、２次電池として使用する場合または充電器として使用する場合に、その使用を任意に設定できる上に、その設定状態を使用者が表示器により容易に認識できるので、その設定ミスによる誤動作を防止できる。

（その他の実施形態）

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第１実施形態では、図２および図３に示すように、送電コイル１１３は、平面渦巻き型コイル１１３ａ、磁性シート１１３ｂ、および金属シート１１３ｃから構成し、受電コイル１３１は、平面渦巻き型コイル１３１ａ、磁性シート１３１ｂ、および金属シート１３１ｃから構成するようにした。しかし、送電コイル１１３および受電コイル１３１は、金属シート１１３ｃ、１３１ｃをそれぞれ省略するようにしても良い。

【００５１】

この点の構成については、第２実施形態における送電コイル１１３、送電・受電コイル１４５、および受電コイル１３１の各構成についても同様である。

また、第１実施形態では、受電装置１３は、構成要素である受電コイル１３１、受電回路１３２、充放電制御回路１３３、および２次電池１３４を一体化し、受電装置モジュールとして形成するようにしたが、この一体化は少なくとも受電コイル１３１と２次電池１３４であれば良い。

【００５２】

さらに、第２実施形態では、送電・受電兼用装置１４は、構成要素である送電回路１４１、受電回路１４２、２次電池１４３、充放電制御回路１４４、送電・受電コイル１４５、切り換えスイッチＳＷ１～ＳＷ３、設定器１４６、制御回路１４７、および表示器１４８のうち、設定器１４６および表示器１４８を除く他の各構成要素を一体化し、送電・受電兼用装置モジュールとして形成するようにした。しかし、この一体化は少なくとも送電・受電コイル１３１と２次電池１４３であれば良い。

【００５３】

また、第１実施形態および第２実施形態では、携帯電話に適用した場合について説明したが、これに代えて携帯用のコンピュータなどの携帯端末、またはビデオカメラのような携帯機器に適用できる。

【図面の簡単な説明】

【００５４】

【図１】本発明の第１実施形態の構成を示すブロック図である。

【図２】送電コイルと受電コイルの各構成要素を分解した斜視図である。

【図３】送電コイルと受電コイルの構成を示す断面図である。

【図４】送電装置と受電装置とを、充電器のケースと携帯電話のケースに組み込んだ状態を表す断面図である。

【図５】本発明の第２実施形態の構成を示すブロック図である。

【符号の説明】

【００５５】

１１・・・送電装置、１２、１５・・・携帯電話本体、１３・・・受電装置、１４・・・送電・受電兼用装置、３２・・・受電装置モジュール、１１３・・・送電コイル、１１３ａ、１３１ａ・・・平面渦巻き型コイル、１１３ｂ、１３１ｂ・・・磁性シート、１１３ｃ、１３１ｃ・・・金属シート、１１２、１４１・・・送電回路、１３１・・・受電コイル、１３２、１４２・・・受電回路、１３４、１４３・・・２次電池、１４５・・・送電・受電コイル。

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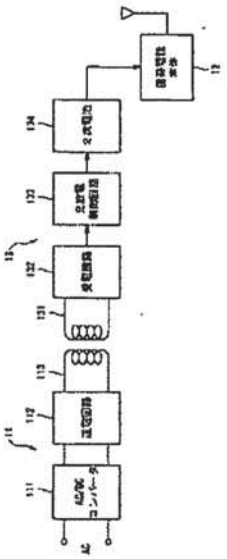
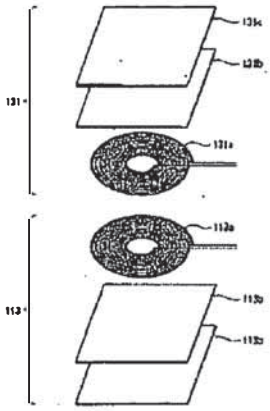
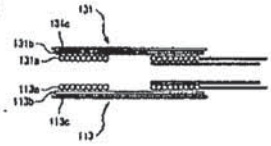
【図１】



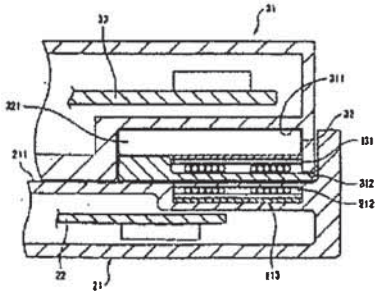
【図２】



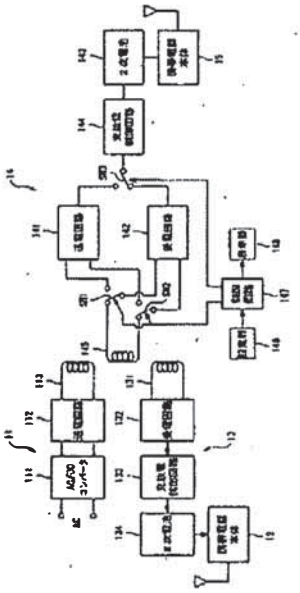
【図３】



【図４】



【図５】



DESCRIPTION JP2006042519

[0001]

The present invention relates to non-contact power transmission apparatus capable of, such as between a charger and a portable terminal such as a mobile phone to carry out a non-contact power transmission.

[0002]

Conventionally, as a non-contact power transmission device of this type, regardless of the shape of the bottom of the unit of the portable communication device, and the non-contact power transmission using electromagnetic induction between the power receiving coil of the charging unit and the power transmission coil of the charging unit (for example, see Patent Document 1, Patent Document 2) which was set to improve efficiency is known.

The transmitting coil is wound to the transmitting coil core, the receiving coil is wound in a receiving coil core.

Also, both are composed of rod-like body and the receiving coil and the transmitting coil core core, in use, the end faces of the two cores is in opposition.

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[0003]

Meanwhile, the receiving coil power transmission coil that is used for non-contact power transmission device of the prior art is wound on the core either.

In this case, since the most concentrated on the core, unnecessary radiation due to the magnetic field is negligible, the magnetic field generated from the coil is not particularly necessary to take measures to suppress unnecessary radiation.

However, in order to focus on their core a magnetic field generated from the coil, as described above, it is necessary to structure such as to face the end surfaces simultaneously for the both cores in use.

[0004]

Therefore, as in the prior art, when it is used by winding the core to a different power receiving coil and the transmitting coil, because there are restrictions on the structure and form of the coils, it is difficult to achieve planar thinner and there is a problem that.

Therefore, it is conceivable to realize the thickness of the receiving coil and the transmitting coil, thereby planarization of the two coils, the use of the core is not possible in plan of the same, magnetic field generated from the coil some suppression of unnecessary radiation by, and is necessary to improve the efficiency of power transmission.

[0005]

When In view of the above, to achieve planarization of the receiving coil and the transmitting coil is used for contactless power transmission, suppression of unwanted radiation from the coil, and an object of the present invention, improve the efficiency of power transmission The present invention is to provide a non-contact power transmission apparatus capable.

[0006]

In order to achieve the object of the present invention to solve the above problem, the invention comprises the following configuration.

That is, the first aspect of the present invention, and a power transmission device including a first coil and a power receiving device including a secondary battery and a second coil, wherein the power transmission device is electromagnetically coupled to the second coil, wherein the first coil When it has a transmission means for generating a supply alternating current to the first coil, when the second coil is electromagnetically coupled to the first coil, the power receiving device, alternating current is induced in the second coil and a receiving means for charging the secondary battery by direct current is converted to direct current and converted this further, the second coil and the first coil, so that its plane faces and a spiral the surface opposite the surface on which both of them are opposed to each other and consisting of the second planar coil and the first planar coil is in, said second planar coil and said first planar coil is provided each magnetic sheet was on.

[0007]

The second invention, in the first invention, the outer surface of the magnetic sheet provided on the second planar coil and said first planar coil was further be provided so as to overlap each metal sheet.

In the first or second invention, the second coil constituting the power receiving device, the receiving means, and one of the secondary battery, according to the third invention, integral to the secondary battery and the second coil of at least ized.

[0008]

In the first or second invention, the second coil constituting the power receiving device, the receiving means, and one of the secondary battery, the fourth invention, the secondary battery and the second coil at least, I was to be solidified or accommodated in the case within a given.

In the invention of any one of the fourth and the power receiving device, a fifth aspect of the present invention, and so as to mobile phones through the first.

[0009]

A power transmission device comprising a first coil, and transmission and receiving compatible apparatus including a secondary battery of the first and second coils, a sixth invention, a power receiving device including a secondary battery of the second and third coil and a, when the first coil is electromagnetically coupled to the third coil or the second coil, and a transmission means for generating a supply alternating current to the first coil, wherein the power transmission device, the transmission and receiving combined when the second coil is electromagnetically coupled with said third coil, and a transmission means for generating the supplied AC to the second coil by using a battery as a power supply secondary of said first device, said second coil When you try to electromagnetically coupled with said first coil, and a power receiving means for charging the secondary battery according to claim 1 by a DC that converts alternating current into direct current induced in the second coil, and the transformed , when the third coil electromagnetically coupled to the second coil or the first coil, the power receiving device, the second by a DC that converts alternating current into direct current which is induced in the third coil, and the transformed and a receiving means for charging the secondary battery 2, further wherein the first coil, the second coil, and the third coil, the plane so as to face each other and a spiral and, and a third planar coil first planar coil yl, and the second planar coil, wherein the first planar coil,On the opposite side of the surface facing each of the second planar coil, and the third planar coil was provided to the magnetic sheet.

[0010]

In the sixth invention, the first planar coil, said second planar coil, and the outer surface of the magnetic sheet provided on the third planar coil, further, a seventh aspect of the present invention, provided so as to overlap each metal sheet was so.

Aspect 7 or 6, wherein the second coil constituting the transmission and receiving compatible apparatus, the power transmission means, said receiving means, and of the secondary battery of the first, the eighth invention, the at least In and integrated rechargeable battery of the first and second coil, the third coil which constitutes the power receiving device, the receiving means, and of the secondary battery of said second and said third coil at least I have integrated a secondary battery of the second.

[0011]

Aspect 7 or 6, wherein the second coil constituting the transmission and receiving compatible apparatus, the power transmission means, said receiving means, and of the secondary battery of the first, the ninth invention, the at least In and, so as to solidify or housing, the third coil which constitutes the power receiving device, the receiving means, and the secondary battery of the first and second coil 2 and the second in the case of the given Which of the following cell, secondary battery and the second and the third coil is set to be solidified or housed in the case at least a predetermined.

[0012]

In the invention of any one of the ninth to the power receiving device and the transmission and receiving compatible apparatus, a tenth aspect of the present invention, and so as to mobile phones through 6 respectively.

According to the present invention with the structure as described above, and the power receiving coil and power transmission coil that is used for contactless power transfer is made from the planar coil, at the time of use, although they form a transformer, It can be suppress unnecessary radiation due to the magnetic field such that both coils occurs, it is possible to achieve the efficiency of power transmission.

[0013]

Hereinafter, embodiments of the present invention will be described with reference to the drawings.

[0014]

(First embodiment)

The configuration of the first embodiment of the non-contact power transmission apparatus of the present invention will be described with reference to Figure 1.

Non-contact power transmission apparatus according to the first embodiment is, for example, it is applied to a mobile phone, as shown in Figure 1, the power transmitting device 11 which functions as a charger, 2 as the power of the cellular phone unit 12 l and a power receiving device 13 including: a battery.

[0015]

The power receiving device 13 and the power transmission device 11, by binding electromagnetically, and is adapted to form a non-contact power transmission apparatus that performs transmission power without contact as described below.

As shown in Figure 1, the AC / DC converter 111, a transmission circuit 112, the power transmission device 11, and a transmitting coil 113.

It is intended for converting a predetermined DC voltage to AC voltage of 100 [V] for example is supplied to the home, AC / DC converter 111 is adapted to supply to the transmission circuit 112 and the DC voltage converted .

This is a circuit that generates an AC voltage of a predetermined frequency using the DC voltage from the AC / DC converter 111, transmission circuit 112 is adapted to supply to the transmitting coil 113 to the AC voltage generated.

[0016]

As shown in Figure 1, the power receiving device 13 includes a receiving coil 131, a receiving circuit 132, the charge and discharge control circuit 133, and a secondary battery 134.

Can be housed in a single container together, the secondary battery 134 receiving coil is a component 131, receiving circuit 132, and discharge control circuit 133, or the power receiving device 13, and synthetic thermosetting resin By using integrally modularized was (solidified), it is arranged to form a module powered device (battery pack).

[0017]

The receiving coil 131, when it is used to be close to the power transmission coil 113 of the power transmission device 11, the two coils 131,113 is adapted to form a transformer between them by electromagnetic coupling.

AC voltage induced in the receiving coil 131 by electromagnetic coupling, are supplied to the receiving circuit 132.

Receiving circuit 132 is a circuit that outputs a DC voltage by rectifying the AC voltage induced in the receiving coil 131.

Is supplied to the secondary battery 134 via the discharge control circuit 133, the DC voltage output from the power receiving circuit 132 is adapted to charge the secondary battery 134.

[0018]

And performs control of the charge in the case of charging the secondary battery 134 by the output from the receiving circuit 132, discharge control circuit 133, discharge when operating the mobile phone unit 12 is the load at the secondary battery 134 is a circuit for controlling the.

Secondary battery 134 is a battery such as a lithium ion battery, it can be used repeatedly by charging after discharge.

[0019]

Next, the specific structure of the power receiving coil 131 of the power receiving device 13 and the power transmission coil 113, the power transmitting device 11, will be described with reference to FIGS.

As shown in Figure 2, the planar spiral coil 113a, the magnetic sheet 113b, the power transmission coil 113 is made of a metal sheet 113c.

Then, as shown in Figure 3, the outer surface of the flat spiral coils 113a, so as to cover the outer surface entirety, and is provided in a state in which the metal sheet 113c and the magnetic sheet 113b is stacked.

[0020]

Therefore, as shown in Figure 3, is configured to be larger in the order of metal sheet 113c planar spiral coil 113a, and magnetic sheet 113b,, the components of the power transmission coil 113, a suitable means such as adhesives are and fixed contact or, together.

In addition, as shown in Figure 2, the planar spiral coil 131a, the magnetic sheet 131b, receiving coil 131 is made of a metal sheet 131c.

Then, as shown in Figure 3, the outer surface of the flat spiral coils 131a, so as to cover the outer surface entirety, and is provided in a state in which the metal sheet 131c and the magnetic sheet 131b is stacked.

[0021]

Therefore, as shown in Figure 3, is configured to be larger in the order of metal sheet 131c planar spiral coil 131a, and magnetic sheet 131b,, the components of the receiving coil 131, a suitable means such as adhesives are and fixed contact or together.

In addition, a planar spiral coil 113a of the power transmission coil 113 side and the planar spiral coil 131a of the receiving coil 131 side, in use, to form a transformer its inner side each other to face, as shown in Figure 3 has become.

For this reason, when in use, can suppress unnecessary radiation by the magnetic field planar spiral coil 113a, 131a occurs, metal sheet 113c, the 131c, magnetic sheet 113b, 131b is due to the electric field planar spiral coil 113a, 131a occurs I have been able to suppress unnecessary radiation.

[0022]

Here, in which the planar spiral coils 113a, 131a is made of insulated wires, such as twisted or single wire, wound spirally in the same plane as shown in Figures 2 and 3 the wire .

Moreover, it becomes a magnetic material plate-like or sheet-like, magnetic sheet 113b, 131b is used, magnetic silicon steel sheet, amorphous metal.

[0023]

The metal sheet 113c, the 131c, is made of a metallic material or sheet-like plate, and aluminum is used.

Next, a specific example of incorporating each cell phone case and the case of the charger, and a power receiving unit 13 and the power transmission device 11 having a structure as shown in Figures 1 to 3, with reference to Figure 4 described.

[0024]

Each element is built into the case 21 of the charger shown in Figure 4, which constitute the power receiving device 13 shown in Figure 1, each element constituting the power transmission device 11 shown in Figure 1, a cell phone case shown in Figure 4 It is built into the 31.

Case 21 of the charger, as shown in Figure 4, on the upper side, I have provided a mobile phone accommodating portion 211 of the case 31 of the mobile phone is accommodated when charging the mobile phone.

Also, with the power transmission coil receiving portion 212 on the lower side of the mobile phone housing portion 211, to the power transmission coil receiving portion 212, case 21 of the charger in a state where the power transmission coil 113 shown in Figure 3, for example sealed are housed.

Furthermore, the case 21 of the charger, the circuit board 22 mounted with components such as power transmission circuit 112 and the AC / DC converter 111 of the power transmission device 11 is accommodated.

[0025]

Case 31 of the cellular phone, as shown in Figure 4. in its lower part, a housing portion 311 which houses a power receiving device module 32 modularized the power receiving device 13 shown in Figure 1, the exchange of the power receiving device module 32 and a, a lid 312 for opening and closing of the housing portion 311 when.

Here, as described above, the power receiving device module 32 is housed in one container together, the secondary battery 134 constituting the power receiving device 13, the receiving coil 131, receiving circuit 132, and discharge control circuit 133, , or is obtained by modularized together with the synthetic resin and thermosetting.

[0026]

As shown in the figure, the power receiving device module 32 shown in Figure 4, the case 321 such secondary battery 134 receiving circuit 132, and discharge control circuit 133, is, and is housed in a case 321 of a rectangular-shaped thin The receiving coil 131 is integrally attached to the casing 321 of the lower surface.

Also, the case 31 of the portable phone, the circuit board 33 mounted with electronic components of the various circuits making up the main body of the cellular phone 12 is housed.

[0027]

Next, an operation example of the first embodiment having such a configuration will be described with reference to FIGS.

Will be described as being charged using the power transmission device 11, the secondary battery 134 of the power receiving device 13.

In this case, to a state brought close to the power transmission coil 113 of the power transmission device 11 and the receiving coil 131 of the power receiving device 13, for electromagnetic coupling of two coils 131,113.

In this case, the receiving coil 131 and the power transmission coil 113, for example, I will state shown in Figure 4 or Figure 3.

[0028]

Thus, the receiving coil 131 and the power transmission coil 113 is electromagnetically coupled to the secondary battery 134 of the power receiving device 13, charging by the power transmitting device 11 is started.

This charging time, charging of the secondary battery 134 is performed by receiving circuit 132.

This charging time, electric field and magnetic field is generated in the receiving coil 131 and the transmitting coil 113, there is the unnecessary radiation.

However, as shown in Figure 3, the magnetic sheet 113b, the 131b, it is possible to suppress unnecessary radiation due to magnetic fields flat spiral coils 113a, 131a is generated, the metal sheet 113c, 131c is generated planar spiral coil 113a, the 131a to suppress unnecessary radiation due to the electric field to be.

[0029]

Monitors the state of charge of the secondary battery 134, the charging is terminated, the charge and discharge control circuit 133 stops the charging of the secondary battery 134 by the receiving circuit 132.

In this way, when the charging is completed to the secondary battery 134, and away from the power transmission coil 113 of the power transmission device 11 and the receiving coil 131 of the power receiving device 13, whereby the main body of the cellular phone 12, 2, which is charged the I can be used as a power source to the next battery 134.

[0030]

As described above, in this first embodiment, the receiving coil 131 and the power transmission coil 113 is used for contactless power transfer is made from the planar coil, In use, they form a transformer, but both power transmission and efficient, can suppress unnecessary radiation due to the electric field and magnetic field from the coil can be.

[0031]

(Second Embodiment)

The configuration of the second embodiment of the non-contact power transmission apparatus of the present invention will be described with reference to FIG.

[0032]

Non-contact power transmission apparatus according to the second embodiment is, for example, it is applied to a mobile phone, as shown in Figure 5, the power transmitting device 11 which functions as a charger, 2 as the power of the cellular phone unit 12 and a transmission and receiving device 14 combined, including the secondary battery as a power source of the mobile phone unit 15 and the power receiving device 13, including: a battery, functions as a charger.

Then, the power transmission device 11 is included in it when it was formed, respectively, non-contact power transmission equipment by the electromagnetically coupled to the powered device 13 or transmission and receiving compatible apparatus 14, was combined with the transmission and receiving compatible apparatus 14 It can be charged by a secondary battery that is included in it if it is possible to charge the battery 2, bound to the powered device 13.

Also form a non-contact power transmission system by binding electromagnetically power receiving apparatus 13, transmission and receiving compatible apparatus 14 is enabled to charge the storage batteries included in the power receiving device 13 at this time.

[0033]

Next, the specific configuration of each part of the second embodiment will be described with reference to FIG.

Power receiving device 13 and the power transmission device 11, so that the same structure as the power receiving device 13 and the power transmission device 11 shown in Figure 1, and the same reference numerals are added to the same components, description of the configuration is omitted here .

As shown in Figure 5, a transmission circuit 141, a receiving circuit 142, a secondary battery 143, the charge and discharge control circuit 144, the transmission and receiving coil 145, transmission and receiving device 14 combined, the selector switch SW1~SW3 and, I'm provided with a setting device 146, a control circuit 147, and a display 148.

[0034]

141, 143 incoming circuit 142,2 battery, 144 charge and discharge control circuit, transmission and receiving coil 145, the changeover switch SW1~SW3, setting device 146, the transmission and receiving compatible apparatus 14, control circuit power transmission circuit, which is a component of the display 148, or is contained in a single container together, each component other than the display unit 148 and the setting device 146, modularized together or by using a synthetic thermosetting resin and 147, and then (solidified), it is arranged to form a transmission and receiving module compatible apparatus.

[0035]

Here, it is basically the same as the power receiving device module has a module of the power receiving device 13 shown in Figure 1, the transmission and receiving compatible apparatus module is formed similarly to the power receiving device module 32, for example, shown in Figure 4 that.

In operation, generates an AC voltage of a predetermined frequency using the DC voltage supplied from the secondary battery 143, transmission circuit 141 is a circuit for supplying to the transmission and receiving coil 145 of the AC voltage generated.

If the power is transmitted thereto from the power transmitting device 11 transmission and receiving coil 145 is electromagnetically coupled with the power transmission coil 113 of the power transmission device 11, the receiving circuit 142 rectifies the AC voltage induced in the transmission and receiving coil 145 circuit for generating a DC voltage, that the AC - DC converter is a circuit.

Is supplied to the secondary battery 143 via the discharge control circuit 144, the DC voltage generated by the power receiving circuit 142 is adapted to charge the secondary battery 143.

[0036]

Secondary battery 143 is a battery such as a lithium ion battery, it can be used repeatedly by charging after discharge.

Performs control of the charging (monitoring) in the case of charging the secondary battery 143 through 142 receiving circuit, the charge and discharge control circuit 144 operates the mobile phone unit 15 is a load and power transmission circuit 141 in the secondary battery 143 is a circuit for controlling the discharge (monitor) when.

[0037]

The transmission and receiving coil 145, when it is used to be close to the power transmission coil 113 of the power transmission device 11, the two coils 145,113 is adapted to form a transformer between them by electromagnetic coupling .

Also, the transmission and receiving coil 145, in the case of using is brought close to the receiving coil 131 of the power receiving device 13, the two coils 145,131 are adapted to form a transformer between them by electromagnetic coupling have.

In other words, the receiving coil 131 transmitting coil 113, and the transmission and receiving coil 145, is adapted to be separated from each other and can be electromagnetically coupled to each other.

[0038]

SW1, SW2 select switch is configured to perform a selective connection with the transmission and receiving coil 145, and the receiving circuit 142 or the power transmission circuit 141.

Also, changeover switch SW3 is configured to perform a selective connection between the secondary battery 143, and the receiving circuit 142 or the power transmission circuit 141.

Normally, the contacts of the changeover switch SW1~SW3 These are connected to the power receiving side circuit 142, for example as shown.

[0039]

The setting unit 146, and is intended user to selectively set the use of the receiving circuit 142 or the power transmission circuit 141, the configuration data are inputted to the control circuit 147.

According to the setting data from the setting device 146, the control circuit 147 is a circuit that causes the display unit 148 displays the operation state to control the switching of the contacts of the changeover switch SW1~SW3.

The display 148 is made of a liquid crystal display device, predetermined information is intended to be displayed as described above.

[0040]

Next, a specific configuration of the transmission and receiving coil 145 113, and receiving coil 131, the power transmission coil shown in FIG 5, will be described with reference to FIG.

Receiving coil 131 and the transmitting coil 113 shown in Figure 5, configured in the same manner as the receiving coil 131 and the transmitting coil 113 of the first embodiment shown in FIG.

Also, transmission and receiving coil 145 shown in Figure 5 is configured in the same manner as the receiving coil 131 or the transmitting coil 113 for example shown in Figure 3.

[0041]

With this configuration, in use, to form a transformer coils two of which are electromagnetically coupled to each other, receiving coil 131 113, and the transmission and receiving coil 145, the power transmission coil shown in Figure 5, when the thus power transmission efficiency by suppressing unnecessary radiation caused by an electric field or a magnetic field generated by each coil.

Next, an operation example of the second embodiment having such a configuration will be described with reference to FIG.

[0042]

Here, in the second embodiment, similarly to the first embodiment, it may be charged by the power transmitting device 11 and 134 secondary battery of the power receiving device 13, but in this case because it is already explained, the following I The operation of other cases.

First, a description will be given when charging with the power transmitting device 11, the secondary battery 143 of the transmission and receiving compatible apparatus 14 mounted on a main body of the cellular phone 15.

In this case, it is in a state where it is brought close to the power transmission coil 113 of the power transmission device 11 and transmission and receiving coil 145 of the transmission and receiving device 14 combined, both coils 145,113 are electromagnetically coupled.

[0043]

In this state, the setting unit 146, the setting is made to the effect that charging the secondary battery 143 using the power transmission device 11, the setting data is input to the control circuit 147.

Accordance with the configuration data, causes the display unit 148 to display to that effect, the position shown in Figure 5, the contact of the changeover switch SW1~SW3, that is, the control circuit 147, is connected to the receiving circuit 142 side.

[0044]

As a result, the secondary battery 143 of the transmission and receiving compatible apparatus 14, charging by the power transmitting device 11 is started.

This charging time, charging of the secondary battery 143 is performed by receiving circuit 142.

In addition, the charging time, electric field and magnetic field is generated by the 145 transmission and receiving coil and the transmitting coil 113, there is the unnecessary radiation.

However, at this time, the transmission and receiving coil 145 and the power transmission coil 113 is configured in the same manner as the receiving coil 131 and the power transmission coil 113 shown in Figure 3 as described above.

For this reason, in the same manner as the receiving coil 131 and the transmitting coil 113 shown in Figure 3, transmission and receiving coil 145 and the transmitting coil 113 can suppress unnecessary radiation due to the electric field and magnetic field coil generates.

[0045]

Monitors the state of charge of the secondary battery 143, the charging is terminated, the charge and discharge control circuit 144 stops the charging of the secondary battery 143 by the receiving circuit 142.

Then, 134 secondary battery of the power receiving device 13 to be mounted on the mobile phone unit 12 is unusable, by using the transmission and receiving compatible apparatus 14 mounted on a main body of the cellular phone 15, the charging of the secondary battery 134 will be described to be charged.

[0046]

In this case, it is in a state where it is brought close to the transmission and receiving coil 145 of the transmission and receiving unit 14 serves a receiving coil 131 of the power receiving device 13, both coils 131,145 are electromagnetically coupled.

In this state, it is performed in the setting unit 146 to set the effect that charging the secondary battery 134 by the transmission and receiving device 14 combined, the setting data is input to the control circuit 147.

In accordance with the setting data, and causes the display 148 to display to that effect, the position opposite to the position shown in the figure, the contact of the changeover switch SW1~SW3, that is, the control circuit 147 switches the power transmission circuit 141 side .

[0047]

As a result, 134 secondary battery powered device 13, charging by the transmission and receiving compatible apparatus 14 is started.

This charging time, charging of the secondary battery 134 is performed by receiving circuit 132.

In addition, the time of charging, electric field and magnetic field is generated by the transmission and 145 receiving coil and the receiving coil 131, there is the unwanted radiation.

However, at this time, the transmission and receiving coil 145 and receiver coil 131 is configured in the same manner as the receiving coil 131 and the power transmission coil 113 shown in Figure 3 as described above.

Similar to the receiving coil 131 and the transmitting coil 113 shown in Figure 3, transmission and receiving coil and 145 ,, receiving coil 131 can suppress unnecessary radiation due to the electric field and magnetic field coil generates for this.

[0048]

Monitors the state of charge of the secondary battery 134, the charging is terminated, the charge and discharge control circuit 133 stops the charging of the secondary battery 134 by the receiving circuit 132.

As described above, in this second embodiment, the receiving coil 131 113, and the transmission and receiving coil 145, power transmission coils to be used for non-contact power transmission is changing suddenly planar coil, In use, the two of which transformer is formed by the coil of Tsu, it can be, and can suppress unnecessary radiation due to magnetic or electric fields from the coils forming the transformer, to improve the efficiency of power transmission.

[0049]

Also, in this second embodiment, it is mounted on a portable phone unit 15 and transmission and receiving compatible apparatus 14 including a secondary battery 143 functions as a charger, the mobile phone body 12 to the power receiving device 13 including a secondary battery 134 was like to be mounted on.

Therefore, according to the second embodiment, a mobile phone equipped with the power receiving device 13 becomes unavailable, 134 secondary battery of the power receiving device 13 using a mobile phone equipped with a transmission and receiving compatible apparatus 14 it is possible to charge, it is very convenience.

[0050]

Furthermore, in the transmission and receiving compatible apparatus 14 of the second embodiment, when used as a battery charger or when used as a secondary battery, on which can be set freely its use, display unit user the setting state it can be easily recognized by, it is possible to prevent malfunction due to the misconfiguration.

Other Embodiments

In the first embodiment, as shown in Figures 2 and 3, composed of a metal sheet 113c planar spiral coil 113a, and magnetic sheet 113b,, the receiving coil 131, the power transmission coil 113, the planar spiral coil 131a, I was to be made of a metal sheet and 131c magnetic sheet 131b,.

However, the receiving coil 131 and the transmitting coil 113 may be omitted each metal sheet 113c, and 131c.

[0051]

The configuration of this point, it is the same for each component of the receiving coil 131 power transmission coils in the second embodiment 113, and transmission and receiving coil 145,.

In the first embodiment, the power receiving device 13, and integrating the secondary battery 134 receiving coil is a component 131, receiving circuit 132, and discharge control circuit 133, it is arranged to form a power receiving device module This integration may be any secondary battery 134 and the receiving coil 131 at least.

[0052]

Furthermore, in the second embodiment, transmission and receiving device 14 combined, 141, 143 receiving circuit battery 142,2, 144 charge and discharge control circuit, transmission and receiving coil 145, the selector switch SW1~SW3 transmission circuit which is a component , of the display device 148 set 146, and a control circuit 147, and integrating the components other than the display unit 148 and the setting device 146, it is arranged to form a transmission and receiving compatible apparatus module.

However, this integration may be any secondary battery 143 and the transmission and receiving coil 131 at least.

[0053]

In the second embodiment and the first embodiment has been described as being applied to a mobile phone, but can be applied to a portable device such as a video camera or mobile terminals, such as portable computers and in place of this.

[0054]

Is a block diagram showing a configuration of a first embodiment of the present invention.

Is an exploded perspective view of each component of the receiving coil and the transmitting coil.

Is a cross-sectional view showing the structure of a receiving coil and transmitting coil.

Is a cross-sectional view showing a state incorporated in the cell phone case and the case of the charger, and a power transmitting apparatus and the power receiving apparatus.

Is a block diagram showing the configuration of a second embodiment of the present invention.

[0055]

11 ... the power transmission device, 12 and 15 ... mobile phone body, 13 ... powered device, 14 ... transmission and receiving compatible apparatus, 32 ... powered device module, 113 ... power transmission coil, 113a , 131a ⋯ planar spiral coil, 113b, 131b ⋯ magnetic sheet, 113c, 131c ⋯ metal sheet, 112,141 ... power transmission circuit, 131 ... receiving coil, 132, 142 ... incoming circuit, 134,143 ... secondary battery, 145 ... transmission and receiving coil.

CLAIMS JP2006042519

[0001]

And a power transmission device including a first coil and a power receiving device including a secondary battery and a second coil,

When the first coil is electromagnetically coupled to the second coil, wherein the power transmission device has a transmission means for generating an alternating current supplied to the first coil,

When the second coil is electromagnetically coupled to the first coil, the power receiving device, for charging of the secondary battery by a DC that converts alternating current into direct current induced in the second coil, and the transformed and a receiving means,

Further, the second coil and the first coil consists second planar coil and the first planar coil that plane is adapted to face a spiral,

And said second planar coil and the first planar coil, the non-contact power transmission device to the surface opposite to the surface in which the two faces, and characterized by providing each of the magnetic sheet.

[0002]

The outer surface of the magnetic sheet provided on the second planar coil and the first planar coil, further, the non-contact power transmission device according to claim 1, characterized in that is provided to overlap each metal sheet.

[0003]

The second coil constituting the power receiving device, the receiving means, and one of the secondary battery, to claim 1, characterized in that it is integrated to the secondary battery and the second coil of at least non-contact power transmission device according.

[0004]

The second coil constituting the power receiving device, the receiving means, and one of the secondary batteries, the secondary battery and the second coil, it has to be solidified or accommodated in a case at least a predetermined The contactless power transmission apparatus according to claim 1, wherein the.

[0005]

The power receiving device, the non-contact power transmission apparatus according to claim 1 of any one of claims 1 to 4, characterized in that it was mounted on a cellular phone.

[0006]

And a power transmission device including a first coil, and the transmission and receiving combined device including a secondary battery of the first and second coil and a power receiving device including a secondary battery of the second and third coil,

The power transmission device,

When electromagnetically coupled to the third coil of the first coil or the second coil, and a transmission means for generating an alternating current supplied to the first coil,

The transmission and receiving compatible apparatus is,

when the second coil is electromagnetically coupled with said third coil, and a transmission means for generating an alternating current supplied to the second coil by using a battery as a power supply of the secondary first,

when the second coil is electromagnetically coupled to the first coil, and receiving means for charging the secondary battery according to claim 1 by a DC that converts alternating current into direct current induced in the second coil, and the transformed and a door,

The powered device,

When electromagnetically coupled to the second coil and the third coil or the first coil, the secondary battery and the second by a DC that converts alternating current into direct current which is induced in the third coil, and the transformed and a receiving means for charging,

Further, the first coil, the second coil, and the third coil, the third planar first planar coil the plane is in opposition to each other a spiral, and the second planar coil, and a coil,

And wherein the first planar coil, the second planar coil, and the third planar coil, the non-contact power transmission apparatus is characterized in that a surface opposite to a surface facing, respectively, and provided with a magnetic sheet.

[0007]

The first planar coil, said second planar coil, and the outer surface of the magnetic sheet provided on the third planar coil, further, according to claim 6, characterized in that is provided to overlap each metal sheet non-contact power transmission equipment.

[0008]

The second coil constituting the transmission and receiving compatible apparatus, said power transmission means, said receiving means, and of the secondary battery according to claim 1, the integrated rechargeable battery of the first and the second coil, at least,

And the third coil which constitutes the power receiving device, the receiving means, and of the secondary battery and the second, characterized in that it has integrated rechargeable battery and the second and the third coil at least The contactless power transmission apparatus according to claim 6 or 7.

[0009]

The second coil constituting the transmission and receiving compatible apparatus, said power transmission means, said receiving means, and of the secondary battery according to claim 1, the secondary battery of the first and the second coil is at least a predetermined and so as to solidify or housed in the case,

And the third coil which constitutes the power receiving device, the receiving means, and of the secondary battery of the second secondary battery and the second and the third coil is housed within a case at least a predetermined or the non-contact power transmission apparatus according to claim 6, characterized in that it is arranged to solidify.

[0010]

The power receiving device and the transmission and receiving combined device, non-contact power transmission apparatus according to claim 1 any one of claims 9 to claim 6, characterized in that it was mounted on a cellular phone, respectively.

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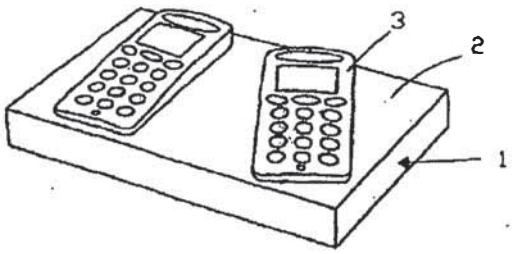
(54) Title: PLANAR INDUCTIVE BATTERY CHARGER



(57) Abstract: There is provided a planar inductive battery charging system designed to enable electronic devices to be recharged. The system includes a planar charging module having a charging surface on which a device is placed. Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that couple energy inductively to a secondary winding formed in the device. The invention also provides secondary modules that allow the system to be used with conventional electronic devices not formed with secondary windings.

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PLANAR INDUCTIVE BATTERY CHARGER

FIELD OF THE INVENTION

This invention relates to a battery charger, and in particular to a battery charger having a planar surface on which one or more battery powered devices may be placed for battery recharging through induction. The invention also extends to a battery charging system for use with conventional electronic devices and that allows conventional electronic devices to be charged using the battery charging system of the present invention.

BACKGROUND OF THE INVENTION

Portable electronic equipment such as mobile phones, handheld computers, personal data assistants, and devices such as a wireless computer mouse, are normally powered by batteries. In many cases, rechargeable batteries are preferred because of environmental and economical concerns. The most common way to charge rechargeable batteries is to use a conventional charger, which normally consists of an AC-DC power supply (in case of using the ac mains) or a DC-DC power supply (in case of using a car battery). Conventional chargers normally use a cord (an electric cable for a physical electrical connection) to connect the charger circuit (a power supply) to the battery located in the portable electronic equipment. The basic schematic of the conventional battery charger is shown in Fig.1.

PRIOR ART

Inductive electronic chargers without direct physical electrical connection have been developed in some portable electronic equipment such as electric toothbrushes

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where because they are designed to be used in the bathroom in the vicinity of sinks and water, it is not safe to provide a conventional electrical connection. US6,356,049, US6301,128, US6,118,249, also all describe various forms of inductive chargers. These inductive type chargers, however, use traditional transformer designs with windings wound around ferrite magnetic cores as shown in Fig.2. The main magnetic flux between the primary winding and secondary winding has to go through the magnetic core materials. Other contactless chargers proposed also use magnetic cores as the main structure for the coupled transformer windings.

A contactless charger using a single primary printed winding without any EMI shielding has been proposed by Choi et al in "A new contactless battery charger for portable telecommunications/computing electronics" ICCE International Conference on Consumer Electronics 2001 Pages 58-59. However, the magnetic flux distribution of a single spiral winding has a major problem of non-uniform magnetic flux distribution. As illustrated further below, the magnitude of the magnetic field in the centre of the core of a spiral winding is highest and decreases from the centre. This means that if the portable electronic device is not placed properly in the central region, the charging effect is not effective in this non-uniform field distribution. Furthermore, without proper EMI shielding, undesirable induced currents may flow in other metallic parts of the portable electronic equipment.

SUMMARY OF THE INVENTION

According to the present invention there is provided a battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer,

said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

In a preferred embodiment the primary winding is formed on a planar printed circuit board.

Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface. In this way the precise position and orientation of the electronic device on the charging surface is not critical. To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array.

In a preferred embodiment the primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface. This shielding may include a sheet of ferrite material, and more preferably also may further include a sheet of conductive material such as copper or aluminium

It is an advantage of the present invention that in preferred embodiments the planar charging surface may be large enough to receive two or more electronic devices, and the primary charging circuit is adapted to charge two or more devices simultaneously. In this way it is possible to charge more than one device simultaneously. For example the planar charging surface may be divided into a plurality of charging regions, which regions may be defined by providing a plurality of primary transformer windings arranged in a regular array and connecting the windings in groups to define said charging regions. A further advantage of the present invention is that it enables the possibility of allowing a device to move over the charging surface while being charged

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at the same time. This possibility is particularly useful to a device which is designed to be moved such as a wireless computer mouse

Viewed from another aspect the present invention provides a battery charging system comprising a charging module comprising a primary charging circuit and being formed with a charging surface for receiving an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device.

Preferably, the shielding comprises a sheet of ferrite material and a sheet of conductive material such as copper.

Preferably the winding is formed integrally with a back cover of said device.

An important aspect of the present invention is that it provides a battery charging system that employs a localised charging concept. In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged. In other words, when a device is placed on a planar charging surface that is greater in size than the device, energy is only transferred from that part of the planar charging surface that is directly beneath the device, and possibly also immediately adjacent areas that are still able to couple to the secondary coil.

Viewed from another aspect the present invention provides a battery charging system comprising a primary module and at least one secondary module, said primary

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module comprising means for connecting to a mains supply, and at least one primary winding adjacent to a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent to a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

According to another aspect the invention also extends to a secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Fig.1 is a schematic view of a conventional prior art battery charger with direct electrical connection,

Fig.2 is a schematic view of a conventional magnetic core-based transformer as used in prior art inductive battery charger systems,

Fig.3 is a schematic view of a planar transformer with shielding,

Figs.4(a)-(c) are (a) a perspective view of a battery charger system according to an embodiment of the present invention, (b) a view similar to (a) but showing

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the structure of the primary charging system, and (c) a view similar to (a) and (b) but showing the top cover removed for clarity,

Figs.5(a) & (b) show the structure of the primary charger with the top cover removed for clarity, and in Fig.5(a) with the structure shown in exploded view,

Figs.6(a) & (b) show (a) a single spiral PCB winding, and (b) the measured magnetic field distribution of a single spiral winding,

Figs.7(a) & (b) illustrate the use of a magnetic core to control magnetic field distribution,

Fig.8 shows an embodiment of the invention in which a plurality of primary windings are arranged in an array structure,

Figs.9(a) & (b) shows (a) a 4 x 4 primary winding array, and (b) the resulting magnetic field distribution,

Figs.10(a)-(c) illustrate an embodiment of the invention in which primary windings are arranged in groups with Fig.10(c) showing the equivalent circuit,

Fig.11 shows an example of the back cover of an electronic device designed to be recharged using an embodiment of the present invention,

Figs.12(a)-(d) show exploded views of the back cover of Fig.11,

Figs.13(a) & (b) show views of a watch that may be recharged in accordance with an embodiment of the invention,

Fig.14 shows a charging module in accordance with an alternative embodiment of the invention,

Fig.15 shows a first layer of a 4x5 winding array for use in a multi-layer embodiment,

Fig.16 shows a second layer of a 3x4 winding array for use in conjunction with the layer of Fig.15 in a multi-layer embodiment,

Fig.17 shows the layers of Fig.15 and Fig.16 in the two-layer structure,

Fig.18 is simplified version of Fig.15,

Fig.19 is a simplified version of Fig.16,

Fig.20 is a simplified version of Fig.17,

Fig.21 is a plot showing the smoothing effect of the two-layer structure,

Fig.22 shows a hexagonal spiral winding,

Fig.23 is a simplified form of Fig.22,

Fig.24 shows a single-layer of hexagonal spiral windings,

Fig.25 shows two adjacent hexagonal spiral windings,

Fig.26 shows the mmf distribution of the adjacent windings of Fig.25,

Fig.27 shows three adjacent hexagonal spiral windings and the peaks and minima of the flux distribution,

Fig.28 shows two overlapped layers of hexagonal spiral windings,

Fig.29 shows the location of the peak flux in the structure of Fig.28,

Fig.30 corresponds to Fig.29 but also shows the location of the flux minima,

Fig.31 shows an embodiment of the invention formed with three overlapped layers,

Fig.32 corresponds to Fig.31 but shows the location of the flux peaks,

Fig.33 is a plot showing the uniformity of the flux distribution along a line,

Fig.34 shows a square spiral winding,

Fig.35 is a simplified version of Fig.34,

Fig.36 shows a first layer of square spiral windings,

Fig.37 corresponds to Fig.36 but shows the location of the flux maxima and minima,

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Fig.38 shows two overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.39 shows three overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.40 shows four overlapped layers of square spiral windings including the location of the flux maxima and minima,

Fig.41 illustrates a battery charging system according to a further embodiment of the invention,

Fig.42 is a view similar to Fig.41 but part broken away to show the primary winding,

Fig.43 is a view similar to Fig.42 but of an alternate embodiment,

Figs.44(a) and (b) illustrate possible magnetic cores for use in the embodiment of Fig.42,

Fig.45 shows an equivalent circuit for the charging system of an embodiment of the invention,

Fig.46 illustrates an example of a secondary module for use in an embodiment of the invention,

Fig.47 shows a part broken away view of secondary module of an embodiment of the invention,

Fig.48 is a view similar to Fig.47 but of a further embodiment,

Fig.49 is a view showing the complete charging system according to an embodiment of the invention,

Fig.50 is a view similar to Fig.49 but showing how the charging system according to an embodiment of the invention can be used to charge multiple devices having different forms of charging connections, and

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Fig.51 is a view illustrating how an embodiment of the present invention can be used to enable a conventional electronic device to be charged using an inductive charging platform as shown in Fig.4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described in respect of a preferred embodiment in the form of an inductive battery charger for portable electronic equipment such as mobile phones, handheld computers and personal digital assistants (PDA), and devices such as a wireless computer mouse.

Referring firstly to Fig.4, the inductive charger system comprises two modules, a power delivering charger module that contains the primary circuit of a planar isolation transformer and a secondary circuit that is located in the portable electronic equipment to be charged. In this embodiment of the invention, the charger circuit is located within a housing 1 that is formed with a flat charging surface 2. The secondary circuit is formed in the portable equipment to be charged (in this example a mobile phone 3) and the equipment is formed with at least one planar surface. As will be seen from the following description the equipment is charged simply by placing the equipment on the surface so that the planar surface on the equipment is brought into contact with the flat charging surface 2. It is a particularly preferred aspect of the present invention that the equipment to be charged does not have to be positioned on the charging surface in any special orientation. Furthermore, in preferred embodiments of the invention two or more mobile devices may be charged simultaneously on the same charging surface, and/or a device that is designed to be moved (such as a wireless computer mouse) can be charged while being moved over the charging surface (which could be integrated into a computer mouse pad). It will also be seen from the following description that the energy

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transfer is "localised" in the sense that energy is only transferred from the charging surface to the device from that part of the charging surface that is directly beneath the device (and possibly to a lesser extent regions adjacent thereto).

Referring in particular to Fig.4(b) the primary charging module comprises a printed circuit board 4 formed with at least one spiral conductive track formed thereon as a primary winding. It will be understood, however, that the primary winding need not necessarily be formed on a PCB and could be formed separately. Alternatively, multiple PCBs each formed with at least one winding could be "stacked" on top of each other to increase the total flux. Preferably, as will be described further below, there are in fact a plurality of such spiral tracks disposed in an array as shown in Fig.4(c) in which a top insulating sheet has been removed for clarity. Beneath the PCB 4 (ie the side of the PCB away from the charging surface) is provided EMI shielding comprising firstly a ferrite sheet 5 adjacent the PCB 4, and then a conductive sheet 6 which in this example may be a copper sheet. Beneath the copper sheet 6 may be provided any suitable form of substrate material 7, eg a plastics material. Above the PCB 4 may be provided a sheet of insulating material 8 which forms the charging surface. Preferably the PCB 4, the EMI shielding sheets 5,6, the substrate 7 and the insulating cover sheet 8 may also be generally the same size and shape, for example rectangular, so as to form the primary charging module with the charging surface being large enough to accommodate at least one, and more preferably two or more, devices to be charged. Figs.5(a) and (b) also show the structure of the charging module without the cover sheet and without any devices to be charged thereon for the sake of clarity.

As shown in Fig.4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings. The secondary winding is also planar and is located in the

portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit. The rectified DC voltage is applied to the battery via mechanical contacts provided in an integrated back cover as will be described further below. No physical electrical connection between the primary charger circuit and the portable electronic equipment is needed.

The primary charger circuit has (1) a switched mode power electronic circuit, (2) the primary side of a planar transformer that consists of a group of primary windings connected in series or in parallel or a combination of both, (3) an EMI shield and (4) a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The schematic of the primary charger system is shown in Fig.5(a) and (b) without the insulating cover.

The battery charging system can be powered by AC or DC power sources. If the power supply is the AC mains, the switched mode power electronic circuit should perform a low-frequency (50 or 60Hz) AC to DC power conversion and then DC to high-frequency (typically in the range from 20kHz to 10MHz) AC power conversion. This high-frequency AC voltage will feed the primary planar windings of the primary charger circuit. If the power supply is a battery (e.g. a car battery), the switched mode power supply should perform a DC to high-frequency AC power conversion. The high-frequency voltage is fed to the primary windings of the planar transformer.

Preferably, the charger should be able to charge one or more than one items of portable electronic equipment at the same time. In order to achieve such a function, the AC magnetic flux experienced by each item of portable equipment placed on the charging surface should be as even as possible. A standard planar spiral winding as

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shown in Fig.6(a) is not suitable to meet this requirement because its flux distribution is not uniform as shown in Fig.6(b) when the winding is excited by an AC power source. The reason for such non-uniform magnetic flux distribution is that the number of turns in the central region of the single spiral winding is largest. As the magnitude of the magnetic flux and the magnetomotive force (mmf) is proportional to the product of the number of turn and the current in the winding, the magnetic flux is highest in the centre of the winding.

One method to ensure uniform magnetic flux or mmf distribution is to use a concentric primary winding with a planar magnetic core as shown in Fig.7(a). This magnetic core-based approach allows the magnetic flux to concentrate inside the core and typical magnetic flux distribution is shown in Fig.7(b). In general, the flat charging interface surface of the primary charger should be larger than the total area of the portable electronic equipment.

In order to ensure that more than one item of portable electronic equipment can be placed on the flat charging surface and charged simultaneously, a second and more preferred method proposed is to ensure that the magnetic flux distribution experienced by each items of portable electronic equipment is as uniform as possible. This method can be realized by using a "distributed" primary planar transformer winding array structure as shown in Fig.8. This planar winding array consists of many printed spiral windings formed on the PCB. These printed spiral windings can be hexagonal, circular, square or rectangular spirals, and can be connected in series, in parallel or a combination of both to the high-frequency AC voltage generated in the power supply in the primary charger circuit. The array should comprises relatively closely spaced coils so as to be able to generate the required near-uniform magnetic flux distribution, as an array of widely spaced apart coils may not generate such a near-uniform field.

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Fig.9(a) shows a practical example with the transformer winding array connected in series so that all the fluxes created in the windings point to the same direction. Fig.9(b) show the measured flux distribution of one planar transformer when the windings in the transformer array are connected in series. This measurement confirms the near uniform magnetic flux distribution of the array structure. Comparison of Fig.6(b) and Fig.9(b) confirms the improvement of the uniform magnetic field distribution using the transformer array structure. In addition, this transformer array structure provides for the possibility of multiple primary transformer windings being provided for localized charging as will now be explained.

The primary transformer windings can also take the form of a combination of series and parallel connections if desired. Such an arrangement allows the charging surface to be divided into various charging regions to cater for different sizes of the secondary windings inside the portable electronic equipment. Fig.10(a) illustrates this localized charging zone principle. Assume that the transformer array is divided into 4 zones (A, B, C, and D). The transformer windings within each zone are connected in series to form one primary winding group with the distributed magnetic flux feature. There will be four primary windings in the equivalent circuit as shown in Fig.10(c). If the portable electronic equipment is placed on Zones A and B as shown in Fig.10(b), the equivalent electrical circuit is shown in Fig.10(c). Only the parallel primary transformer winding groups for Zones A and B are loaded because they can sense a nearby secondary winding circuit in the portable electronic equipment. Therefore, they will generate magnetic flux in Zones A and B. Primary transformer windings C and D are not loaded because they have no secondary transformer circuit close to them and their equivalent secondary circuits are simply an open-circuit (Fig.10(c)). As a result, power transfer between the primary charger circuit and the secondary windings inside the

portable electronic equipment takes place basically through the coupled regions (areas) of the charging interface surface covered by the portable electronic equipment. The non-covered area of the charging surface will transfer virtually no energy. This special design avoids unnecessary electromagnetic interference. A further advantage of this localised energy transfer concept, is that it enables a movable device (such as a wireless computer mouse) to be continually charged as it moves over the charging surface. In the case of a wireless computer mouse, for example, the primary charging circuit could be integrated into a mousepad and the mouse may be charged as it rests on and/or moves over the mousepad.

The back cover of the portable electronic equipment is a detachable back cover shown in Fig.12(a) that covers the battery and which may be removed when the battery is replaced. In preferred embodiments of the present invention, this back cover has a built-in secondary planar transformer winding 10, a diode rectifier circuit 13 and preferably a thin EMI shield 11,12 as shown in Fig.12(b) & (c). When the back cover side of the portable equipment is placed near the flat charging surface of the primary charger circuit, this secondary winding couples the energy from the nearby primary transformer winding or windings. The rectifier circuit rectifies the coupled AC voltage into a DC voltage for charging the battery through mechanical contacts 14. This rectifier circuit also prevents the battery from discharging into the secondary winding. In order to avoid induced circuit from circulating in other metal parts inside portable electronic circuit, it is preferable to include a thin EMI shield as part of the integrated back cover structure as shown in Fig.12. This EMI shield can be a thin piece of ferrite material (such as a flexible ferrite sheet developed by Siemens) or ferrite sheets, or more preferably a combination of a ferrite sheet 11 and then a thin sheet 12 of copper of another conductive material such as aluminium..

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It will thus be seen that, at least in its preferred forms, the present invention provides a new planar inductive battery charger for portable electronic equipment such as mobile phones, handheld computers, personal data assistant (PDA) and electronic watches, and wireless computer mice. The inductive charger system consists of two modules, including (1) a power delivering charger circuit that contains the primary circuit of a planar isolation transformer and a flat charging surface and (2) a separate secondary transformer circuit that consists of a printed winding, a rectifier and preferably a thin EMI shield and which is located in the portable electronic equipment to be charged.

An advantage of the present invention, at least in preferred forms, is that the primary charger circuit system has the primary side of a planar transformer and a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The secondary circuit can be integrated into the back cover of the portable electronic device or separately placed inside the electronic device. The invention also extends to a back cover design with an in-built secondary circuit for the portable equipment. The secondary winding of the planar transformer can be EMI shielded and integrated into the back cover adjacent to the battery in the portable electronic device. As long as the back cover sides of the portable electronic device are placed on the charger surface, one or more portable electronic devices can be charged simultaneously, regardless of their orientations.

Figs.13(a) and (b) show how an embodiment of the invention may be used to recharge a watch battery. A watch is formed with a basic watch mechanism 20, which is powered by a rechargeable battery 21. The watch mechanism is shielded from electrical interference in the charging process by an EMI shield consisting of, for example, a copper sheet 22 and a ferrite sheet 23 (with the copper sheet closer to the watch

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mechanism than the ferrite sheet). The other side of the EMI shield is provided a planar coreless transformer secondary winding 24 formed with electrical contacts 26 for connection to the battery 21 and with a rectifier circuit to prevent discharge of the battery. Finally, the watch structure is completed by the provision of a planar back cover 25 formed of non-metallic material. It will be understood that the watch battery may be recharged by placing the watch on the charging surface of a battery charging system as described in the above embodiments such that the back cover 25 lies flat on the planar charging surface. Electrical energy is then coupled from the primary winding(s) in the battery charging module to the secondary winding in the watch and then to the rechargeable battery.

In the embodiments described above the charging module is formed as a single integral unit (as shown for example in Figs.4 and 5). However, in some situations it may be desirable to separate the electronic charging circuit from the planar charging surface. This possibility is shown in Fig.14 in which the electronic charging circuit 30 is connected by a cable 31 to the charging surface 32. The charging surface 32 includes an insulating top cover, the planar primary windings printed on a PCB, and a bottom EMI shield formed of ferrite and a conductive sheet such as copper. This embodiment has the advantage that the charging surface is relatively thin, and therefore may be useful for example when the device to be charged is a wireless computer mouse because the charging surface can double as a mousepad as well as a charging surface.

In the embodiments described above a single layer of transformer arrays is provided. However, in order to generate a more uniform magnetic field distribution, multi-layer transformer arrays can be used. The following embodiments describe how multiple layers of transformer arrays may be used that can provide a very uniform magnetic field distribution on the charging surface.

Fig.15 shows a 4x5 primary planar transformer winding array which consists of square-sprial winding patterns. This can be fabricated on one layer of the printed circuit board structure. It should be noted that, for an individual winding pattern in the array, the magnitude of the magnetic flux is highest in the center of the spiral winding. The magnitude of the magnetic flux is smallest in the small gap between adjacent winding patterns.

A second layer with a 3x4 transformer winding array is shown in Fig.16. The individual winding patterns in both layers are identical. As shown in Fig.17, by having the two layers of arrays arranged in such a manner that the center (region of maximum magnetic flux magnitude) of a winding pattern on one layer is placed on the gap (region of minimum magnetic flux magnitude) between adjacent winding patterns on the other layer, the variation of the magnetic field magnitude can be minimized and the magnetic flux magnitude can therefore be made as even as possible over the overlapped surface. The essence of the multi-layer transformer arrays is to have a displacement between the individual winding patterns of the two layers so that the regions of the maximum magnetic field magnitude of one layer is "evened out" by the regions of the minimum magnetic field magnitude.

In order to examine the 'uniform magnetic field magnitude' feature of the proposed overlapped multi-layer transformer arrays, this 'magnitude smoothing' concept is illustrated in simplified diagrams in Fig.18 to 20. Fig.18 is a simplified version of Fig.15. Each solid square in Fig.18 represents a square-spiral winding pattern in the first layer (Fig.15). Fig.19 is a simplified version of the Fig.16. Each dotted square represents a square-spiral winding pattern in the second layer (Fig.16). The simplified version of the multi-layer array structure is shown in Fig.20. From Fig.20, it can be seen that the overlapped array structure (with correct displacement between the

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two layers) divides each square-spiral winding pattern into four smaller sub-regions. The important feature is that the four sub-regions are identical in terms of winding structure. Despite that fact that the distribution of the magnetic field magnitude on the surface of each individual square-spiral winding is not uniform, the distribution of the resultant magnitude field magnitude on the surface of each sub-region is more or less identical because of the overlapped multi-layer winding structure. The concept of the generating uniform magnetic field magnitude over the charging surface is illustrated in Fig.21.

In this example, a multi-layer transformer winding array structure that can provide a uniform magnetic field magnitude distribution is described. This example is based on square-spiral winding patterns. In principle, winding patterns of other shapes can also be applied as long as the resultant magnetic field magnitude distribution is as uniform as possible.

The use of two layers of transformer arrays can reduce the variation in the magnetic flux over the charging surface. However, there may still be some variations and the use of a three or four layer structure may provide a still more uniform flux distribution as described in the following embodiments.

The following embodiment is a structure comprising three layers of planar winding arrays. This PCB winding structure can generate magnetomotive force (*mmf*) of substantially even magnitude over the charging surface. Each winding array consists of a plurality spiral windings each of which are of an hexagonal shape. A spiral winding arranged in a hexagonal shape is shown in Fig.22. For simplicity, it will be represented as a hexagon as shown in Fig.23. A plurality of hexagonal spiral windings can be arranged as an array as shown in Fig.24. These windings can be connected in parallel, in series or a combination of both to the electronic driving circuit. If a current passes

through each spiral winding pattern, a magnetomotive force (*mmf*), which is equal to the product of the number of turns (*N*) and current (*I*) (i.e. *NI*), is generated. Fig.25 shows two spiral winding patterns adjacent to each other and the per-unit *mmf* plot over the distance (dotted line) can be linearized as shown in Fig.26. It can be seen that the *mmf* distribution over the distance is not uniform. The maximum *mmf* occurs in the center of the hexagonal pattern and the minimum *mmf* occurs in the edge of the pattern.

Fig.27 shows three adjacent windings. The maximum *mmf* region is labelled by a symbol 'P' (which stands for Peak *mmf*). The minimum *mmf* region at the junction of two patterns is labeled as 'V' (which stands for Valley of the *mmf* distribution). In order to generate a uniform *mmf* distribution over the planar charging surface, two more layers of PCB winding arrays should be added. This principle is explained firstly by adding a second layer of PCB winding array to the first one as shown in Fig.28. The second layer is placed on the first one in such a way that the peak *mmf* positions (P) of the patterns of one layer are placed directly over the valley positions (V) of the patterns in the other layer. Fig.29 highlights the peak positions of the patterns that are directly over the valley positions of the other layer for the two overlapped PCB layers in Fig.28.

It can be observed from Fig.29, however, that the use of two layers of PCB winding arrays, while presenting an improvement over a single layer, does not offer the optimal solution for generating uniform *mmf* over the inductive charging surface. For each hexagonal pattern in the 2-layer structure, the peak positions occupy the central position and three (out of six) vertices of each hexagon. The remaining three vertices are valley positions (V) that need to be filled by a third layer of PCB winding arrays. These valley positions are shown in Fig.30 as empty squares.

Careful examination of Fig.30 shows that there are six peak positions (P) surrounding each valley position. Therefore, a third layer of a hexagonal PCB winding

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array can be used to fill up all these remaining valley positions. By placing the central positions (peak *mmf* positions) of the hexagonal winding patterns of the third layer of the PCB winding array over the remaining valley positions of the two-layer structure, an optimal three-layer structure is formed as shown in Fig.31. Fig.32 highlights the peak *mmf* positions of the three-layer structure. It can be observed that all central positions and vertices of all hexagonal patterns have peak *mmf*.

In order to confirm that the *mmf* over the surface has uniform *mmf* distribution, any distance between any two adjacent peak *mmf* positions can be considered as illustrated in Fig.33. If the winding patterns are excited in the same manner and polarity so that the *mmf* generated by each layer of the winding array are always in the same direction at any moment, the resultant *mmf* is simply the sum of the *mmf* generated by each layer. The dotted line in Fig.33 shows that the resultant *mmf* over the distance between any two adjacent peak positions in Fig.33 is equal to 1.0 per unit. This confirms that the proposed three-layer PCB winding array structure can be used to generate highly uniform *mmf* over the inductive charging surface. When used as a contactless, inductive charging surface, this uniform *mmf* distribution feature ensures that, for a given airgap, a secondary PCB coupling winding can always couple the same amount of magnetic flux regardless of the position of the secondary (coupling) PCB on the inductive charging surface. In addition, the voltage induced in the secondary winding would be the same over the inductive charging surface.

In another embodiment, the three-layer PCB winding array structure can be constructed as a four-layer PCB, with one of the four layers accommodating the return paths of the spiral windings to the electronic driving circuit.

A further embodiment is based again on square spiral winding patterns. In this embodiment four layers of square-spiral winding arrays are used to generate highly

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uniform *mmf* over the PCB surface. As in the hexagonal embodiment described above, for convenience of illustration each square-spiral winding pattern (Fig.34) is simplified as a square symbol (Fig.35) in the following description.

Fig.36 shows the first layer of the square-spiral PCB winding array. The *mmf* in the central region of each square pattern is highest. These regions are highlighted as 'Peak' or (P) in Fig.37. The regions of the minimum *mmf* (i.e. the valleys) occurs along the edges of the square patterns. These regions are highlighted with dots (•) in Fig.37.

In order to reduce the *mmf* ripples on the surface, the peak (P) positions of a second layer of square-spiral PCB winding array can placed over some of the valley positions (•) as shown in Fig.38. When a third layer of square-spiral PCB winding array is added to the structure in Fig.38, the resultant layout is shown in Fig.39. It can now be observed that one more layer of the square-spiral PCB windings is needed to fill up all the valleys with peaks as shown in Fig.40.

The inductive battery charging platform described above, which can be regarded as the primary circuit of a transformer system (or the primary inductive charging system), can be used as a standard battery charging platform for portable electronic equipment with compatible inbuilt secondary circuitry in the electronic equipment to be charged. However, existing electronic equipment that is not designed for compatibility with the abovedescribed battery charging platform cannot take advantage of the convenience offered by the battery charging platform. Another embodiment of the present invention therefore provides both a battery charging system that can stand independently and can be used to charge existing conventional devices, and a means by which a conventional electronic device can be charged using the charging platform described above.

Referring firstly to Fig.41 there is shown therein a perspective view of a part of a battery charging system according to an embodiment of the present invention. The part of the charging system shown in Fig.41 may be termed the primary inductive charging system since as will be explained below it comprises at least one primary winding. The part of the battery charging system shown in Fig.41 may also be considered to be an extension system since in preferred forms it may be adapted to charge multiple devices and is therefore analogous to a conventional extension lead that allows multiple items of electronic equipment to share the same power socket.

The charging system is provided with multiple charging slots 100,101,102 for receiving secondary charging modules to be described further below. As will be explained further below each charging slot is provided with a primary winding. Fig.41 shows a schematic of the primary inductive charging extension system with three charging slots. However, it should be noted that the number of slots is not restricted to three and can be as few as a single charging slot, or can be more than three. It will be understood that the number of charging slots dictate the number of devices that can be charged simultaneously. The primary charging extension system is connected to the mains through a plug 103 and includes a power electronic circuit 104 that provides a high-frequency (typically in the range of 1kHz to 2MHz) AC voltage to the primary windings that are located under the charging slot surfaces. It should be noted that the surfaces of the slots are flat and the slots are separated from each other by dividing walls. Each slot is therefore the same size as the surface of a housing of a secondary module to be described below, and the separating walls and mechanical switches to be described below together act to engage a secondary module and hold it in a correct orientation for efficient charging.

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Each primary winding can be a coil 105 as shown in Fig.42 or a printed-circuit-board (PCB) winding 106 as shown in Fig.43. If the primary winding is a coil 105, the coil 105 is preferably accommodated in a space 107 defined by a magnetic structure 108 such as the two examples shown in Fig.44(a) and (b) in which the coil is wound around a magnetic core 108. If a PCB winding is used, appropriate electromagnetic (EM) shielding, such as the combined use of ferrite and copper sheets described in US 6501364, can be placed under the PCB winding in order to ensure that the magnetic flux generated in the PCB winding will not penetrate through the base of the primary inductive charging extension system. Preferably, mechanical switches 109 can be provided in each charging slot that when closed activate the primary winding to the high-frequency AC voltage source when the secondary charging module (to be described below) is inserted in that particular slot. As discussed above, the mechanical switches may also serve to engage and hold the secondary module in place. This mechanism ensures that only windings in the slots used by the secondary modules are excited by the high-frequency AC voltage source. The equivalent circuit is shown in Fig.45.

It will also be understood that the primary winding could be constructed as a multiple layer structure as discussed above in order to provide a particularly preferred even flux distribution over the charging surface.

Fig.46 shows a typical secondary charging module 200 for use with the primary charging extension system shown in Fig.41. Each secondary module has a conventional cable 201 and charger connecter 202 that is adapted to be received within the charging socket of a conventional electronic device. It will be understood that different secondary charging modules 200 may be provided differing only by the type of the connector 202. Each secondary charging module 200 is provided with a housing 203 that contains a

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secondary circuit to be described below. The housing is preferably rectangular (but of course could be any suitable shape) and of such a size that it may be received in one of the slots 100-102 of the primary charging extension system. The housing 203 should have at least one preferably flat surface for placing on the charging slot of the primary charging extension system. This flat surface is preferably parallel to the plane of the secondary winding within the housing such that when the secondary module is placed in a slot of the primary extension system the secondary winding is substantially parallel to the primary winding beneath the surface of the slot. The housing 203 of the secondary module should preferably be made of non-conductive and non-ferromagnetic material so that no current will be induced in the housing material.

As can be seen from Figs.47 and 48 inside each secondary charging module 200 are at least one secondary winding 204 and charger circuitry 205 that receives the induced AC voltage in the secondary winding and provides a regulated DC output voltage for the charging purpose. The secondary winding should be kept inside the housing. The secondary winding can be a coil (Fig.47) or it can be printed on a PCB (Fig.48). The function of the secondary winding is to act as the secondary winding of a transformer system to pick up the changing magnetic flux generated by the primary winding of the primary charging extension system.

The secondary coil or PCB winding should be placed close to the (preferably flat) surface of the housing of the secondary charging module so as to pick up maximum changing AC magnetic flux from the primary inductive charging extension system or platform. According to Faraday's Law, an AC voltage will be induced across the secondary winding if the secondary winding senses a changing magnetic flux (that can be generated by the primary winding in the primary inductive charging system).

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The terminals of the secondary winding are connected to the input terminals of an electronic circuit 205 that (1) performs the AC-DC power conversion function (i.e. rectifying the AC voltage into DC) and (2) preferably also regulate the DC voltage to a desired value (typically in the range from 3V to 24V) within a certain tolerance. Through a cable and a charger connector for connecting to charging socket in the portable equipment, this DC voltage can be used to charge the portable equipment a shown in Fig.49.

The secondary winding design (such as number of turns and dimensions of windings), the DC regulated voltage level and the type of connector can be designed according to the charging requirements of specific electronic products. Therefore, different secondary charging modules can be designed for different ranges of products, but all secondary modules are compatible with the same primary charging extension system as shown in Fig.50 in which two different types of secondary modules adapted for charging different devices and having different connectors 202,202' are shown in adjacent slots of the primary charging extension system. As the primary inductive charging extension system preferably has several charging slots for accommodating the secondary charging modules, it can be used to charge several items of conventional portable electronic equipment simultaneously.

A further advantage of the secondary charging module is that it allows a conventional electronic device to be charged using the inductive battery charging platform described above. Although a conventional electronic device cannot be charged by placing it directly on the charging platform surface because it does not have the in-built secondary winding, instead a secondary charging module can be placed in the inductive charging system and charge the conventional device therefrom as shown in Fig.51

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In principle, the housing of the secondary charging module can have more than one preferably flat interface surface. If the housing is a cuboid it will have two large opposed interface surfaces (eg upper and lower surfaces of a relatively thin flat cuboid structure a shown in the Figures) and with this cuboid design, either interface surface of the secondary module housing can be placed on the charging slots of the primary inductive charging extension system or other charging platform. This cuboid design makes the secondary charging modules very user-friendly because it does not matter which way up the housing of the secondary module is placed on the primary charging surface.

In summary, a preferred embodiment of the secondary charging module consists of

(i) a non-conductive housing that has at least one surface (and preferably two surfaces) for placing on the charging slot of the primary charging extension system or the charging platform and that accommodates the secondary winding and circuitry for charging the electronic equipment,

(ii) A secondary winding, that can either be printed in a printed-circuit-board (PCB) or a conductor coil,

(iii) an AC-DC power conversion circuit that converts the ac induced voltage picked by the secondary winding from the primary. AC voltage excitation into a regulated or unregulated DC voltage, typically in the range from 3V to 24V,

(iv) a conventional cable that connects the DC voltage output of the secondary circuitry to a connector that is compatible with the charging socket in the conventional electronic equipment.

It will thus be seen that, at least in preferred forms, the charging system of the present invention including the proposed secondary charging modules offers users a

convenient and user-friendly battery charging system for a wide range of portable electronic equipment. Using the appropriate charger connectors that are compatible with different portable equipment, the proposed charging system enables one single charging system (that occupies only one power point or socket in the ac mains) to charge a wide range of electronic equipment.

The present invention, at least in preferred forms, provides a new charging system allows more than one piece of equipment to be charged simultaneously, and regardless of their orientations on the charging surface, and allows a movable device to be charged while it moves over the charging surface.

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CLAIMS

1. A battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer, said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

2. A battery charger system as claimed in claim 1 wherein said transformer primary winding is formed on a printed circuit board.

3. A battery charging system as claimed in claim 1 wherein the magnetic flux generated by said primary winding is substantially unifonn over at least a major part of said planar charging surface.

4. A battery charging system as claimed in claim 1 wherein said charging module comprises a plurality of primary windings.

5. A battery charging system as claimed in claim 4 wherein said primary windings are disposed in a regular array.

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6. A battery charging system as claimed in claim 4 wherein said primary windings are formed in a multi-layer structure comprising at least two layers and with each said layer including an array of primary windings.

7. A battery charging system as claimed in claim 6 wherein the array of a first said layer is offset relative to the array of a second said layer whereby regions of said first layer generating maximum magnetic flux coincide with regions of said second layer that generate minimum magnetic flux.

8. A battery charging system as claimed in claim 6 comprising three layers of hexagonal windings.

9. A battery charging system as claimed in claim 6 comprising four layers of square windings.

10. A battery charging system as claimed in claim 5 wherein said primary windings are hexagonal, circular, rectangular, square or polygonal in shape.

11. A battery charger system as claimed in claim 1 wherein said shielding includes a sheet of ferrite material.

12. A battery charging system as claimed in claim 11 wherein said shielding further includes a second sheet of conductive material.

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13. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to receive two or more electronic devices, and wherein said primary charging circuit is adapted to charge two or more devices simultaneously.

14. A battery charging system as claimed in claim13 wherein said planar charging surface is divided into a plurality of charging regions.

15. A battery charging system as claimed in claim 14 wherein said primary charging circuit comprises a plurality of primary transformer windings arranged in a regular array and wherein said windings are connected in groups to define said charging regions.

16. A battery charging system as claimed in claim 1 wherein said primary charging circuit comprises an array of primary windings, and wherein when a device is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

17. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to enable a said device to be moved over said charging surface while being charged.

18. A charging module for a battery charging system, said module comprising a primary charging circuit and being formed with a charging surface for receiving

an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

19. A charging module as claimed in claim 18 wherein when an electronic device to be charged is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

20. A charging module as claimed in claim 18 wherein said transformer primary windings are connected to each other in series and/or in parallel.

21. A charging module as claimed in claim 18 wherein said primary transformer windings are planar and substantially parallel to a planar charging surface.

22. A charging module as claimed in claim 21 wherein said primary windings are formed in at least two planes, each said plane including an array of said windings.

23. A charging module as claimed in claim 22 wherein the array of a first said plane is offset relative to the array of a second said plane whereby regions of said first array that generate maximum magnetic flux coincide with regions of said second array that generate minimum magnetic flux.

24. A charging module as claimed in claim 22 comprising three layers of hexagonal windings.

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25. A charging module as claimed in claim 22 comprising four layers of square windings.

26. A charging module as claimed in claim 21 wherein said primary windings are formed on a printed circuit board.

27. A charging module as claimed in claim 21 wherein electromagnetic shielding is provided on the side of said primary windings opposite from said planar charging surface.

28. A charging module as claimed in claim 27 wherein said shielding comprises a sheet of ferrite material.

29. A charging module as claimed in claim 28 wherein said shielding further comprises a second sheet of conductive material.

30. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow two or more devices to be charged thereon simultaneously.

31. A charging module as claimed in claim 18 wherein said charging surface is large enough to allow a device to be moved over the charging surface while being charged.

32. A battery powered portable electronic device comprising a rechargeable battery, and wherein said device includes a planar secondary winding for receiving

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electrical energy from a battery charger, and electromagnetic shielding between said winding and the major electronic components of said device.

33. An electronic device as claimed in claim 32 wherein said shielding comprises a sheet of ferrite material and a sheet of conductive material.

34. An electronic device as claimed in claim 32 wherein said winding is formed integrally with a back cover of said device.

35. A battery charging system comprising a primary module and at least one secondary module, said primary module comprising means for connecting to a mains supply, and at least one primary winding adjacent a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

36. A battery charging system as claimed in claim 35 wherein said primary charging module comprises a plurality of primary windings each associated with a respective charging surface whereby said primary charging module is able to receive a plurality of secondary charging modules simultaneously.

37. A battery charging system as claimed in claim 36 wherein said charging surfaces are provided with engagement means for engaging a secondary module.

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38. A battery charging system as claimed in claim 37 wherein said engagement means include a mechanical switch whereby power is supplied to said primary winding only when a secondary module is engaged by a charging surface.

39. A battery charging system as claimed in claim 35 wherein said primary winding is formed by a coil.

40. A battery charging system as claimed in claim 39 wherein said coil is wound on a magnetic structure.

41. A battery charging system as claimed in claim 39 wherein said coil is parallel to said charging surface.

42. A battery charging system as claimed in claim 35 wherein said primary winding is printed in a printed circuit board.

43. A battery charging system as claimed in claim 42 wherein said printed circuit board is parallel to said charging surface.

44. A battery charging system as claimed in claim 35 wherein said secondary winding is formed by a coil.

45. A battery charging system as claimed in claim 44 wherein said coil is parallel to said charging surface.

46. A battery charging system as claimed in claim 1 wherein said secondary winding is printed on a printed circuit board.

47. A battery charging system as claimed in claim 46 wherein said printed circuit board is parallel to said charging surface.

48. A secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

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【裏面有】

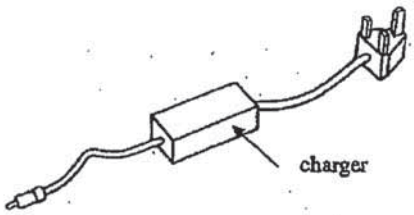

FIG.1 (PRIOR ART)

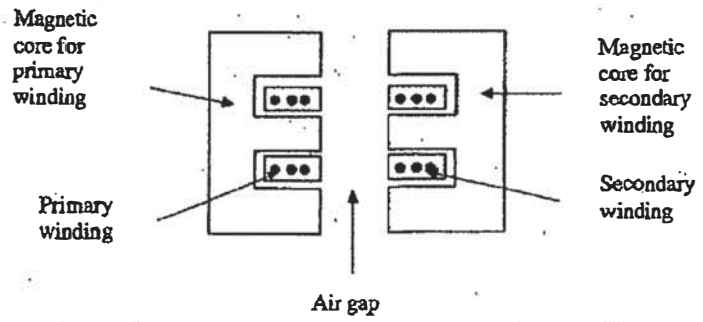

FIG.2 (PRIOR ART)

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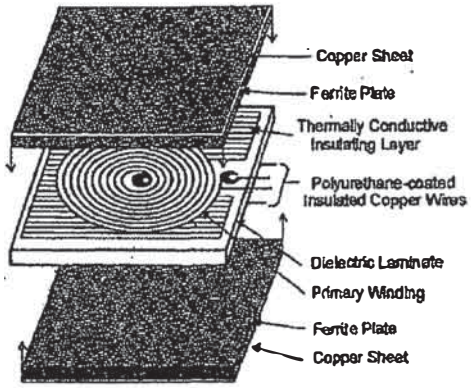

FIG.3 (PRIOR ART)

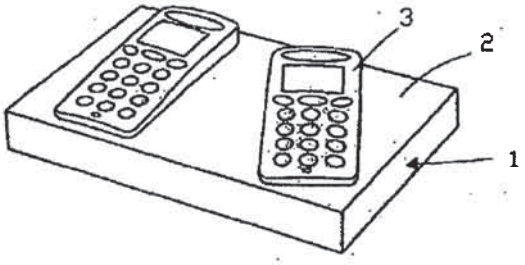

FIG.4(a)

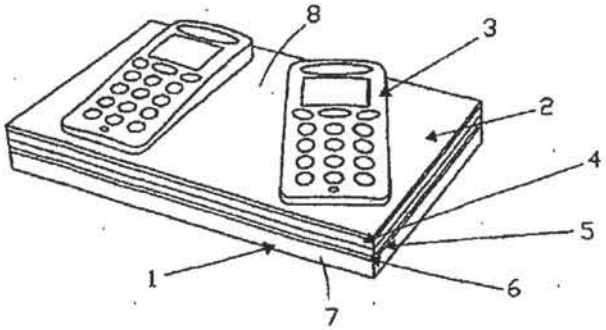

FIG.4(b)

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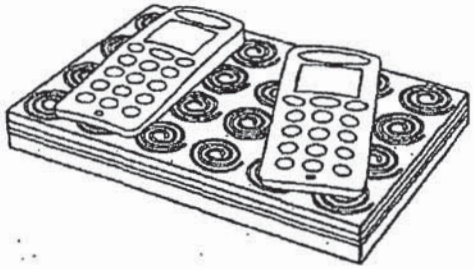

FIG.4(c)

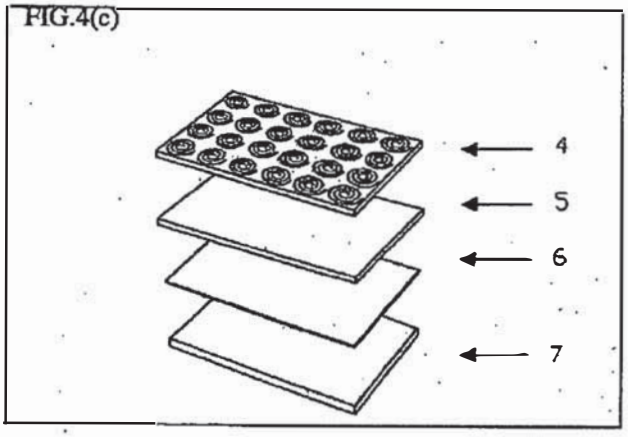

FIG.5(a)

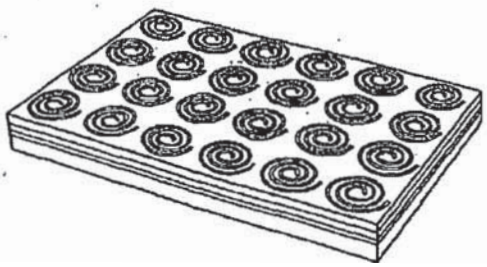

FIG.5(b)

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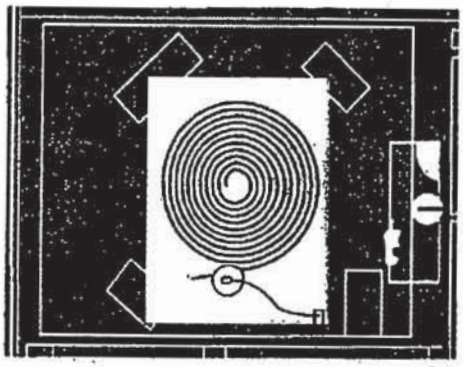

FIG.6(a)

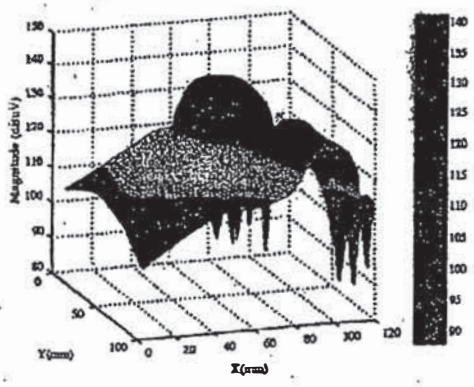

FIG.6(b)

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【裏面有】

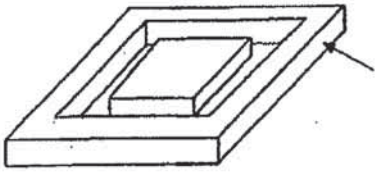

FIG.7(a)

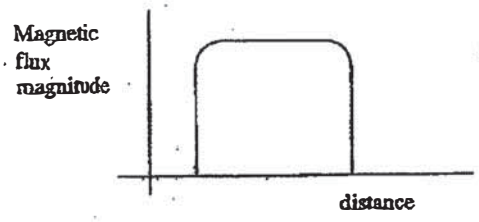

FIG.7(b)

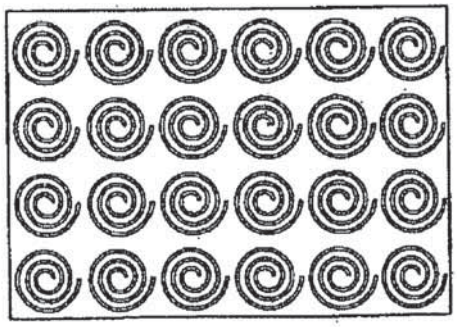

FIG.8

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FIG.9(a)

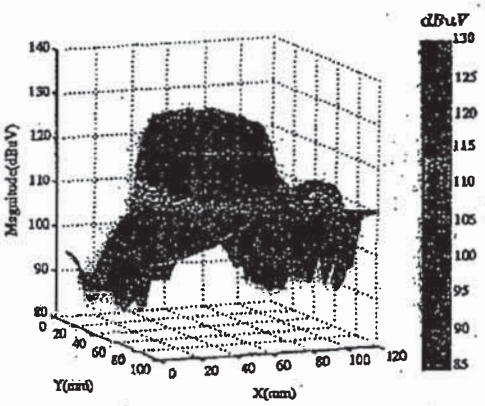

FIG.9(b)

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【裏面有】

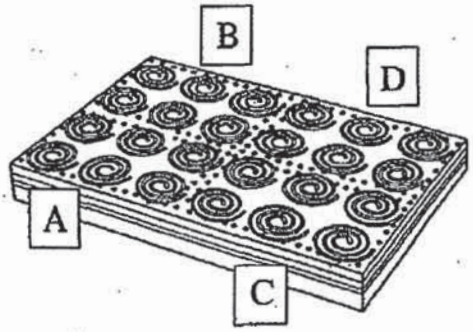

FIG.10(a)

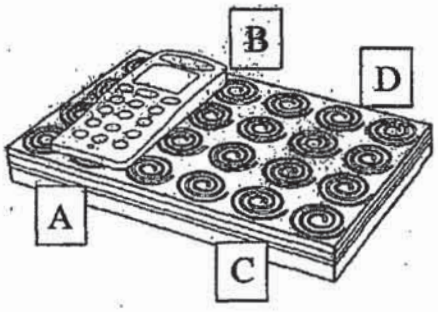

FIG.10(b)

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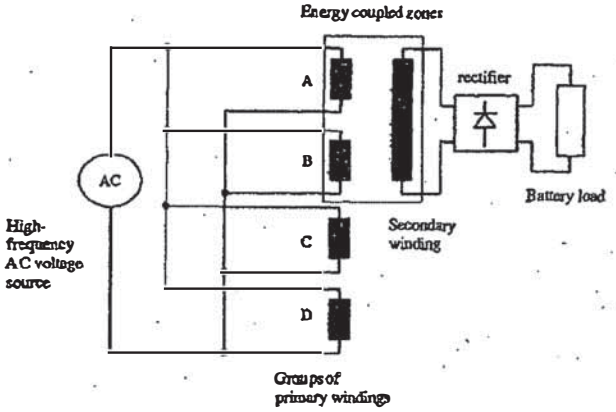

FIG.10(c)

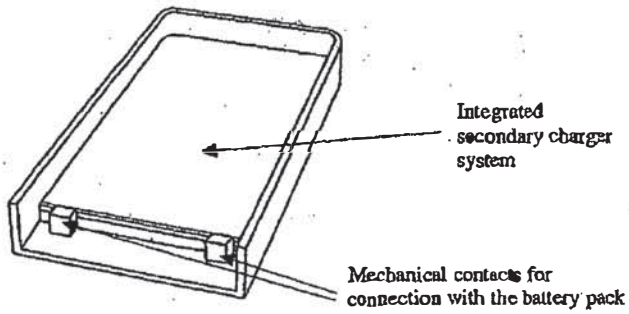

FIG.11

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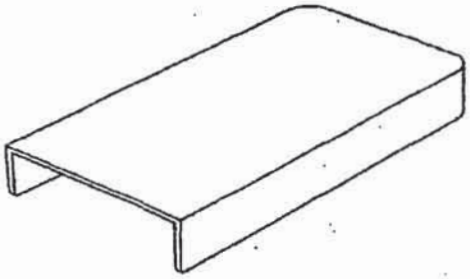

FIG.12(a)

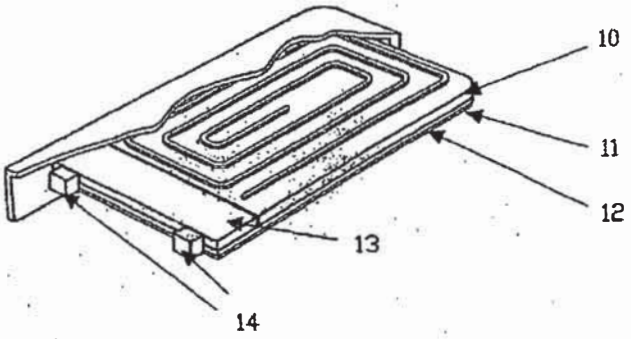

FIG.12(b)

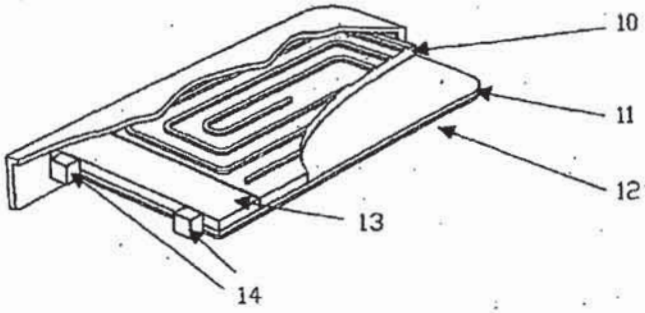

FIG.12(c)

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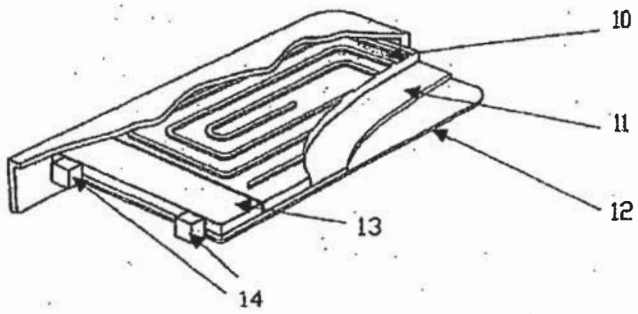

FIG.12(d)

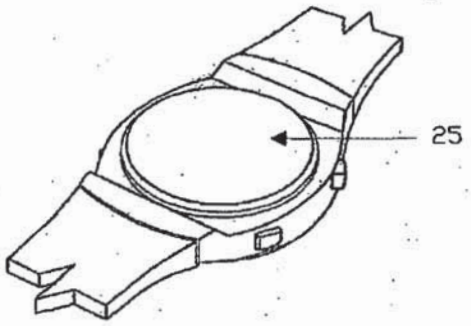

FIG.13(a)

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【裏面有】

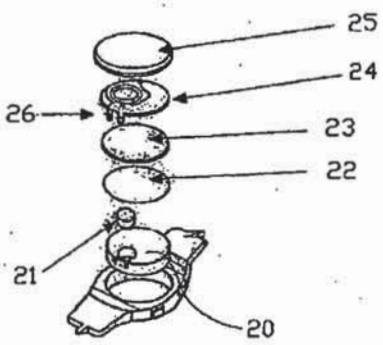

FIG.13(b)

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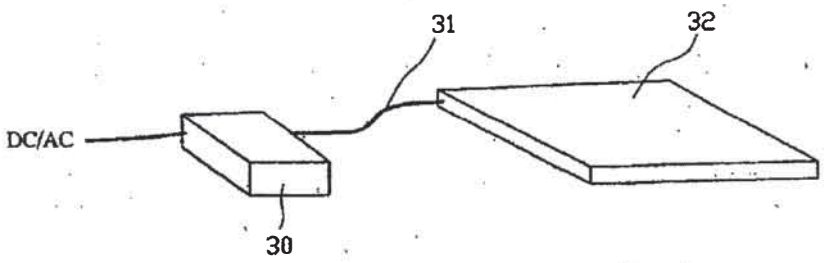

FIG.14

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【裏面有】

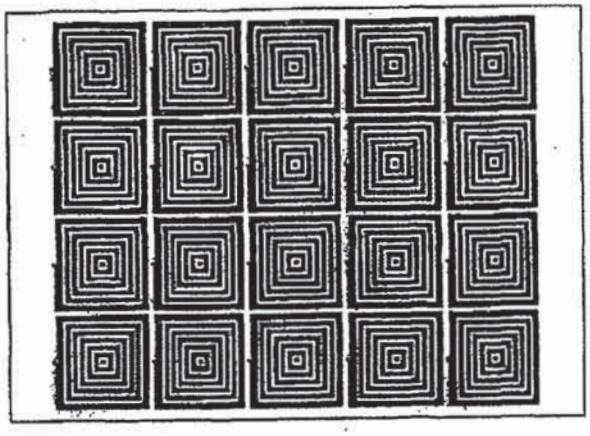


FIG.15

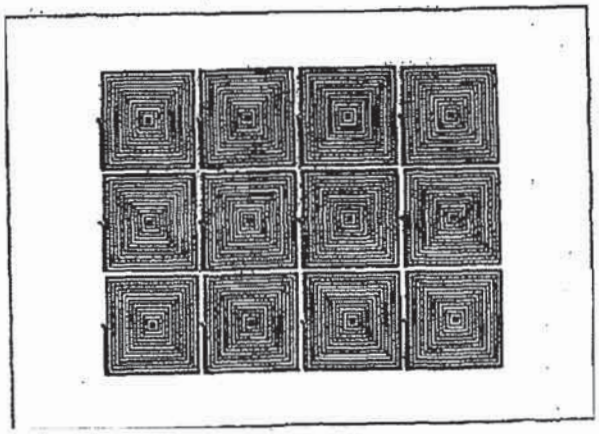


FIG.16

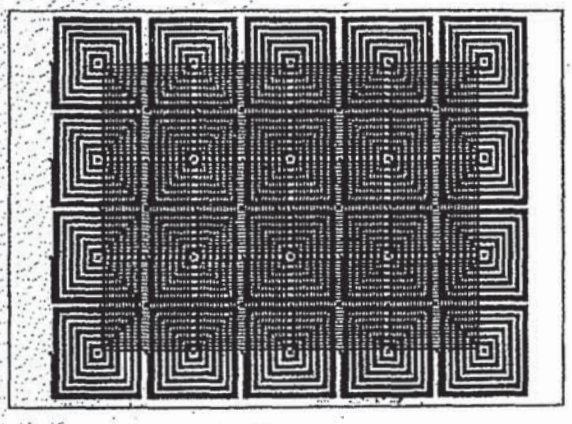


FIG.17

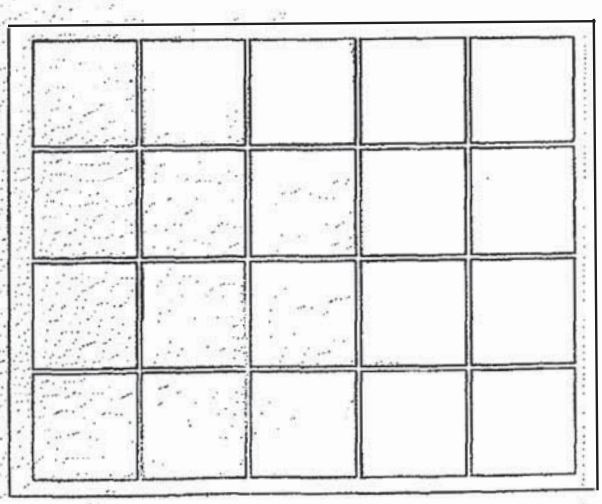


FIG.18

51

【裏面有】

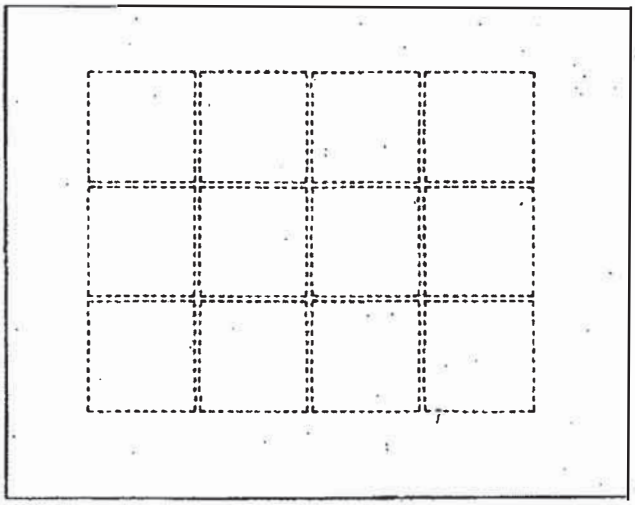
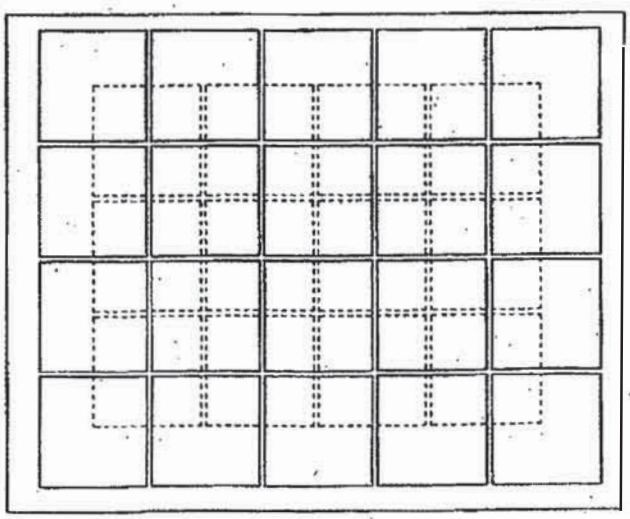


FIG.19



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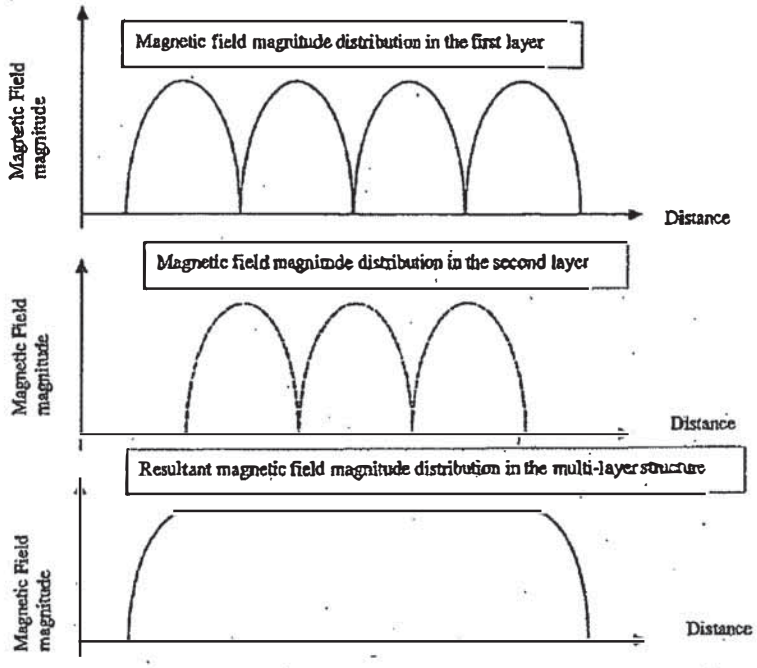

FIG.21

FIG.22

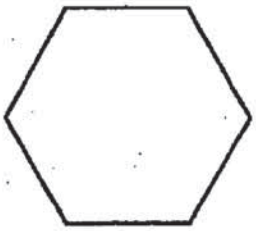

FIG.23

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【裏面有】

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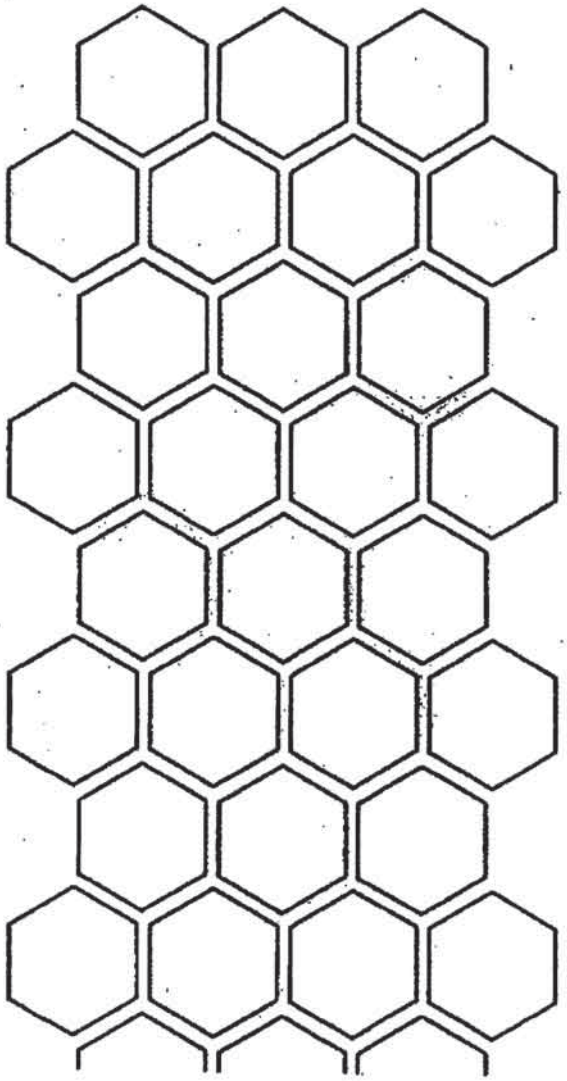

FIG.24

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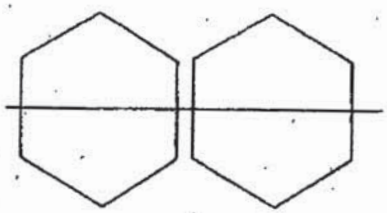

FIG.25

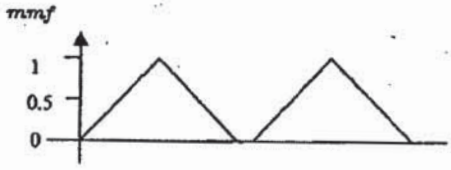

FIG.26

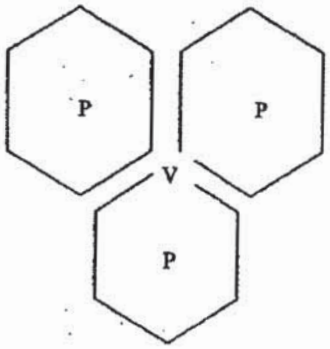

FIG.27

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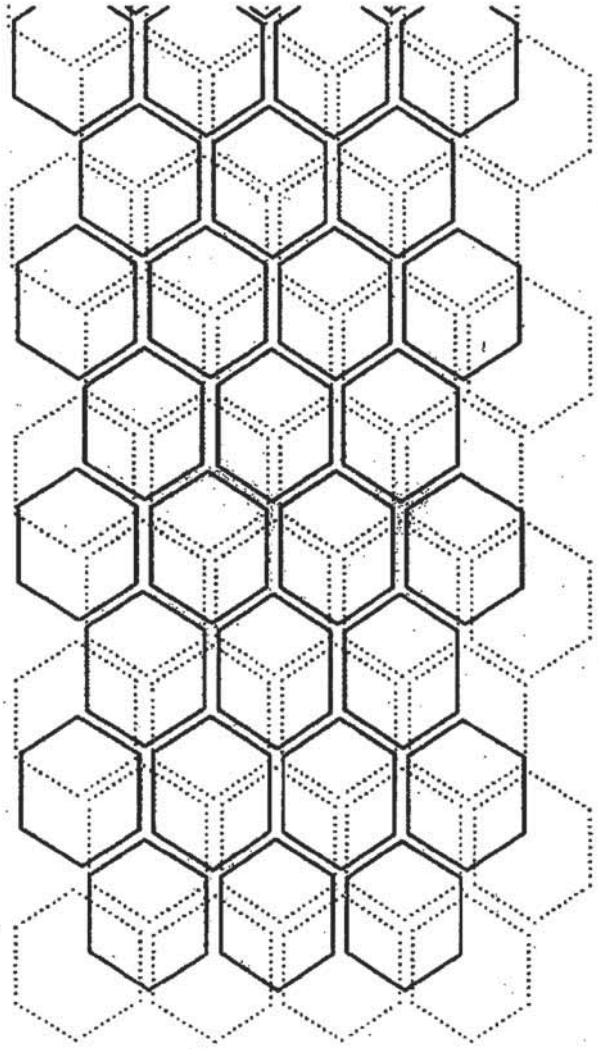

FIG.28

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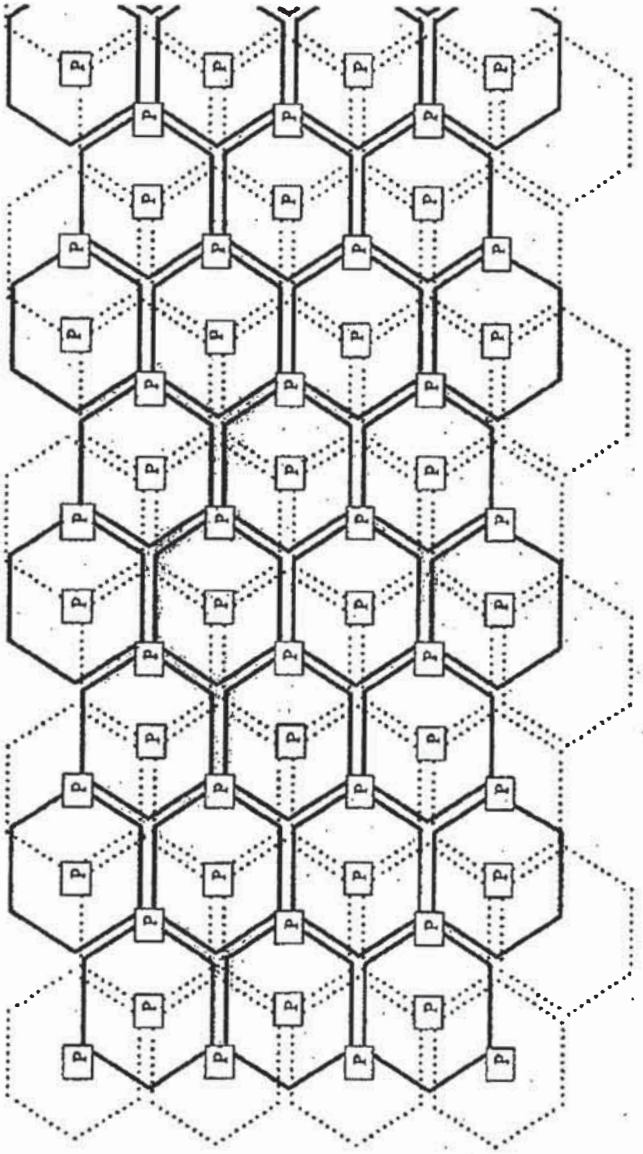

FIG.29

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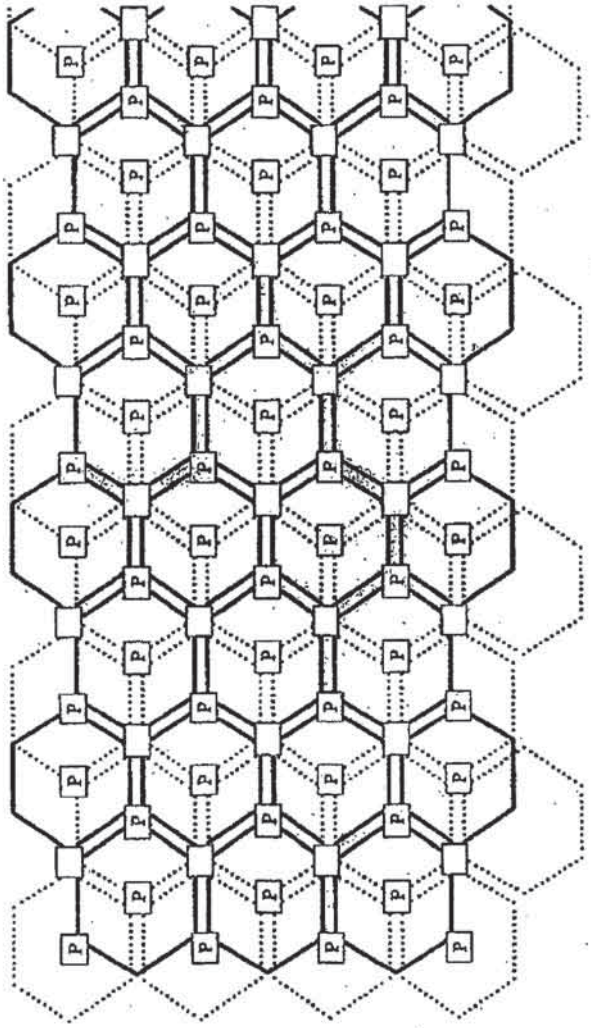

FIG.30

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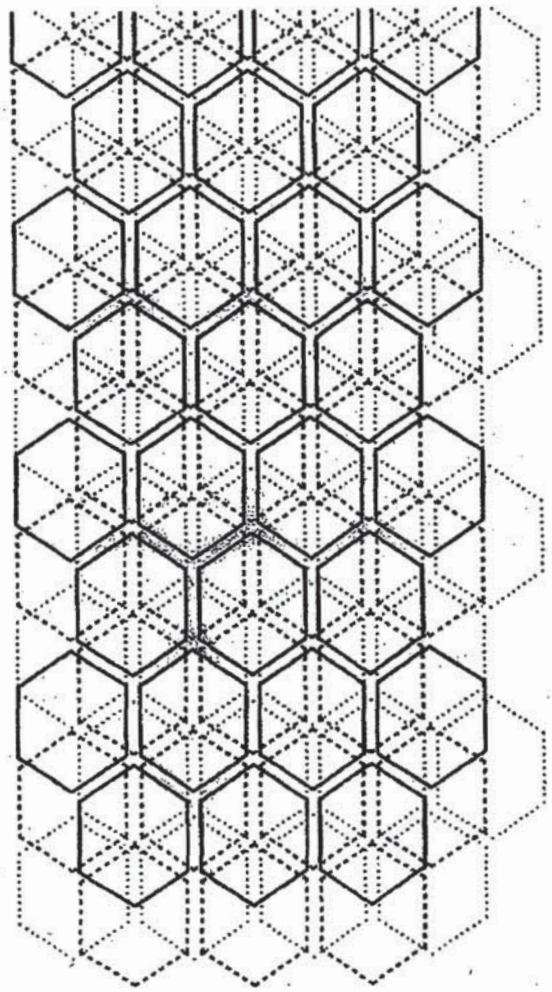

FIG.31

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【裏面有】

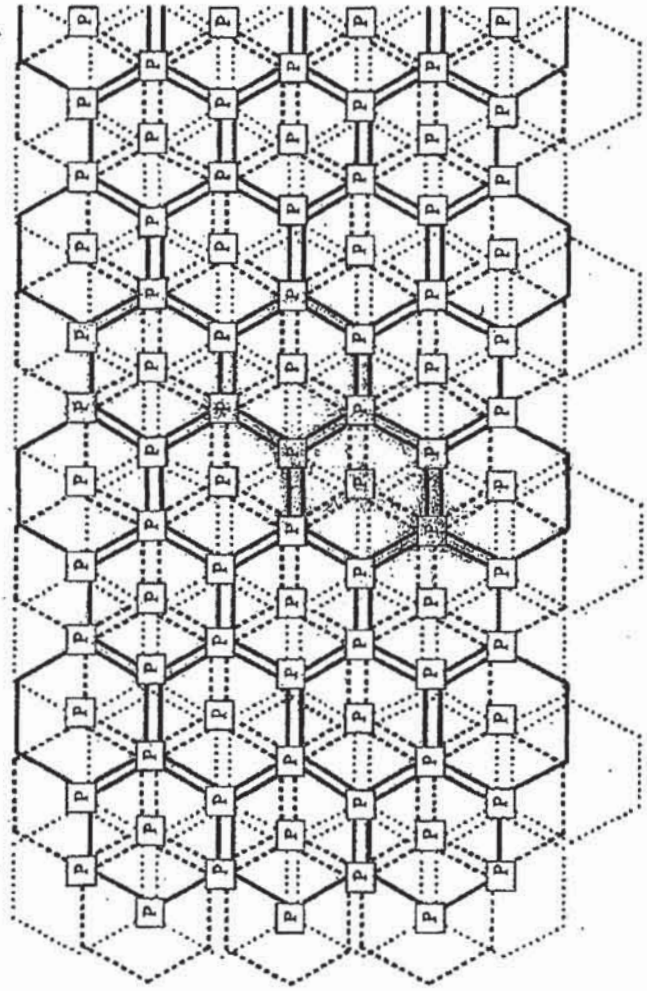

FIG.32

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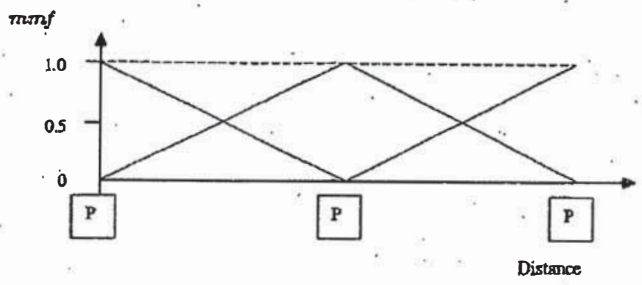

FIG.33

FIG.34

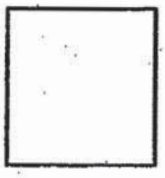

FIG.35

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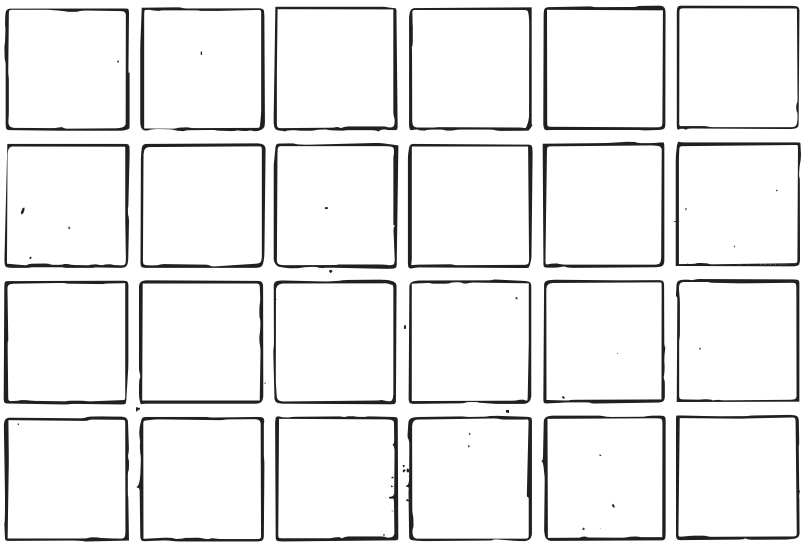

FIG.36

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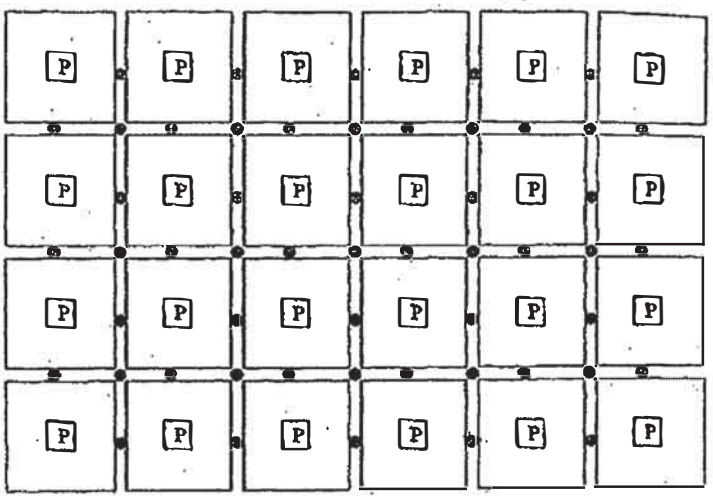

FIG.37

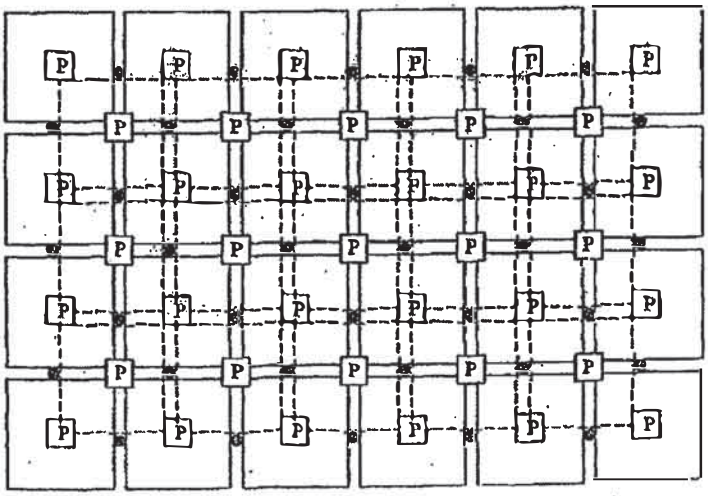

FIG.38

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【裏面有】

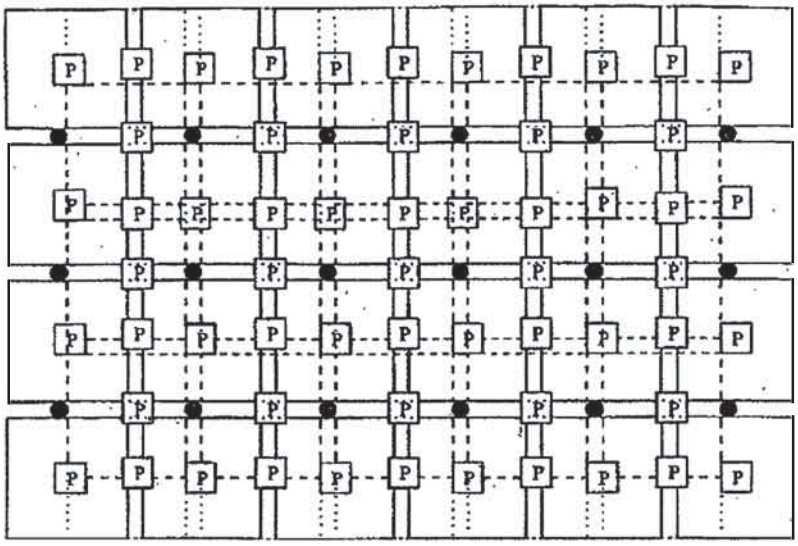

FIG.39

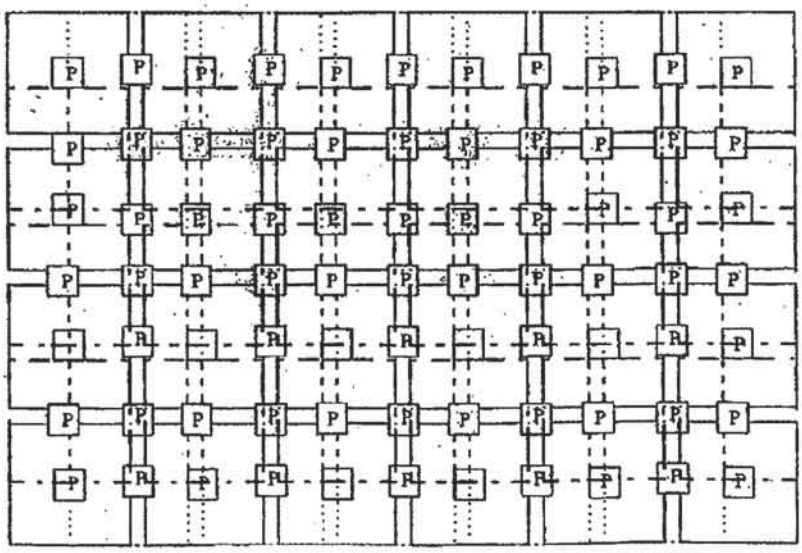

FIG.40

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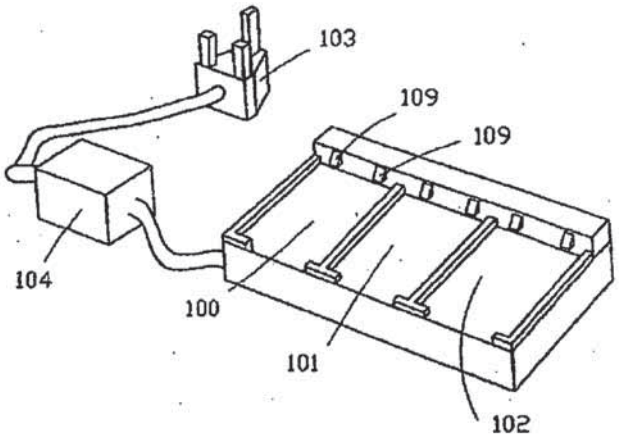

FIG.41

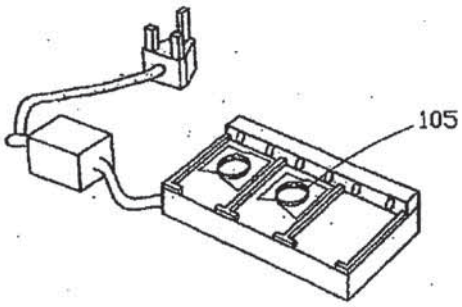

FIG.42

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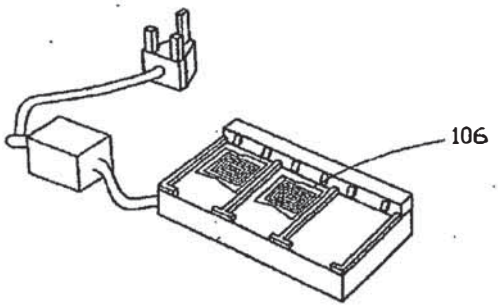

FIG.43

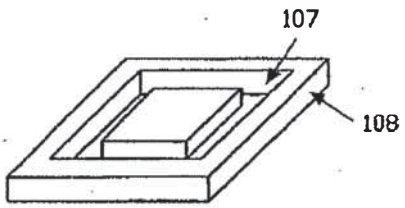

FIG.44(a)

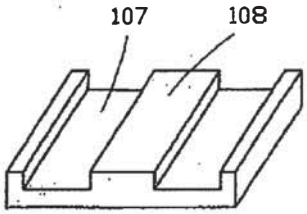

FIG.44(b)

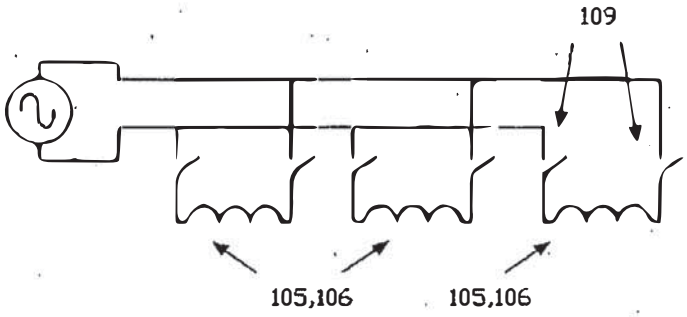

FIG.45

Momentum Dynamics Corporation
Exhibit 1009
Page 626

66

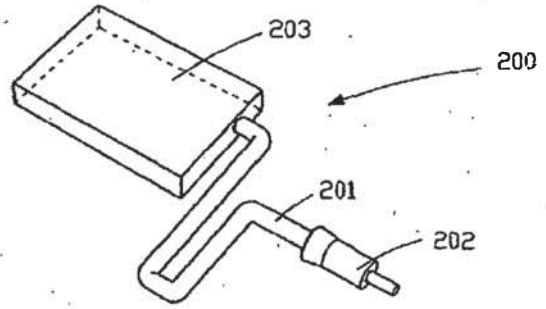

FIG.46

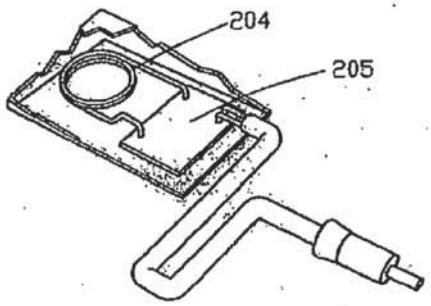

FIG.47

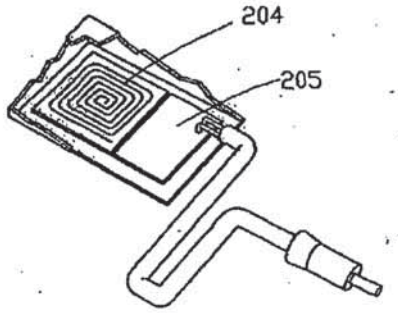

FIG.48

Momentum Dynamics Corporation
Exhibit 1009
Page 627

67

【書類名】

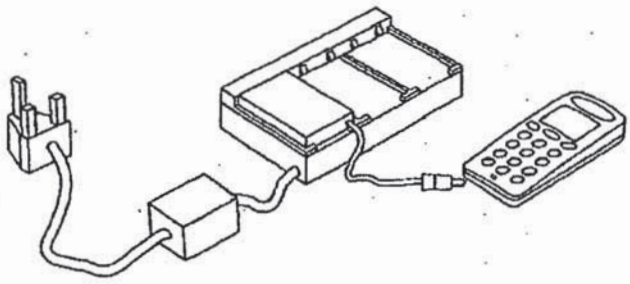

FIG.49

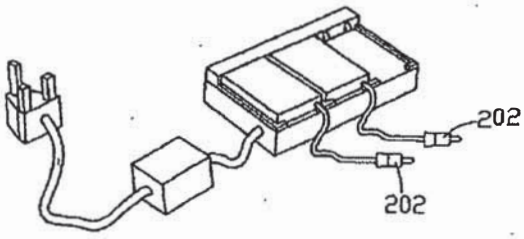

FIG.50

Momentum Dynamics Corporation
Exhibit 1009
Page 628

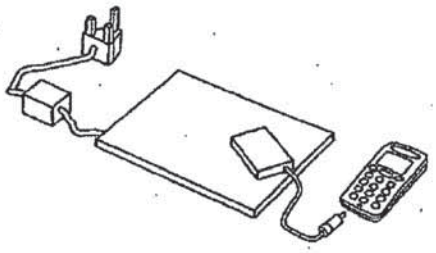

FIG.51

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【裏面有】

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl [7]: H02J 7/00, H01F 38/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI, IEEE (battery, charger, coils, flat, shield)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	HATANAKA, K. et al. "Power Transmission of a desk with a cord-free power supply" IEEE Transactions on Magnetics Volume: 38, Issue: 5, September 2002 Pages 3329-3331	18-21,31
X	HATANAKA, K. et al. "Characteristics of the desk with cord-free power supply" INTERMAG 2002, DIGEST OF TECHNICAL PAPERS 28 April-2 May 2002 Abstract, whole document	18
X	EP 298707 B (SEIKO EPSON CORPORATION) 28 September 1994 Whole document	1,4,11,32
Y	Column 4 line17-22, column 3 lines 11-26	2,3

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2003	- 9 JUL 2003
Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	DALE E. SIVER Telephone No : (02) 6283 2196

Form PCT/ISA/210 (second sheet) (July 1998)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00721

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6008622 A (NAKAWATASE) 28 December 1999 Column 1 lines 39-43, column 2 lines 5-17, 21-23, 49-55	1,4,11,32
Y	US 6265789 B (HONDA et al.) 24 July 2001 Abstract, figures, claim 8, column 7 lines 8-23, column 11 lines 62-66	2,3
Y	WO 00/02212 A (ABIOMED, INC.) 13 January 2000 Abstract, Figure 1,7, page 2 lines 5-9	1,11,32,33
A	US 6172884 B (LANNI) 9 January 2001 Abstract, figures, column 18 line 63 to column 19 line 60	35-36,42,48

Form PCT/ISA/210 (continuation of Box C)(July 1998)

Best Available Copy

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU03/00721

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	298707	JP	62260735	EP	245999	ES	2003287
		US	5246734				
US	6008622	JP	11103531				
US	6265789	EP	977297	WO	9927603		
WO	200002212	AU	48613/99	CA	2336725	EP	1095384
		US	6324430	US	2002055763	US	6389318
		US	2002058971				
US	6172884	US	5479331	US	5686110	US	5838554
		US	5949213	US	6091611	US	6266261
		US	2003042881	AU	200153089	CA	2403856
		EP	1273093	WO	200176051		

END OF ANNEX

Form PCT/ISA/210 (citation family annex) (July 1998)

505337528 02/20/2019

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT5384309

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	LICENSE

CONVEYING PARTY DATA

Name	Execution Date
QUALCOMM INCORPORATED	02/01/2019

RECEIVING PARTY DATA

Name:	WITRICITY CORPORATION
Street Address:	57 WATER STREET
City:	WATERTOWN
State/Country:	MASSACHUSETTS
Postal Code:	02472

PROPERTY NUMBERS Total: 69

Property Type	Number
Patent Number:	10079510
Application Number:	14386206
Patent Number:	9899145
Patent Number:	6621183
Patent Number:	6705441
Patent Number:	7969269
Application Number:	13930505
Application Number:	14529939
Application Number:	12998031
Patent Number:	8749334
Patent Number:	9466419
Patent Number:	9767955
Patent Number:	10106046
Application Number:	16138653
Application Number:	13261001
Application Number:	13389210
Application Number:	15324736
Patent Number:	9077194
Application Number:	13261259
Application Number:	14948702

Property Type	Number
Application Number:	13698851
Application Number:	13131155
Patent Number:	8923015
Patent Number:	9461480
Application Number:	15281591
Patent Number:	9653207
Application Number:	15449243
Application Number:	13389090
Patent Number:	9369058
Patent Number:	9912250
Application Number:	15902978
Application Number:	13992757
Patent Number:	9666358
Application Number:	15497819
Patent Number:	9620281
Application Number:	15483838
Patent Number:	9966797
Application Number:	15973105
Application Number:	14233261
Application Number:	14240191
Patent Number:	9283858
Patent Number:	9071061
Application Number:	14700770
Application Number:	13814415
Patent Number:	9406436
Application Number:	14365873
Application Number:	14379068
Application Number:	14376401
Application Number:	14424390
Patent Number:	9660702
Application Number:	15487267
Patent Number:	9747792
Application Number:	15676323
Patent Number:	10056784
Application Number:	16117261
Application Number:	14424384
Application Number:	15021440
Application Number:	15510686

Property Type	Number
Application Number:	14410817
Application Number:	14780102
Application Number:	15500314
Application Number:	15324699
Application Number:	15120385
Patent Number:	7279850
Patent Number:	8953340
Application Number:	15746120
Application Number:	15750451
Application Number:	16077219
Application Number:	11575449

CORRESPONDENCE DATA

Fax Number: (617)523-1231

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 6175701000
Email: sallirampersad@goodwinlaw.com
Correspondent Name: GOODWIN PROCTER LLP
Address Line 1: 100 NORTHERN AVENUE
Address Line 2: JOEL E. LEHRER
Address Line 4: BOSTON, MASSACHUSETTS 02210

ATTORNEY DOCKET NUMBER:	123279-186271
NAME OF SUBMITTER:	SHALEENA ALLI-RAMPERSAD/PARALEGAL
SIGNATURE:	/Shaleena Alli-Rampersad/
DATE SIGNED:	02/20/2019
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 45
source=Auckland License Agreement#page1.tif
source=Auckland License Agreement#page2.tif
source=Auckland License Agreement#page3.tif
source=Auckland License Agreement#page4.tif
source=Auckland License Agreement#page5.tif
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ASSIGNMENT

This **ASSIGNMENT** (the "**Assignment**"), dated effective as of 1 February 2019 (the "**Effective Date**"), is made by WiTricity Corporation, a Delaware corporation (the "**Assignee**"), and QUALCOMM Incorporated, a Delaware corporation (the "**Assignor**").

RECITALS

WHEREAS, Assignor, Assignee and QUALCOMM Technologies, Inc., a Delaware corporation, are parties to that certain Asset Purchase Agreement, dated 1 February, 2019 (the "**Asset Purchase Agreement**"), pursuant to which Assignor assigned to Assignee, and Assignee assumed from Assignor, for the consideration, and upon the terms and conditions, set forth in the Asset Purchase Agreement, certain contracts of Assignor, including the Assigned Contract (as defined below).

WHEREAS, capitalized terms used herein but not otherwise defined shall have the meanings given to such terms in the Asset Purchase Agreement.

NOW, THEREFORE, pursuant to the Asset Purchase Agreement, and in consideration of these premises, and for good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, it is agreed that:

1. Subject to the terms of the Asset Purchase Agreement, Assignor hereby grants, sells, conveys, transfers, sets over, delivers, and assigns unto Assignee, its successors and assigns, the contract listed on Schedule A, including without limitation all of Assignor's legal and equitable rights, privileges, interest and duties in and to such contract, and Assignor's rights and licenses in and to any proprietary rights under such contract (the "**Assigned Contract**") and Assignee hereby accepts such assignment.

2. Assignor hereby covenants that from time to time after the delivery of this instrument, at Assignee's reasonable request and without further consideration, Assignor will execute and deliver any further documents and take any further actions as reasonably may be required to convey, transfer to and vest in Assignee, and to put Assignee in possession of, any of the Assigned Contract transferred hereby.

3. Assignor hereby requests the United States Patent and Trademark Office Commissioner for Patents and any other applicable governmental entity or registrar (including any applicable foreign or international office or registrar), to record Assignee as the assignee and owner of the Assigned Contract.

4. Nothing contained in this Assignment shall be deemed to modify, supersede, enlarge or affect the rights of any person under the Asset Purchase Agreement. If any provision of this Assignment is inconsistent or conflicts with the Asset Purchase Agreement, the Asset Purchase Agreement shall control.

5. All of the covenants, terms and conditions set forth herein shall be binding upon and shall inure to the benefit of the parties hereto and their respective successors and assigns.

6. No modification, waiver or termination of this Assignment shall be binding unless executed in writing by the party to be bound thereby. No waiver of any of the provisions of this Assignment shall be deemed or shall constitute a waiver of any other provision hereof, nor shall such waiver constitute a continuing waiver unless otherwise expressly provided.

7. This Assignment is governed by, and all disputes arising under or in connection with this Assignment shall be resolved in accordance with, the laws of the State of Delaware, United States (to the exclusion of its conflict of laws rules).

8. This Assignment may be executed and delivered (including by facsimile or electronic transmission) in two or more counterparts, and by the different parties hereto in separate counterparts, each of which when executed and delivered shall be deemed to be an original but all of which taken together shall constitute one and the same agreement.

(REMAINDER OF PAGE INTENTIONALLY LEFT BLANK)

IN WITNESS WHEREOF, the parties have executed this Assignment on the date first above written.

QUALCOMM INCORPORATED

By: _____
Name: Raymond B Hom
Title: VP, Patent Counsel

ACKNOWLEDGMENT

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California

County of San Diego____)

On 1 February 2019, before me, Angela R. Gonzales, Notary Public, personally appeared Raymond B Hom, who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature Angela Gonzales (Seal)

ANGELA R. GONZALES
Commission # 2144941
Notary Public - California
San Diego County
My Comm. Expires Mar 26, 2020

WiTricity Corporation

By: _____
Name: Donald R. Peck
Title: Chief Financial Officer

[SIGNATURE PAGE TO ASSIGNMENT]

SCHEDULE A TO ASSIGNMENT

1. The Amended and Restated License Agreement, dated October 14, 2011, by and between Auckland UniServices Limited and Qualcomm Incorporated as the successor in interest to Halo Inductive Power Technologies Limited, as amended by that certain letter agreement dated July 31, 2012, by and between Auckland UniServices Limited and Qualcomm Incorporated, as amended by that certain Second Amendment, dated October 14, 2011, as amended by that certain Third Amendment, dated October 14, 2011, as amended by that certain Fourth Amendment, dated May 1, 2017.

Confidential

AUCKLAND UNISERVICES LIMITED,
a company incorporated and registered in
New Zealand with company number 373821
(the "Licensor")

HALO INDUCTIVE POWER TECHNOLOGIES LIMITED,
a company incorporated and registered in
Guernsey, Channel Islands, with company number 51792
(the "Licensee")

AMENDED AND RESTATED LICENSE AGREEMENT

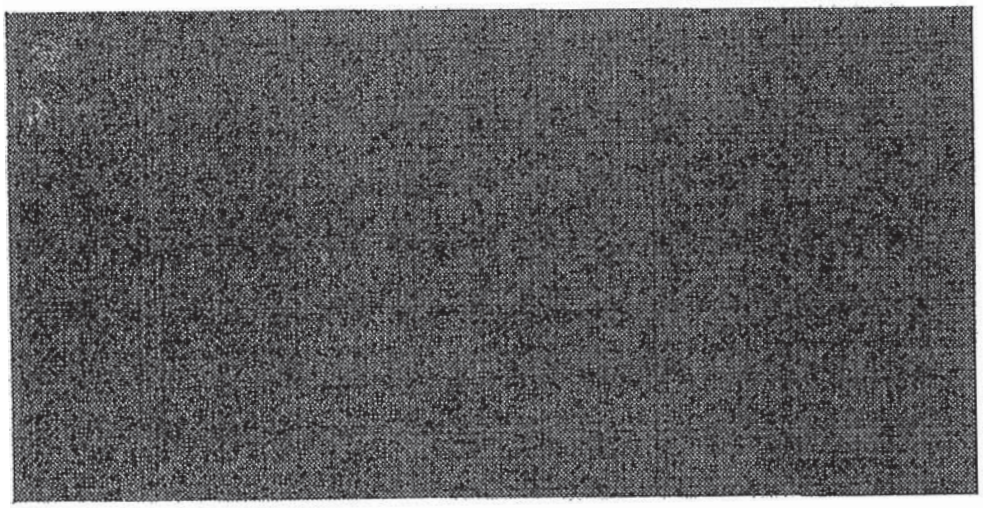
AMENDED AND RESTATED
LICENSE AGREEMENT

THIS AMENDED AND RESTATED LICENSE AGREEMENT (this "Agreement") is executed by the Licensor (as defined below) and the Licensee (as defined below) on this 11th day of October, 2011 (the "Execution Date"). This Agreement shall, however, have retroactive effect to May 10, 2010 since this Agreement shall supersede and replace in its entirety the Original Exclusive License Agreement (as defined below) and Original Joint License Agreement (as defined below) from their inception.

PARTIES

1. AUCKLAND UNISERVICES LIMITED, a company incorporated and registered in New Zealand with company number 373821 (the "Licensor"), and

2. HALO INDUCTIVE POWER TECHNOLOGIES LIMITED, a company incorporated and registered in Guernsey, Channel Islands, with company number 51792 (the "Licensee").



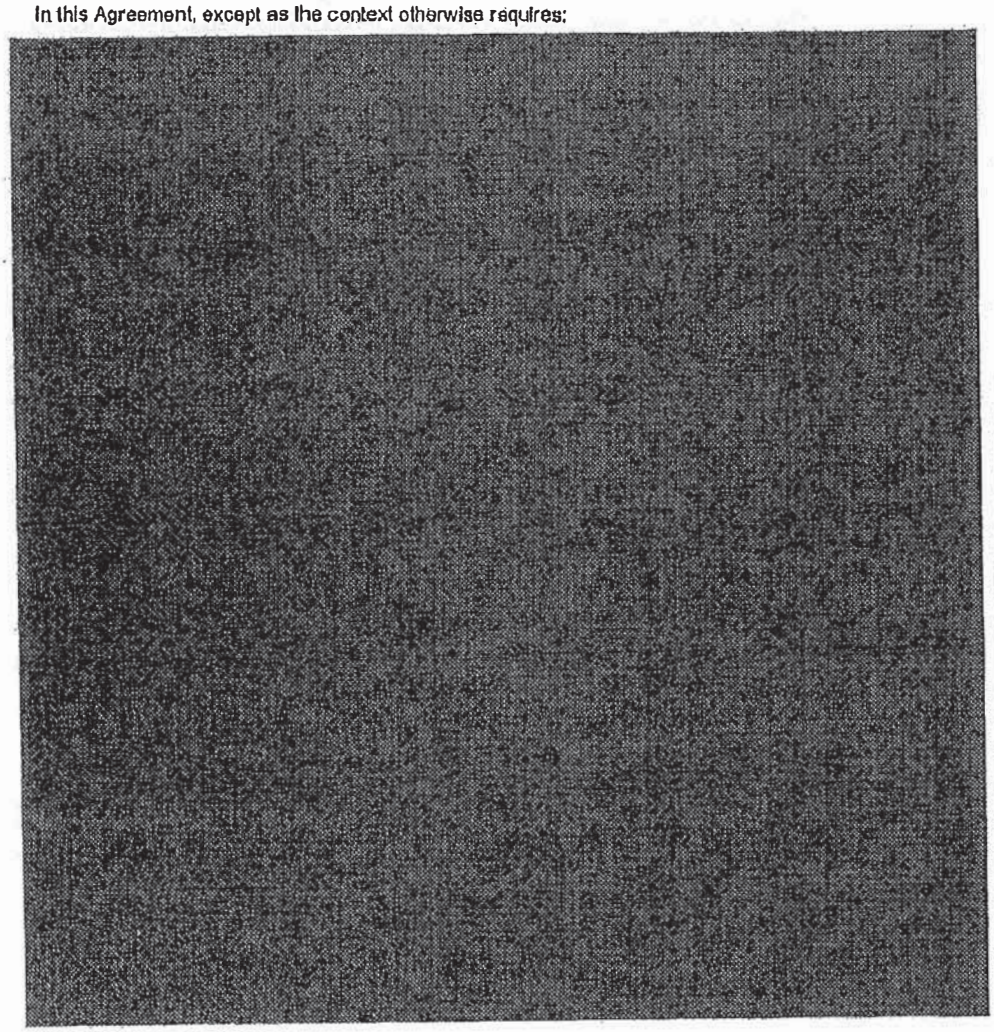
NOW, THEREFORE, for good and valuable consideration, the receipt and legal sufficiency of which is hereby acknowledged, the Licensor and the Licensee hereby amend and restate the Original Exclusive License Agreement and Original Joint License Agreement in their entirety and from their inception, as follows:

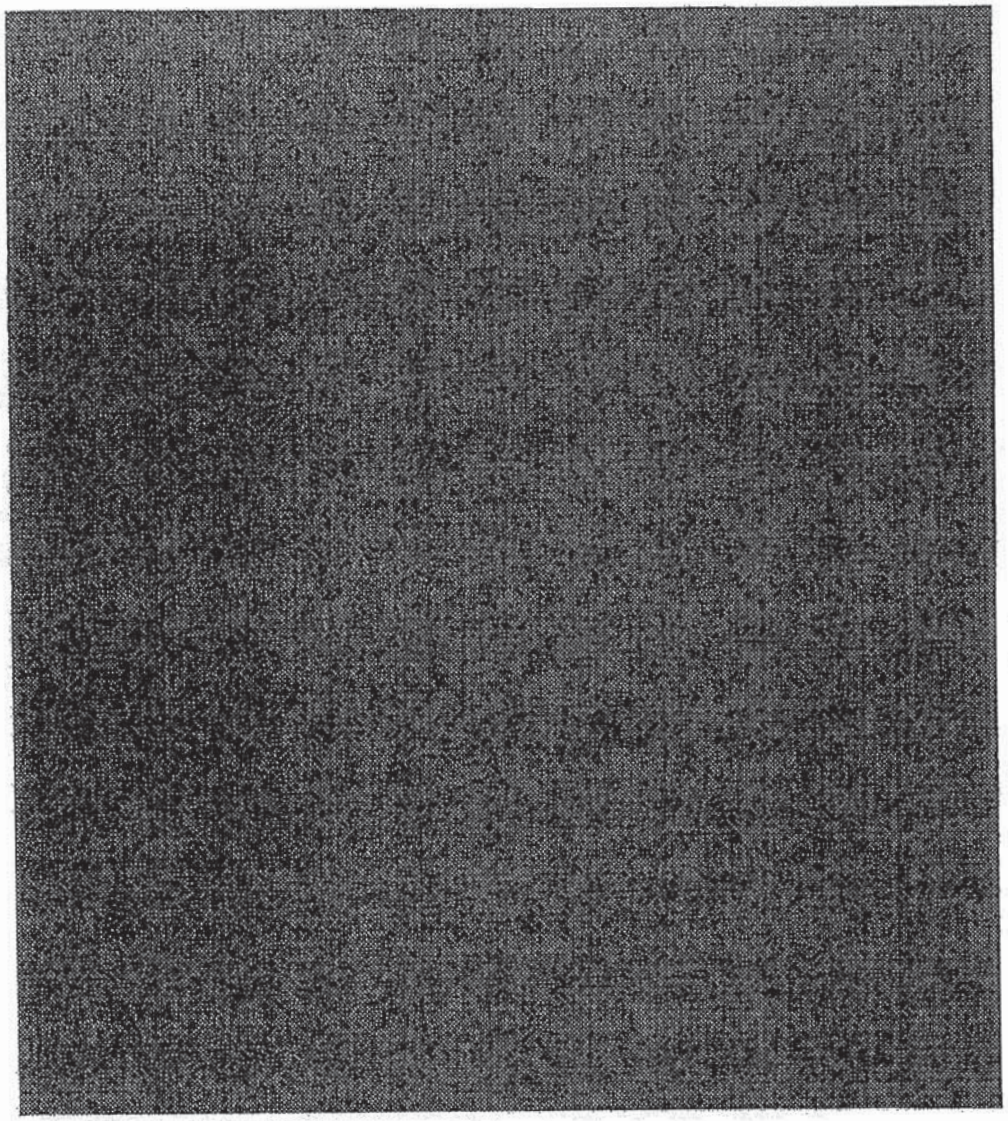
AGREEMENT

1. DEFINITIONS AND INTERPRETATION

Definitions

1.1 In this Agreement, except as the context otherwise requires:





"Dynamic Demand Control" means technology to adjust load elements on a power receiver or transmitter based on the monitoring of the frequency of the transmission or receipt of power, and possibly other power control parameters, in order to permit individual, intermittent power loads to switch on or off at optimal moments in order to balance an overall power system load generation, thereby reducing power mismatches.

"Exclusive Intellectual Property Rights" means all Intellectual Property Rights, including, without limitation, any patent rights and Know-How rights, claiming, protecting or relating to any of the following:

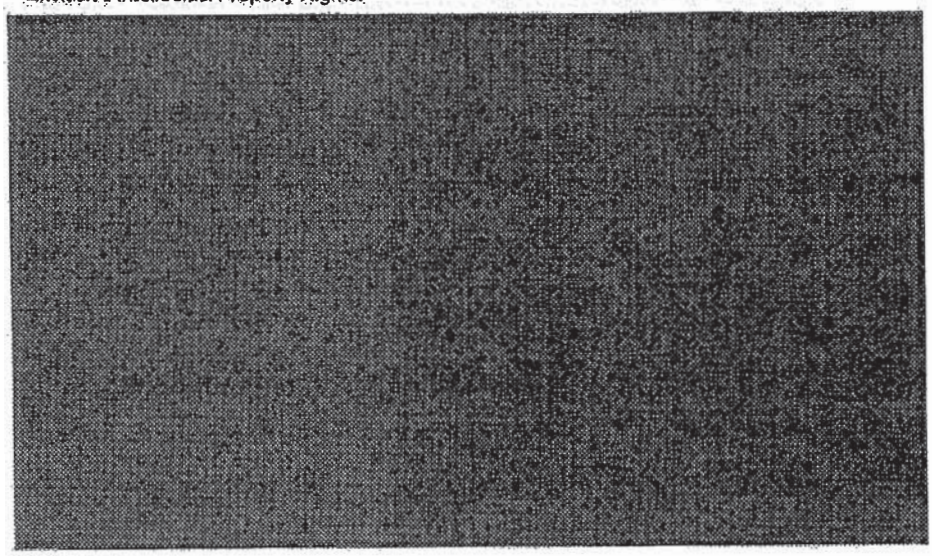
(a) the inventions claimed in the patents and patent applications listed on Schedule 1, including, without limitation, any patents or patent applications deriving priority therefrom;

(b) any improvements to the same;

(c) any technology included in this Agreement by the Licensee through the exercise of its rights under the New Co-operation Agreement to include such technology within the exclusive license granted in this Agreement; or

(d) such other technology relevant to the Field, including, but not limited to, technology relating to IP-DT and Dynamic Demand Control, which were solely owned or controlled by the Licensor on May 19, 2010; which for the avoidance of doubt excludes under this clause (d) the patent rights covered by the Licensor's IPT patent families 31, 32, 39, 40, 41 and 42 (as disclosed by the Licensor to the representatives of Qualcomm immediately prior to the Execution Date).

"Exclusive Licensed Product" means any product the manufacture, use, sale, importation, exportation or disposal of which would, but for the license granted hereunder, infringe any of the Exclusive Intellectual Property Rights.



[redacted]

"Field" means products which enable a Road Vehicle to initiate, capture, control, transmit and/or receive energy or power on a wireless basis by means of magnetic and/or resonant induction.

[redacted]

"Improvements" means any improvements, modifications, additions or developments of or to any of the claims made in a patent or patent application, permitted to be included in that patent or patent application.

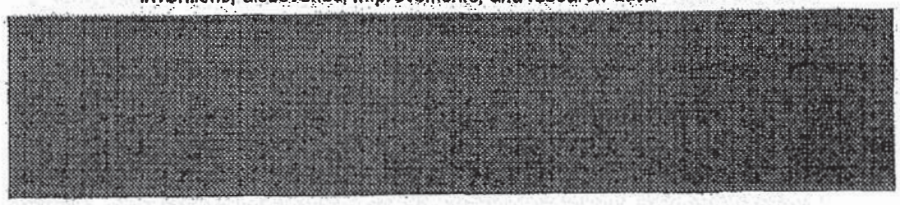
"Intellectual Property Rights" means any and all rights to and interests in, or protecting, any and all industrial and intellectual property of any kind, whether or not in a material form, including but not limited to:

(a) copyrights (excluding those in academic articles), trade mark rights, design rights, all rights relating to confidential information and inventions, patent applications and patents (or equivalent in any jurisdiction), together with any right to apply for

Momentum Dynamics Corporation
Exhibit 1009
Page 647

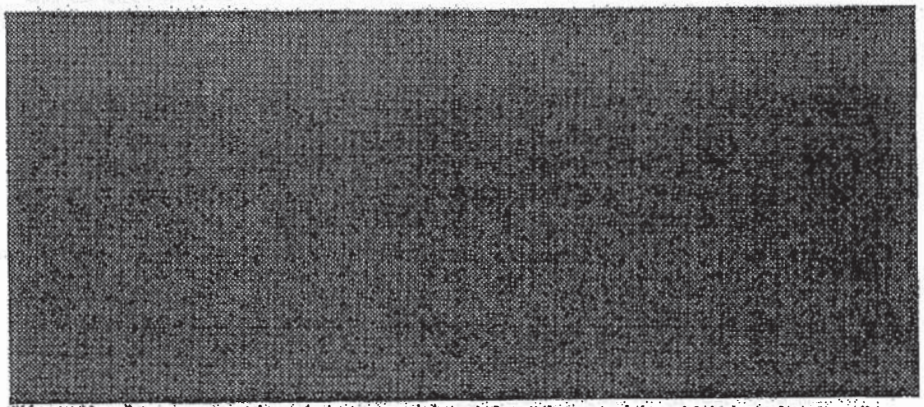
registration of any such intellectual property rights anywhere in the world, any right to claim priority under international convention for any such applications and all rights conferred by such industrial or intellectual property when registered or granted; and

(b) all rights to and in any processes, formulae, designs, reports, drawings, specifications, software, blue prints, Know-How, experiences, characteristics, inventions, discoveries, improvements, and research data.



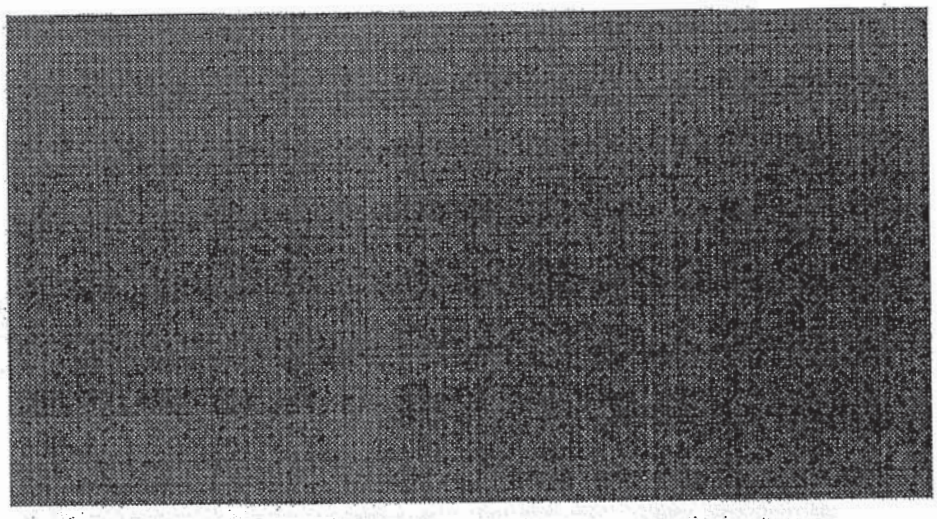
"IP-DT" means inductive power distribution technology.

"IPT" means inductive power technology.

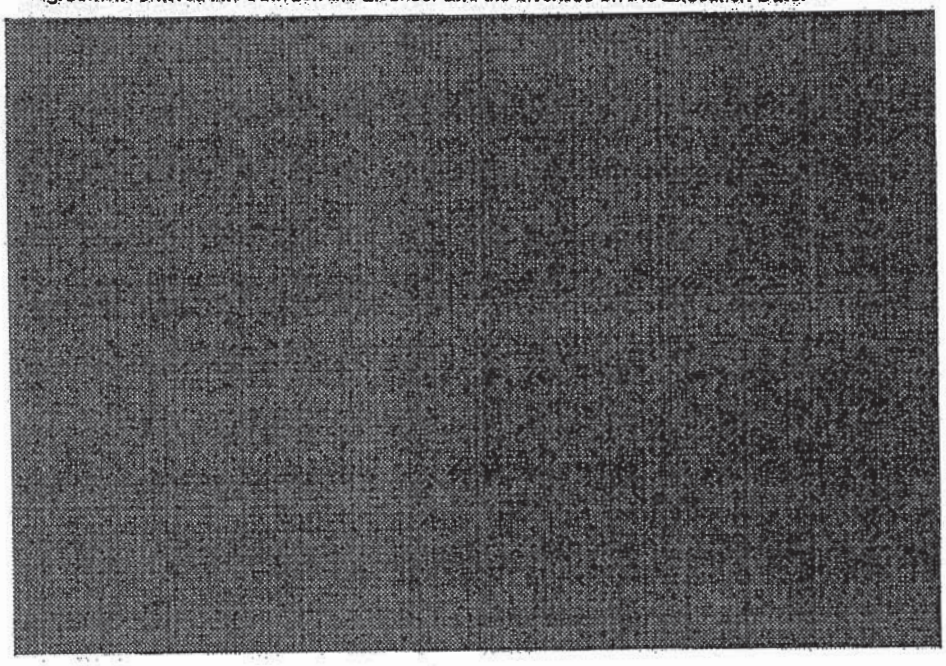


"Know-How" means any knowledge, proprietary information or data which is not generally publicly known, including, without limitation, all manufacturing, formulation and scientific research information, whether or not capable of precise separate description.

***Page 7 redacted



"New Co-operation Agreement" means that certain Amended and Restated Co-operation Agreement entered into between the Licensor and the Licensee on the Execution Date.



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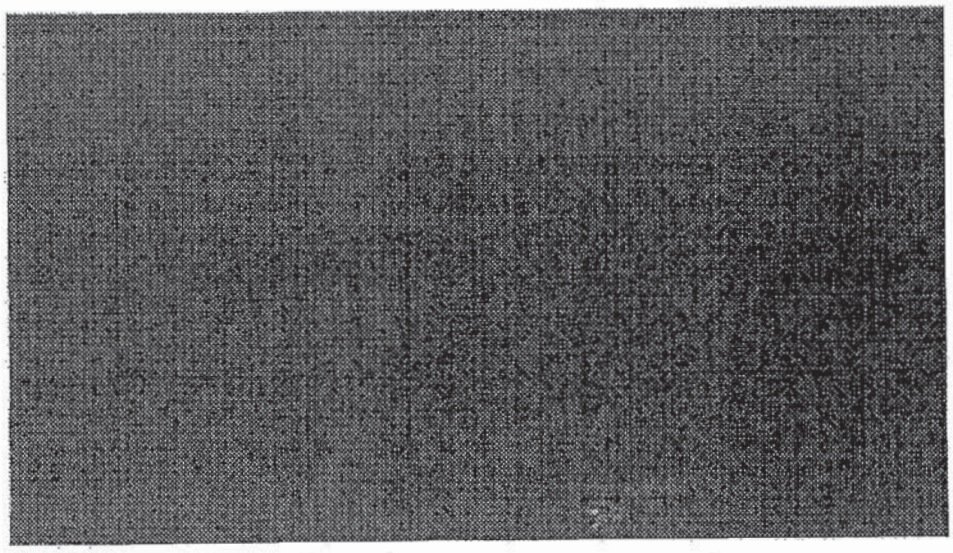


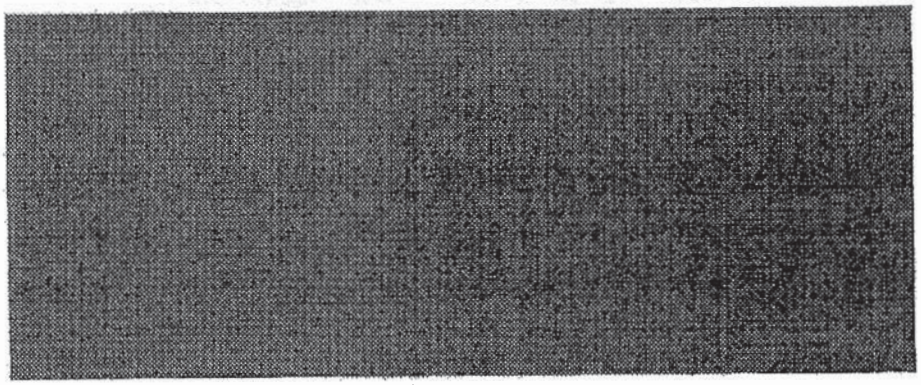
"Road Vehicle" means any vehicle having one or more wheels, which is designed:

(a) for use on a public or private road;

(b) to be driven or controlled by a human driver; and

(c) to transport people or goods.

Notwithstanding anything above, the term "Road Vehicle" does not include any vehicle primarily designed for materials handling use in ports, surface mining and underground mining sites and airports and any forklift, automatic guided vehicle, rail guided vehicle, golf cart, mobility scooter or similar vehicle not designed for use on either a public or private road.



***Page 11 redacted

[redacted]

2. **LICENSE**

License Grant

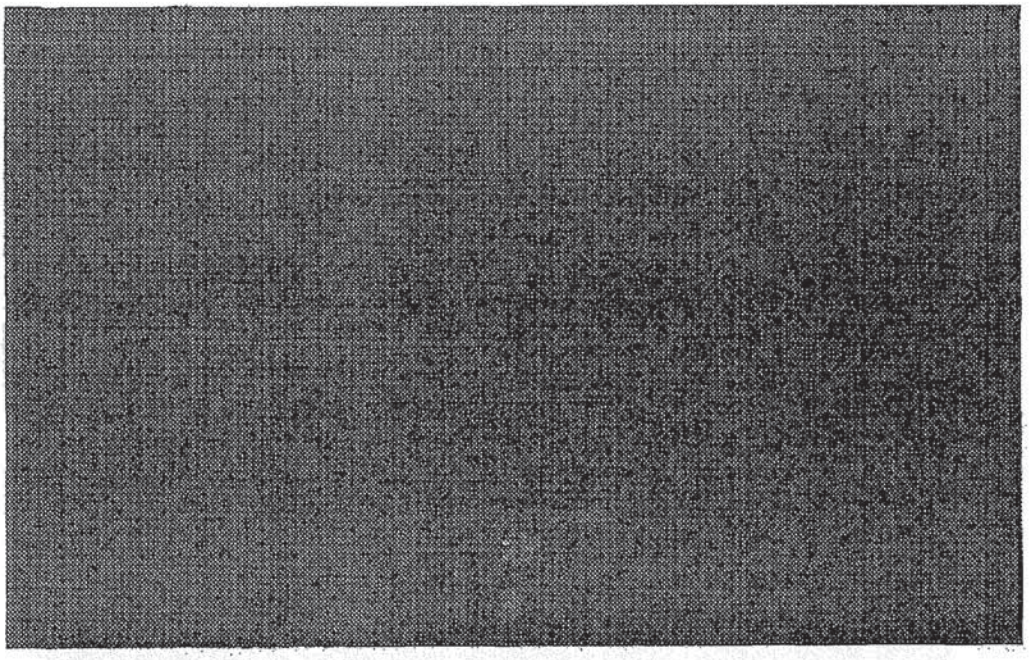
2.1 Subject to the terms and conditions of clause 9.7 of this Agreement, the Licensor hereby grants to the Licensee, and the Licensee hereby accepts:

(a) an exclusive (except as described in clause 2.2 and subject to clause 9.6), non-transferable (except as permitted in clause 11.10), worldwide license under the Exclusive Intellectual Property Rights to use all of the Exclusive Intellectual Property Rights in the Field, and to make, have made, use, sell, offer for sale, import, export and otherwise dispose of Exclusive Licensed Products in the Field. These rights include, without limitation, the right to use, reproduce, display, perform, modify, create improvements, enhancements, and derivative works of, and distribute directly or indirectly through multiple tiers, all works of authorship and technology forming part of the Exclusive Intellectual Property Rights for use in the Field, including without limitation creating Improvements. The Licensee shall have the right to grant sublicenses with respect to all or any portion of the rights granted in this clause 2.1(a), whether directly or indirectly through multiple tiers.

(b) [redacted]

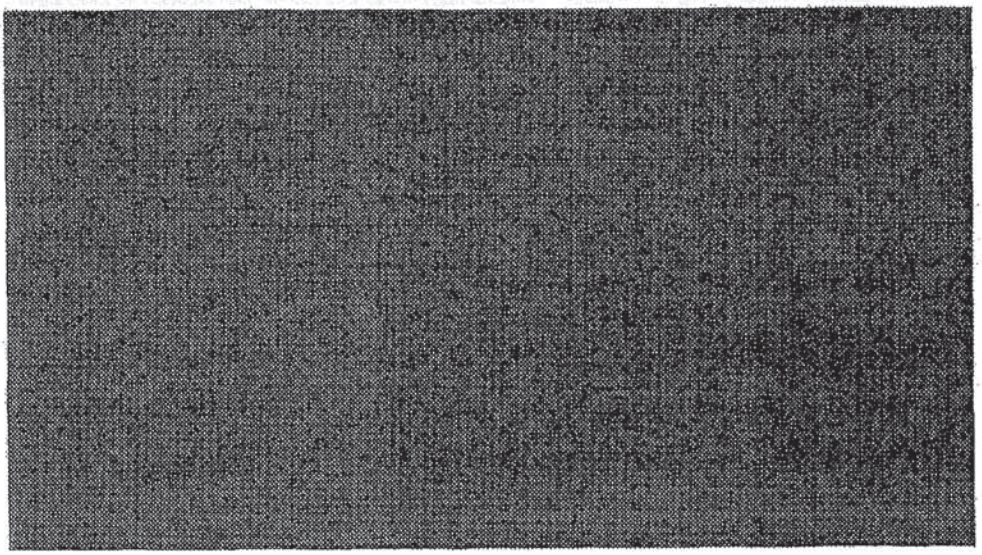
2.2 [redacted]

***Pages 13-43 redacted

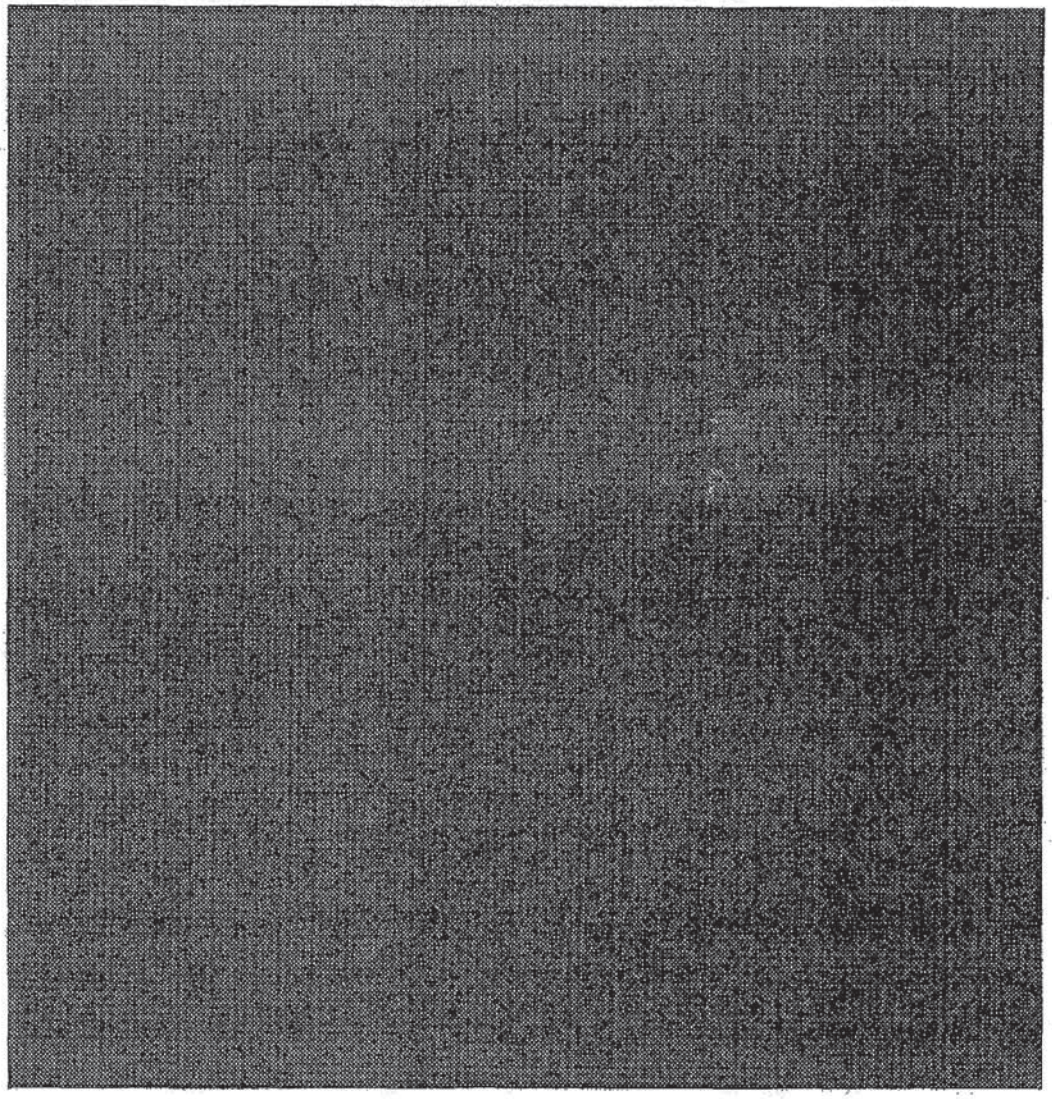


Assignment

11.10



Without limiting the foregoing, the Licensee shall also have the right to assign this Agreement, without obtaining the prior written consent of the Licensor, to Qualcomm or a Qualcomm-designated direct or indirect subsidiary of Qualcomm.



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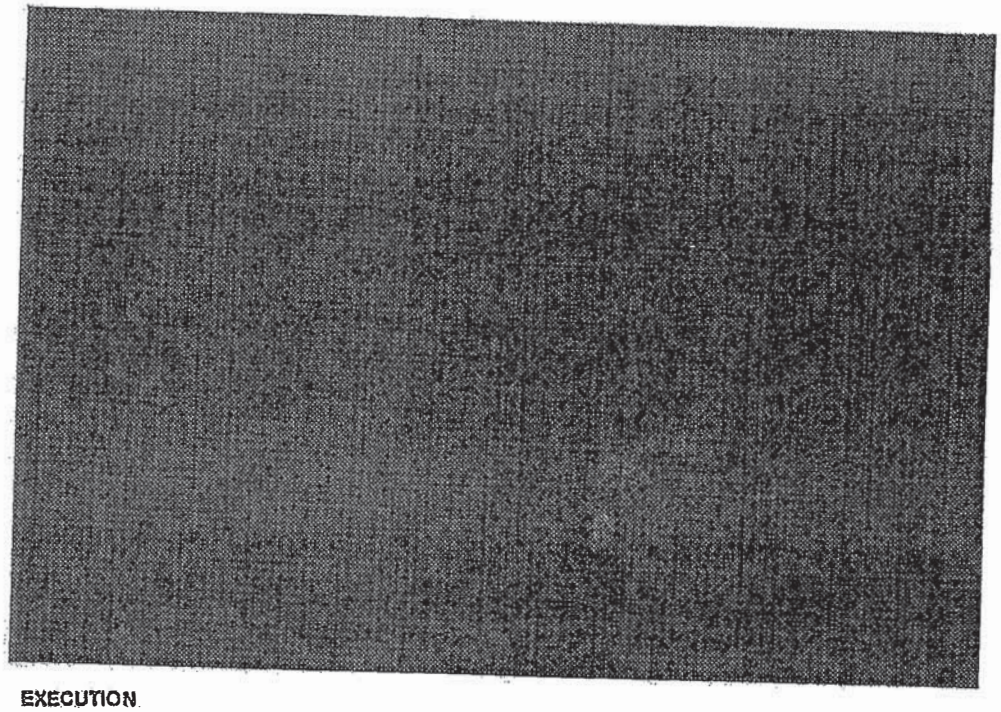

EXECUTION

SIGNED on behalf of AUCKLAND UNISERVICES LIMITED by:	SIGNED on behalf of HALO INDUCTIVE POWER TECHNOLOGIES LIMITED by:
Signature	Signature
Name: Peter Lee	Name: J. MILES
Title: CEO	Title: DIRECTOR

THIRD AMENDMENT

THIS THIRD AMENDMENT is made to the Second Amendment that was made to the Amended and Restated License Agreement dated October 14, 2011, as amended by that certain letter agreement dated July 31, 2012, between Auckland UniServices Limited, a company incorporated and registered in New Zealand with company number 373821 and having its place of business at Level 10, 70 Symonds Street, Auckland Central, Auckland, New Zealand ("**UniServices**"), and QUALCOMM Incorporated, a Delaware corporation having its place of business at 5775 Morehouse Drive, San Diego, CA 92121 ("**Qualcomm**") (collectively, the "**Agreement**"), and is entered into effective as of October 14, 2011. UniServices and Qualcomm may be referred to individually as a "**Party**" and collectively as the "**Parties**" in this Third Amendment.

THIRD AMENDMENT:

NOW, THEREFORE, the Parties hereby agree as follows:

1. Headings; Definitions. Section headings used in this Third Amendment are inserted for the purpose of convenience only and are not intended to affect the meaning or interpretation of any provision of this Third Amendment. For the purpose of the construction and interpretation of this Third Amendment, the word "**including**" (and variations thereof such as "**include**" and "**includes**") will not be deemed to be a term of limitation, but rather will be deemed to be followed by the words "**without limitation,**" and the words "**herein,**" "**hereof,**" and "**hereunder**" will refer to this Third Amendment as a whole. Unless otherwise specified herein, capitalized terms used in this Third Amendment given to such terms in the Agreement.

2. Schedules 1, 2 and 5. Schedule 1 to the Agreement is superseded and replaced in its entirety by Schedule 1 that is attached to this Third Amendment. Schedule 2 to the Agreement is superseded and replaced in its entirety by Schedule 2 that is attached to this Third Amendment. Schedule 5 to the Agreement is superseded and replaced in its entirety by Schedule 5 that is attached to this Third Amendment.

3. No Other Amendment. Except as expressly set forth in this Third Amendment, the Agreement shall remain in full force and effect without any modification. The terms and conditions of this Third Amendment and the Agreement supersedes all prior and contemporaneous oral or written understandings between the Parties with respect to their subject matter, and constitute the entire agreement of the Parties with respect to

such subject matter. The terms and conditions of this Third Amendment and the Agreement shall not be modified or amended, except by a writing signed by (i) an authorized representative of UniServices and (ii) the then-current President or Corporate Secretary of Qualcomm (or his or her authorized designee).

IN WITNESS WHEREOF, the Parties have, through their duly authorized representatives, caused this Third Amendment to be entered into effective as of the Third Amendment Date. This Third Amendment may be signed in counterparts.

Auckland UniServices Limited	**QUALCOMM Incorporated**
By: W.H.G. Charles	By:
Printed Name: W.H.G. CHARLES	Printed Name: Adam Schwartz
Title: General Manager	Title: VP & Asst Secretary
Date: 23/1/2017	Date: Feb 3, 2017

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Schedule 1
Patent Families Exclusively Licensed

Inductive Power Distributions System - Inventors: Boys and Green

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT04	121457WO	PCT	2/5/1992	PCT/GB1992/000220		Expired
IPT04	121457NZP1	NZ	3/26/1991	237572		Expired
IPT04	121457NZP3	NZ	9/30/1991	240018		Expired
IPT04	121457NZP2	NZ	9/19/1991	239862		Expired
IPT04	121457NZ	NZ	1/23/1992	237572	237572	Expired
IPT04	121457NZ	NZ	7/1/1991	238815		Abandoned
IPT04	121457AU	AU	2/5/1992	1992012373	658605	Expired
IPT04	121457CA	CA	2/5/1992	2106784	2106784	Expired
IPT04	121457EP	EP	2/5/1992	92904583.9	577611	Expired
IPT04	121457FR	FR	2/5/1992	92904583.9	577611	Expired
IPT04	121457DE	DE	2/5/1992	69227242.9	577611	Expired
IPT04	121457GB	GB	2/5/1992	92904583.9	577611	Expired
IPT04	121457NL	NL	2/5/1992	92904583.9	577611	Expired
IPT04	121457IT	IT	2/5/1992	92904583.9	577611	Expired
IPT04	121457SE	SE	2/5/1992	92904583.9	577611	Expired
IPT04	121457ES	ES	2/5/1992	92904583.9	577611	Expired
IPT04	121457EPD2	EP(Div 2)	2/5/1992	01130829.3		Abandoned
IPT04	121457EPD1	EP	2/5/1992	97202324.6	818868	Revoked/Invalidated
IPT04	121457JP	JP	2/5/1992	1992-504164	2667054	Expired
IPT04	121457JPD1	JP(Div)	4/14/1995	1995-889076	3304677	Expired
IPT04	121457JPD2	JP(Div 2)	3/15/2002	2002-071125	3729787	Expired
IPT04	121457JPD3	JP(Div3)	8/10/2005	2005-231427	3776115	Expired
IPT04	121457KR	KR	2/5/1992	10-1993-0702898	180047	Expired
IPT04	121457MX	MX	3/13/1992	9201100	182161	Expired
IPT04	121457US	US	1/30/1992	07/827,887	5293308	Granted
IPT04	121457TW	TW	2/7/1992	081100829	201828	Expired

Resonant Power Supplies - Inventors: Boys and Green

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT05	121458NZP1	NZ	8/12/1991	239366		Expired
IPT05	121458NZP2	NZ	8/23/1991	239533	239533	Expired
IPT05	121458NZ	NZ	8/3/1992	239366	239366	Expired
IPT05	121458	US	8/5/1992	07/926,051	5450305	Expired

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IPT05	121458AU	AU	8/7/1992	1992023966	656803	Abandoned
IPT05	121458JP	JP	8/7/1992	1993-504165	3178837	Abandoned
IPT05	121458KR	KR	8/7/1992	10-1994-0700424	10-0163412	Abandoned
IPT05	121458TW	TW	8/7/1992	94-700424	81106363	Abandoned
IPT05	121458WO	PCT	8/7/1992	PCT/GB1992/001463		Expired

Supply of Power to Primary Conductors (G2/G3) – Inventors: Boys and Green

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT09	121460NZP1	NZ	12/5/1997	329340		Expired
IPT09	121460NZP2	NZ	3/18/1998	329991		Expired
IPT09	121460	NZ	12/7/1998	504852	504852	Lapsed
IPT09	121460	NZ	12/4/2001	515941		Abandoned
IPT09	121460WO	PCT	12/4/1998	PCT/NZ1998/00179		Expired
IPT09	121460DE	DE	12/4/1998	69841810.7	1050094	Abandoned
IPT09	121460	US	12/4/1998	09/555,796	6621183	Granted
IPT09	121460EP	EP	12/4/1998	98962726.0	1050094	Abandoned
IPT09	121460AU	AU	12/4/1998	17898/99		Abandoned
IPT09	121460TW	TW	12/4/1998	87120180	125932	Abandoned
IPT09	121460KR	KR	12/4/1998	10-2000-7006157		Abandoned
IPT09	121460JP	JP	12/4/1998	2000-524850		Abandoned

Control of Series Resonant Inductive Pick-ups – Inventors: Boys and Stielau

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT10	121461NZP1	NZ	9/9/1999	337716		Abandoned
IPT10	121461PCT	PCT	9/9/2000	PCT/NZ2000/000175		Expired
IPT10	121461AU	AU	9/6/2000	74620/0	772748	Abandoned
IPT10	121461	US	9/6/2000	10/070,620	6705441	Granted
IPT10	121461JP	JP	9/6/2000	2001-522645	4456789	Granted
IPT10	121461NZ	NZ	9/6/2000	337716	337716	Abandoned
IPT10	121461CA	CA	9/6/2000	2383644	2383644	Abandoned
IPT10	121461EP	EP	9/6/2000	00963170.6	1219000	Granted
IPT10	121461DE	DE	9/9/2000	60045515.7	1219000	Granted
IPT10	121461FR	FR	9/9/2000	00963170.6	1219000	Granted
IPT10	121461GB	GB	9/9/2000	00963170.6	1219000	Granted

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Pick-Up Apparatus for Inductive Power Transfer Systems – Inventors: Boys, Covic and Elliot

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT23	121462NZ1	NZ	5/2/2006	546955		Expired
IPT23	121462WO	PCT	5/2/2007	PCT/NZ2007/000097		Expired
IPT23	121462	US	5/2/2007	12/226,956	7969269	Re-Issue Filed – (see IPT81)
IPT23	121462R1	US	6/28/2013	12/930,505		Pending
IPT23	121462R1D1	US	10/31/2014	14/529,939		Pending
IPT23	121462NZ2	NZ	5/2/2007	546955	546955	Granted
IPT23	121462EP	EP	5/2/2007	07793941.1		Pending
IPT23	121462CN	CN	11/2/2008	200780020724.0	ZL200780020724.0	Granted

Inductively Coupled AC Power Transfer – Inventors: Boys and Green

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT27	121463NZP1	NZ	4/17/2009	576320		Expired
IPT27	121462NZ	NZ	9/11/2008	571222	571222	Granted
IPT27	121463EP	EP	9/11/2009	09813290.5		Pending
IPT27	121463JP	JP	9/11/2009	2011-526828	5756754	Granted
IPT27	121463KR	KR	9/11/2009	10-2011-7008327		Pending
IPT27	121463CN	CN	9/11/2009	200980143019.9	ZL200980143019.9	Granted
IPT27	121463	US	9/11/2009	12/998,031		Pending
IPT27	121463WO	PCT	9/11/2009	PCT/NZ2009/000191		Expired

Multi Power Sourced Electric Vehicle – Inventors: Boys and Covic

Case	QC Ref No	Country	Filing Date	Application No.	Grant Number	Status
IPT28	121464NZP1	NZ	5/10/2007	555128		Expired
IPT28	121464NZ	NZ	5/29/2008	555128	555128	Granted
IPT28	121464NZP2	NZ	7/20/2007	556646		Expired
IPT28	121464	US	5/9/2008	12/451,436	8749334	Granted
IPT28	121464NZD1	NZ(Div)	8/26/2009	579313	579313	Granted
IPT28	121464AU	AU	5/9/2008	2008251143	2008251143	Granted
IPT28	121464CN	CN	5/9/2008	200880023317.X	1142755	Granted
IPT28	121464WO	PCT	5/9/2008	PCT/NZ2008/000103		Expired
IPT28	121464KR	KR	5/9/2008	10-2009-7025202		Pending
IPT28	121464EP	EP	5/9/2008	08766952.9		Pending

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IPT28	121464NZD1D1	NZ	3/1/2011	591463		Abandoned
IPT28	121464CA	CA	5/9/2008	2687060		Pending
IPT28	121464JP	JP	5/9/2008	2010-507347		Pending
IPT28	121464IN	IN	5/9/2008	7552/DELNP/2009		Pending
IPT28	121464AUD1	AU(Div)	2/28/2012	2012201155		Pending
IPT28	121464CND1	CN(Div)	1/14/2013	201310012148.2		Pending
IPT28	121464CND1D1	CN(Div)	5/9/2015	201510164448.1		Pending
IPT28	121464KRD1	KR(Div)	12/23/2013	10-2013-7034223		Pending
IPT28	121464KRD2	KR(Div)	3/25/2015	10-2015-7007587		Pending
IPT28	121464D1	US(Div)	3/14/2014	13/999,663		Pending
IPT28	121464D2	US(Div)	5/5/2014	14/120,197		Pending
IPT28	121464JPD1	JP(Div)	2/9/2015	2015-023233		Pending

Inductive Power Transfer Apparatus - Inventors: Boys and Huang

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT29A	121494NZP1	NZ	2/5/2009	574677		Expired
IPT29A	121494NZ	NZ	5/5/2010	574677/556137		Abandoned
IPT29A	121494WO	PCT	2/5/2010	PCT/NZ2010/000017		Expired
IPT29A	121494EP	EP	2/5/2010	10738795.3		Pending
IPT29A	121494	US	2/5/2010	13/138,299	9,283,858	Granted

Inductive Power Transfer Apparatus - Inventors: Boys, Covic, Hugang and Budhia

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT29B	121494NZP1	NZ	2/5/2009	574677		Expired
IPT29B	121497NZP1	NZ	4/8/2009	576137		Expired
IPT29B	121497NZD1	NZ(Div)	5/31/2010	585802		Abandoned
IPT29B	121497NZD1D1	NZ(Div)	11/30/2011	596792		Abandoned
IPT29B	121497NZD1D1D1	NZ	5/5/2010	611167		Abandoned
IPT29B	121497WO	PCT	2/5/2010	PCT/NZ2010/000018		Expired
IPT29B	121497CN	CN	2/5/2010	201080012846.7	ZL201080012846.7	Granted
IPT29B	121497CND1	CN(Div)	9/25/2015	201510621373.5		Pending
IPT29B	121497CA	CA	2/5/2010	2751595		Pending
IPT29B	121497IN	IN	2/5/2010	6327/DELNP/2011		Pending
IPT29B	121497JP	JP	2/5/2010	2011-549109		Pending
IPT29B	121497JPD1	JP(Div)	7/6/2015	2015-135622		Pending
IPT29B	121497EP	EP	2/5/2010	10738796.1		Pending
IPT29B	121497KR	KR	2/5/2010	10-2011-7020758		Pending

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Momentum Dynamics Corporation
Exhibit 1009
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IPT29B	121497	US	2/5/2010	13/138,298	9,071,061	Granted
IPT29B	141497C1	US	4/30/2015	14/700,770		Pending

Inductive Power Transfer Apparatus and Electrical Autocycle Charger, Including the Inductive Power Transfer Apparatus – Inventors: Boys and Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT34	121465NZP1	NZ	5/12/2009	576909		Expired
IPT34	121465NZD1	NZ(Div)	11/14/2011	596393		Abandoned
IPT34	121465NZ	NZ	5/12/2010	576909		Abandoned
IPT34	121465WO	PCT	5/12/2010	PCT/NZ2010/000088		Expired
IPT34	121465JP	JP	5/12/2010	2012-510770		Pending
IPT34	121465JPD1	JP	11/13/2005	2015-223470		Pending
IPT34	121465CN	CN	5/12/2010	201080031336.4		Pending
IPT34	121465	US	5/12/2010	13/261,001		Pending
IPT34	121465EP	EP	5/12/2010	10775151.3		Pending

Vehicular Roadway Inductive Power Transfer Systems – Inventors: Boys and Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT35	121466P1	US	8/7/2009	61/273,701		Expired
IPT35	121466WO	PCT	8/6/2010	PCT/NZ2010/000159		Expired
IPT35	121466WO2	PCT	7/9/2015	PCT/NZ2015/050088		Expired
IPT35	121466CN	CN	8/6/2010	201080042396.6	201080042396.6	Granted
IPT35	121466	US	8/6/2010	13/389,210		Pending
IPT35	121466IN	IN	8/6/2010	1935/DELNP/2012		Pending
IPT35	121466EP	EP	8/6/2010	10806690.3		Pending
IPT35	121466KR	KR	8/6/2010	10-2012-7006120		Pending
IPT35	121466JP	JP	8/6/2010	2012-523582		Pending
IPT35	121466JPD1	JP(Div)	8/6/2010	2014-12113		Pending
IPT35	121466NZP1	NZ	7/9/2014	627280		Expired

Power Control in IPT Roadway– Inventors: Boys/Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT36	121467WO	PCT	9/9/2010	PCT/NZ2010/000181		Expired
IPT36	121467JP	JP	9/9/2010	2012-528772		Pending
IPT36	121467P1	US	9/9/2009	61/276,204		Expired
IPT36	121467	US	9/9/2010	13/395,173	9,077,194	Granted

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IPT36	121467EP	EP	9/9/2010	10815680.3		Pending

Series AC Controller – Inventors: Boys, Covic and Wu

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT37	121469NZP1	NZ	10/12/2009	580388		Expired
IPT37	121469WO	PCT	10/12/2010	PCT/NZ2010/000203		Expired
IPT37	121469NZ	NZ	10/19/2010	580388	580388	Granted
IPT37	121469	US	10/12/2010	13/261,259		Pending
IPT37	121469C1	US	11/23/2015	14/948,702		Pending

Multiphase Inductive Power Transfer System – Inventors: Boys, Covic, Budhia and Kissin

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT43	121470NZP1	NZ	5/19/2010	585483		Expired
IPT43	121470NZP2	NZ	8/25/2010	587567		Expired
IPT43	121470NZ	NZ	6/3/2011	585483	585483	Granted
IPT43	121470WO	PCT	5/19/2011	PCT/NZ2011/000079		Expired
IPT43	121470	US	5/19/2011	13/698,851		Pending
IPT43	121470CN	CN	5/19/2011	201180035293.1		Pending
IPT43	121470EP	EP	5/19/2011	11783803.7		Pending
IPT43	121470JP	JP	5/19/2011	511125/2013		Pending
IPT43	121470MY	MY	5/19/2011	PI2012700954		Pending

Bi-Directional Inductive Power Transfer – Inventor: Madawala

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT45	121471NZP1	NZ	11/26/2008	573241		Expired
IPT45	121471NZP2	NZ	9/3/2009	579498		Expired
IPT45	121471WO	PCT	11/26/2009	PCT/NZ2009/000259		Expired
IPT45	121471	US	11/26/2009	13/131,155		Pending
IPT45	121471NZ	NZ	12/21/2009	573241	573241	Granted
IPT45	121471NZD1	NZ(Div)	1/03/2010	582580	582580	Granted

Primary Side Power Transfer for Inductive Power Transfer – Inventor: Madawala

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT46	121472NZP1	NZ	9/3/2009	579499		Expired
IPT46	121472NZP2	NZ	9/3/2009	579498		Expired

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IPT46	121472NZ	NZ	11/26/2008	573241	573241	Granted
IPT46	121472WO	PCT	11/26/2009	PCT/NZ2009/000263		Expired
IPT46	121472	US	11/26/2009	13/131,153	8,923,015	Granted
IPT46	121472C1	US	12/29/2014	14/584,320		Pending

Inductive Power Transfer System – Inventors: Madawala and Thrimawithana

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT47	121473NZP1	NZ	6/30/2010	586526		Expired
IPT47	121473WO	PCT	6/30/2011	PCT/NZ2011/000124		Expired
IPT47	121473	US	6/30/2011	13/807,436		Pending
IPT47	121473NZ	NZ	7/28/2011	586526	586526	Granted

Inductive Power transfer Apparatus – Inventors: Boys, Covic and Budhia

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT49	121498NZP1	NZ	8/5/2010	587222		Expired
IPT49	121498WO	PCT	8/5/2011	PCT/NZ2011/000153		Expired
IPT49	121498	US	8/5/2011	13/814,415		Pending
IPT49	121498NZ	NZ	8/19/2011	587222		Abandoned
IPT49	121498NZD1	NZ(Div)	2/20/2013	607346		Abandoned
IPT49	121498NZD1D1	NZ(Div)	6/12/2014	626194		Abandoned

Inductive Power Transfer System – Inventors: Covic and Kissin

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT50	121474WO	PCT	8/6/2010	PCT/NZ2010/000160		Expired
IPT50	121474	US	8/6/2010	13/389,090		Pending
IPT50	121474EP	EP	8/6/2010	10806691.1		Pending
IPT50	121474KR	KR	8/6/2010	10-2012-7006121		Pending
IPT50	121474IN	IN	8/6/2010	1947/DELNP/2012		Pending
IPT50	121474CN	CN	8/6/2010	201080042400.9		Pending
IPT50	121474JP	JP	8/6/2010	2012-523583		Pending
IPT50	121474JPD1	JP(Div)	10/22/2015	2015-208300		Pending

Inductive Power Transfer Control (IPT pick-up controller) – Inventors: Covic, Boys and Huang

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT51	121487NZP1	NZ	8/13/2010	587357		Expired

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IPT51	121487NZ	NZ	8/18/2011	587357	587357	Granted
IPT51	121487WO	PCT	8/12/2011	PCT/NZ2011/000155		Expired
IPT51	121487IN	IN	8/12/2011	2106/DELNP/2013		Pending
IPT51	121487KR	KR	8/12/2011	10-2013-7005935		Pending
IPT51	121487US	US	8/12/2011	13/816,630	9,369,058	Granted
IPT51	121487D1	US	5/9/2016	15/150,385		Pending
IPT51	121487EP	EP	8/12/2011	11816674.3		Pending
IPT51	121487CN	CN	8/12/2011	201180049292.2		Pending
IPT51	121487JP	JP	8/12/2011	2013-524812		Pending

Inductive Power Transfer Apparatus with AC and DC Output – Inventors: Covic, Boys and Robertson

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT52	121488NZP1	NZ	12/10/2010	589865		Expired
IPT52	121488WO	PCT	12/9/2011	PCT/NZ2011/000256		Expired
IPT52	121488US	US	12/9/2011	13/992,757		Pending
IPT52	121488NZ	NZ	12/12/2011	589865	589865	Granted

Inductive Power Transfer Pick-up Circuits – Inventors: Covic and Robertson

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT53	121489NZP1	NZ	9/3/2010	587780		Expired
IPT53	121489WO	PCT	9/5/2011	PCT/NZ2011/000181		Expired
IPT53	121489IN	IN	9/5/2011	2869/DELNP/2013		Pending
IPT53	121489EP	EP	9/5/2011	11822189.4		Pending
IPT53	121489JP	JP	9/5/2011	2013-527033		Pending
IPT53	121489US	US	9/5/2011	13/82,0477		Pending
IPT53	121489CN	CN	9/5/2011	201180051750.6		Pending
IPT53	121489NZ	NZ	12/5/2011	587780	587780	Granted
IPT53	121489KR	KR	9/5/2011	10-2013-7008491		Pending

Inductive Power Receiver Apparatus (Bipolar Receiver Pad) – Inventors: Covic and Budhia

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT54	121490NZP1	NZ	11/1/2010	588937		Expired
IPT54	121490WO	PCT	8/5/2011	PCT/NZ2011/000154		Expired
IPT54	121490KR	KR	8/5/2011	10-2013-7005726		Pending
IPT54	121490JP	JP	8/5/2011	2013-524060	5941046	Granted
IPT54	121490EP	EP	8/5/2011	11814854.3		Pending

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IPT54	121490IN	IN	8/5/2011	1921/DELNP/2013		Pending
IPT54	121490US	US	8/5/2011	13/814,542		Pending
IPT54	121490CN	CN	8/5/2011	201180048057.3		Pending

Load Control for Bi-Directional Inductive Power Transfer Systems – Inventors: Madawala, Thrimawithana

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT55	146623NZP1	NZ	6/27/2011	593764		Expired
IPT55	146623WO	PCT	6/27/2012	PCT/NZ2012/000107		Expired
IPT55	146623	US	6/22/2012	14127,882		Pending
IPT55	146623KR	KR	6/27/2012	10-2014-7001559		Pending
IPT55	146623JP	JP	6/27/2012	2014-518471		Pending
IPT55	146623EP	EP	6/27/2012	12804818.8		Pending
IPT55	146623CN	CN	6/27/2012	201280030503.2		Pending
IPT55	146623NZ	NZ	7/9/2012	593764	593764	Granted

Interoperability of Magnetic Structures for Inductive Power Transfer Systems – Inventors: Covic

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT57	121491NZP1	NZ	7/8/2011	593977		Expired
IPT57	121491NZP2	NZ	12/23/2011	597367		Expired
IPT57	121491WO	PCT	7/9/2012	PCT/NZ2012/000121		Expired
IPT57	121491JP	JP	7/9/2012	2014-518475		Pending
IPT57	121491EP	EP	7/9/2012	12820784.2		Pending
IPT57	121491US	US	7/9/2012	14/131,138		Pending
IPT57	121491CN	CN	7/9/2012	201280037549.7		Pending
IPT57	121491KR	KR	7/9/2012	10-2014-7003472		Pending
IPT57	121491NZD1	NZ(Div)	3/31/2014	623198		Abandoned
IPT57	121491NZ	NZ	10/8/2012	593977		Abandoned

Double Conductor Single Phase Inductive Power Transfer Tracks – Inventors: Covic and Raabe

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT58	121492NZP1	NZ	7/19/2011	594158		Expired
IPT58	121492WO	PCT	7/19/2012	PCT/NZ2012/000127		Expired
IPT58	121492US	US	7/19/2012	14/233,261		Pending
IPT58	121492CN	CN	7/19/2012	201280038877.9		Pending
IPT58	121492EP	EP	7/19/2012	12819897.5		Pending
IPT58	121492JP	JP	7/19/2012	2014-521588		Pending

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IPT58	121492KR	KR	7/19/2012	10-2014-7004312		Pending
IPT58	121492NZ	NZ	10/19/2012	594158		Abandoned
IPT58	121492NZD1	NZ(Div)	3/31/2014	623197		Abandoned

IPT Magnetic Shielding – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT59	121493NZP1	NZ	9/7/2011	595056		Expired
IPT59	121493WO	PCT	9/7/2012	PCT/NZ2012/000160		Expired
IPT59	121493KR	KR	9/7/2012	10-2014-7007332		Pending
IPT59	121493EP	EP	9/7/2012	12829832.0		Pending
IPT59	121493CN	CN	9/7/2012	201280052907.1		Pending
IPT59	121493IN	IN	9/7/2012	1434/DELNP/2014		Pending
IPT59	121493JP	JP	9/7/2012	2014-529639		Pending
IPT59	121493US	US	9/7/2012	14/240,191		Pending

Magnetic Field Shaping for Inductive Power Transfer – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT60	123493NZP1	NZ	10/28/2011	596080		Expired
IPT60	123493NZP2	NZ	12/16/2011	597166		Expired
IPT60	123493NZP3	NZ	9/6/2012	602304		Expired
IPT60	123493WO	PCT	10/29/2012	PCT/NZ2012/000198		Expired
IPT60	123493KR	KR	9/7/2012	10-2014-7014470		Pending
IPT60	123493US	US	10/29/2012	14/354,705		Allowed
IPT60	123493IN	IN	10/29/2012	4062/DELNP/2014		Pending
IPT60	123493EP	EP	10/29/2012	12843894.2		Pending
IPT60	123493JP	JP	10/29/2012	2014-538747		Pending
IPT60	123493CN	CN	10/29/2012	201280064914.3		Pending
IPT60	123493NZ	NZ	1/25/2013	606189		Abandoned
IPT60	123493NZD1	NZ(Div)	8/1/2014	628198		Abandoned

Inductive Power Transfer System and Method – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT61	123494NZP1	NZ	12/16/2011	597174		Expired
IPT61	123494WO	PCT	12/18/2012	PCT/IB2012/002730		Expired
IPT61	123494KR	KR	12/18/2012	10-2014-7019724		Pending
IPT61	123494JP	JP	12/18/2012	2014-546664		Pending

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IPT61	123494US	US	12/18/2012	14/365,873		Pending
IPT61	123494EP	EP	12/18/2012	12858565.0		Pending
IPT61	123494GB	GB	12/18/2012	1412616.3		Pending
IPT61	123494CN	CN	12/18/2012	21280069521.1		Pending
IPT61	123494NZ	NZ	3/15/2013	608273	608273	Granted

Magnetic Structure Interoperability for IPT Systems – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT62	123495NZP1	NZ	9/16/2011	595251		Cognated with IPT57

Multiple Coil Flux Pad – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT63	123496NZP1	NZ	2/16/2012	598253		Expired
IPT63	123496WO	PCT	2/15/2013	PCT/NZ2013/000016		Expired
IPT63	123496KR	KR	2/15/2013	10-2014-7025625		Pending
IPT63	123496JP	JP	2/15/2013	2014-557594		Pending
IPT63	123496IN	IN	2/15/2013	7034/DELNP/2014		Pending
IPT63	123496CN	CN	2/15/2013	201380019993.0		Pending
IPT63	123496US	US	2/15/2013	14/379,068		Pending
IPT63	123496EP	EP	2/15/2013	13749300.3		Pending
IPT63	123496NZ	NZ	4/19/2013	609482	609482	Granted

VAR Control for IPT System – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT64	123497NZP1	NZ	2/2/2012	597987		Expired
IPT64	123497WO	PCT	2/1/2013	PCT/NZ2013/000009		Expired
IPT64	123497EP	EP	2/1/2013	13813549.6		Pending
IPT64	123497US	US	2/1/2013	14/376,401		Pending
IPT64	123497CN	CN	2/1/2013	201380017845.5		Pending
IPT64	123497JP	JP	2/1/2013	2014-555521		Pending
IPT64	123497KR	KR	2/1/2013	10-2014-7024432		Pending
IPT64	123497NZ	NZ	4/16/2013	609519		Abandoned

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Flux Coupling Device and Magnetic Structures Therefor– Inventors: Covic and Budhia

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT65	150927NZP1	NZ	7/9/2012	601154		Expired
IPT65	150927WO	PCT	7/9/2013	PCT/NZ2013/000120		Expired
IPT65	150927JP	JP	7/9/2013	2015-521574		Pending
IPT65	150927CN	CN	7/9/2013	201380046716.9		Pending
IPT65	150927	US	7/9/2013	14/410,817		Pending
IPT65	150927KR	KR	7/9/2013	10-2015-7003352		Pending
IPT65	150927EP	EP	7/9/2013	13816491.8		Pending
IPT65	150927NZ	NZ	7/31/2013	613512		Abandoned

Design Considerations for Variable Coupling Lumped Coil Systems– Inventors: Chang-Yu and Covic

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT66	131923NZP1	NZ	8/31/2012	602184		Expired
IPT66	131923NZP2	NZ	9/14/2012	602543		Expired
IPT66	131923WO	PCT	9/2/2013	PCT/NZ2013/000154		Expired
IPT66	131923NZ	NZ	11/29/2013	618318		Abandoned
IPT66	131923KR	KR	9/2/2013	10-2015-7008302		Pending
IPT66	131923EP	EP	9/2/2013	13833528.6		Pending
IPT66	131923US	US	9/2/2013	14/424,390		Pending
IPT66	131923JP	JP	9/2/2013	2015-529721		Pending
IPT66	131923CN	CN	9/2/2013	201380055662.2		Pending

Inductive Power Transfer Control Using Energy Injection

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT67	146628NZP1	NZ	10/1/2012	602767		Expired
IPT67	146628NZP2	NZ	10/9/2012	602903		Expired
IPT67	146628WO	PCT	10/1/2013	PCT/NZ2013/000184		Expired
IPT67	146628NZ	NZ	10/1/2013	616162		Abandoned
IPT67	146628CN	CN	10/1/2013	201380051407.0		Pending
IPT67	146628EP	EP	10/1/2013	13843553.2		Pending
IPT67	146628JP	JP	10/1/2013	2015-535601		Pending
IPT67	146628KR	KR	10/1/2013	10-2051-7007591		Pending
IPT67	146628	US	10/1/2013	14/432,120		Pending
IPT67	146628IN	IN	10/1/2013	2545/DELNP/2015		Pending

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Wiring Harness and Wireless Power Transfer System—Inventors: Keeling, Beaver, van Boheemen, Kissin, Covic and Boys

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT68	120822P1	US	3/20/2012	61/613,414		Expired
IPT68	120822WO	PCT	3/20/2013	PCT/NZ2013/000045		Expired
IPT68	120822EP	EP	3/20/2013	13764869.7		Pending
IPT68	120822	US	3/20/2013	14/386,206		Pending
IPT68	120822KR	KR	3/20/2013	10-2014-7029391		Pending
IPT68	120822CN	CN	3/20/2013	201380024923.4		Pending
IPT68	120822JP	JP	3/20/2013	2015-501611		Pending

Winding Arrangements in Wireless Power Transfer Systems-- Inventors: Keeling, van Boheemen, Kissin, Beaver, Boys Covic, et al.

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT69	120823P1	US	3/20/2012	61/613,420		Expired
IPT69	120823WO	PCT	3/20/2013	PCT/NZ2013/000046		Expired
IPT69	120823	US	3/20/2013	14/386,311		Pending
IPT69	120823KR	KR	3/20/2013	10-2014-7029392		Pending
IPT69	120823CN	CN	3/20/2013	201380024920.0		Pending
IPT69	120823EU	EP	3/20/2013	13763812.8		Pending
IPT69	120823JP	JP	3/20/2013	2015-501612		Pending

Electromagnetic Field Confinement– Inventors: Covic and Boys

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT70	150928NZP1	NZ	3/27/2013	608759		Expired
IPT70	150928NZP2	NZ	7/10/2013	613099		Expired
IPT70	150928NZ	NZ	3/31/2014	623218		Abandoned
IPT70	150928WO	PCT	3/27/2014	PCT/NZ2014/000054		Expired
IPT70	150928EP	EP	3/27/2014	14774618.4		Pending
IPT70	150928KR	KR	3/27/2014	10-2015-7030134		Pending
IPT70	150928	US	3/27/2014	14/780,102		Pending
IPT70	150928IN	IN	3/27/2014	9057/DELNP/2015		Pending
IPT70	150928CN	CN	3/27/2014	201480028597.9		Pending
IPT70	150928JP	JP	3/27/2014	2016-505431		Pending

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An Output Current Doubler for a Parallel Tuned IPT Pickup - Inventors: Keeling and Boys

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT72	120821NZP1	NZ	12/20/2013	619303		Expired
IPT72	120821NZP2	NZ	8/19/2014	628991		Expired
IPT72	120821WO	PCT	12/19/2014	PCT/NZ2014/050025		Expired
IPT72	120821	US	6/20/2016	15/106,642		Pending
IPT72	120821CN	CN		Unknown		Pending
IPT72	120821EP	EP	12/19/2014	Unknown	14871146.8	Pending
IPT72	120821IN	IN	12/19/2014	Unknown		Pending
IPT72	120821JP	JP	12/19/2014	Unknown	2016-541639	Pending

A Polyphase Inductive Power Transfer System with Individual Control of Phases– Inventors: Madawala and Thrimawithana

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT73	147303NZP1	NZ	8/28/2012	602095		Expired
IPT73	147303NZ	NZ	8/29/2013	614823		Abandoned
IPT73	147303WO	PCT	8/28/2013	PCT/NZ2013/000151		Expired
IPT73	147303	US	8/28/2013	14/424,384		Pending
IPT73	147303KR	KR	8/28/2013	10-2015-7008158		Pending
IPT73	147303JP	JP	8/28/2013	2015-529720		Pending
IPT73	147303CN	CN	8/28/2013	201380053814.5		Pending
IPT73	147303EP	EP	8/28/2013	13832921.4		Pending

Resonant Frequency Compensation– Inventors: Thrimawithana and Madawala

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT76	150997NZP1	NZ	8/11/2014	628544		Expired
IPT76	150997WO	PCT	8/11/2015	PCT/NZ2015/050105		Pending

Vehicle or Moving Object Detection– Inventors: Boys

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT77	146626NZP1	NZ	11/12/2012	603566		Expired
IPT77	146626NZ	NZ	11/12/2013	617614		Abandoned
IPT77	146626WO	PCT	11/12/2013	PCT/NZ2013/000202		Expired
IPT77	146626CN	CN	11/12/2013	201380058928.9		Pending
IPT77	146626EP	EP	11/12/2013	13854136.2		Pending
IPT77	146626KR	KR	11/12/2013	10-2015-7015221		Pending
IPT77	146626JP	JP	11/12/2013	2015-541736		Pending

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IPT77	146626	US	11/12/2013	14/441,682		Pending

Resonant Power Supply with Self Tuning– Inventors: Boys and Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT78	147428NZP1	NZ	9/12/2013	615464		Expired
IPT78	147428WO	PCT	9/10/2014	PCT/NZ2014/000196		Expired
IPT78	147428IN	IN	4/11/2016	201617012657		Pending
IPT78	147428	US	5/15/2014	15/021,440		Pending
IPT78	147428CN	CN	5/15/2014	201480059590.3		Pending
IPT78	147428EP	EP	4/13/2016	14784558.0		Peridling
IPT78	147428JP	JP	5/15/2014	2016-541933		Pending
IPT78	147428KR	KR	5/15/2014	10-2016-7009583		Pending

A Multilevel Converter– Inventors: Rahnamaee, Madawala, Thrimawithana

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT79	152419NZP1	NZ	2/21/2014	621294		Expired
IPT79	152419WO	PCT	2/23/2015	PCT/NZ2015/050016		Pending

Inductive Power Transfer Apparatus– Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT80	150998NZP1	NZ	7/8/2014	627210		Expired
IPT80	150998WO	PCT	7/8/2015	PCT/NZ2015/050087		Pending

Pick-Up Apparatus for Inductive Power Transfer Systems– Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT81	121462R1	US	5/2/2007	13/930,505		Pending (Re-issue, see IPT23)
IPT81	121462R1D1	US	10/31/2014	14/529,939		Pending (Re-issue, see IPT23)

Magnetic Flux Coupling Structures with Controlled Flux Cancellation– Inventors: Tejeda, Covic, Gawith, Boys and Pearce

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT82	150715NZP1	NZ	9/11/2014	631149		Expired
IPT82	150715NZP2	NZ	3/16/2015	706024		Expired
IPT82	150715NZP3	NZ	4/1/2015	706620		Expired
IPT82	150715WO	PCT	9/10/2015	PCT/NZ2015/050139		Pending

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Vertically Stacked Coils for Magnetic Flux Coupling Structures– Inventors: Boys and Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT83	157084NZP1	NZ	4/1/2015	706614		Cognated with IPT82

Multi-Source IPT System for Dynamic EV Charging – Inventors: Duleepa, Udaya

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT84	161482NZP1	NZ	7/20/2015	709915		Expired
IPT84	161482WO	PCT	7/20/2016	PCT/NZ2016/050116		Pending

Hybrid IPT System – Inventors: Madawala, Thrimawithana, Zhao

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT85	161483NZP1	NZ	8/6/2015	710795		Pending

Resonant Power Transfer – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT86	162716NZP1	NZ	2/11/2016	716869		Pending

Resonant Power Transfer – Inventors: Covic, Kamineni, Neath

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT87	164919NZP1	NZ	7/19/2016	722264		Pending

Resonant Power Transfer – Inventors: Covic, Kamineni, Neath

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT88	164878NZP1	NZ	8/1/2016	722771		Pending

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Patent Families Non-exclusively Licensed

Decoupling Circuits – Inventors: Boys and Covic

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT16	154381NZP1	NZ	4/9/2003	525219		Expired
IPT16	154381NZ	NZ	4/5/2004	525219	525219	Abandoned
IPT16	154381NZD1	NZ(Div)	4/5/2004	532156	532156	Abandoned
IPT16	154381WO	PCT	4/5/2004	PCT/NZ2004/000066		Expired
IPT16	154381	US	10/11/2005	11/246,166	7,279,850	Granted

Single phase power supply for inductively coupled power transfer systems – Inventor: Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT22	154385NZP1	NZ	2/28/2006	545664		Expired
IPT22	154385NZ	NZ	2/28/2007	545664	545664	Granted
IPT22	154385EP	EP	2/28/2007	07715993.7		Pending
IPT22	154385WO	PCT	2/28/2007	PCT/NZ2007/000041		Expired
IPT22	154385JP	JP	8/27/2008	2008-557230	5399080	Granted
IPT22	154385	US	8/27/2008	12/224,534	8953340	Granted
IPT22	154385CN	CN	10/7/2008	200780012613.5	ZL200780012613.5	Granted

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Covenanted Solely Owned Patents

Pick-Up Apparatus for Inductive Power Transfer Systems – Inventors: Boys, Covic and Elliot

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT23	121462NZP1	NZ	5/2/2006	546955		Expired
IPT23	121462WO	PCT	5/2/2007	PCT/NZ2007/000097		Expired
IPT23	121462	US	5/2/2007	12/226,956	7969269	Re-Issue Filed - (see IPT81)
IPT23	121462R1	US	6/28/2013	13/930,505		Pending
IPT23	121462R1D1	US	10/31/2014	14/529,939		Pending
IPT23	121462NZ	NZ	5/2/2007	546955	546955	Granted
IPT23	121462EP	EP	5/2/2007	07793941.1		Pending
IPT23	121462CN	CN	11/2/2008	200780020724.0	ZL200780020724.0	Granted

Inductive Power Transfer Apparatus - Inventors: Boys and Huang

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT29A	121494NZP1	NZ	2/5/2009	574677		Expired
IPT29A	121494WO	PCT	2/5/2010	PCT/NZ2010/000017		Expired
IPT29A	121494EP	EP	2/5/2010	10738795.3		Pending
IPT29A	121494	US	2/5/2010	13/138,299	9,283,858	Granted

Inductive Power Transfer Apparatus - Inventors: Boys, Covic, Hugang and Budhia

Case	QC Ref No	Country	Filing Date	Application No	Grant Number	Status
IPT29B	121494NZ	NZ	2/5/2009	574677		Expired
IPT29B	121497NZP1	NZ	4/8/2009	576137		Expired
IPT29B	121497NZD1	NZ(Div)	5/31/2010	585802		Abandoned
IPT29B	121497NZD1D1	NZ(Div)	11/30/2011	596792		Abandoned
IPT29B	121497NZD1D1D1	NZ	5/5/2010	611167		Abandoned
IPT29B	121497WO	PCT	2/5/2010	PCT/NZ2010/000018		Expired
IPT29B	121497CN	CN	2/5/2010	201080012846.7	ZL201080012846.7	Granted
IPT29B	121497CND1	CN(Div)	9/25/2015	201510621373.5		Pending
IPT29B	121497CA	CA	2/5/2010	2751595		Pending
IPT29B	121497IN	IN	2/5/2010	6327/DELNP/2011		Pending
IPT29B	121497JP	JP	2/5/2010	2011-549109		Pending
IPT29B	121497JPD1	JP(Div)	7/6/2015	2015-135622		Pending
IPT29B	121497EP	EP	2/5/2010	10738796.1		Pending

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IPT29B	121497KR	KR	2/5/2010	10-2011-7020758		Pending
IPT29B	121497	US	2/5/2010	13/138,298	9,071,061	Granted
IPT29B	141497C1	US	4/30/2015	14/700,770		Pending

Inductively Powered Mobile Sensor System – Inventors: Budgett, Hu and Malpas

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT 42		NZ	9/16/2004	535390	535390	Granted
IPT 42		AU	9/16/2005	2005285545	2005285545	Granted
IPT 42		GB	9/16/2005	0706623.6	2433656	Granted
IPT 42		US	8/21/2007	11/575,449		Granted
IPT 42		WO	9/16/2005	PCT/NZ2005/000245		Expired

Bi-Directional Inductive Power Transfer – Inventor: Madawala

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT45	121471NZP1	NZ	11/26/2008	573241		Expired
IPT45	121471NZP2	NZ	9/3/2009	579498		Expired
IPT45	121471WO	PCT	11/26/2009	PCT/NZ2009/000259		Expired
IPT45	121471	US	11/26/2009	13/131,155		Pending
IPT45	121471NZ	NZ	12/21/2009	573241	573241	Granted
IPT45	121471NZD1	NZ(Div)	1/03/2010	582580	582580	Granted

Primary Side Power Transfer for Inductive Power Transfer – Inventor: Madawala

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT46	121472NZP1	NZ	9/3/2009	579499		Expired
IPT46	121472WO	PCT	11/26/2009	PCT/NZ2009/000263		Expired
IPT46	121472	US	11/26/2009	13/131,153	8923015	Granted
IPT46	121472C1	US	12/29/2014	14/584,320		Pending

Load Control for Bi-Directional Inductive Power Transfer Systems – Inventors: Madawala, Thrimawithana

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT55	146623NZP1	NZ	6/27/2011	593764		Expired
IPT55	146623WO	PCT	6/27/2012	PCT/NZ2012/000107		Expired
IPT55	146623	US	6/22/2012	14127,882		Pending
IPT55	146623KR	KR	6/27/2012	10-2014-7001559		Pending
IPT55	146623JP	JP	6/27/2012	2014-518471		Pending
IPT55	146623EP	EP	6/27/2012	12804818.8		Pending

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IPT55	146623CN	CN	6/27/2012	201280030503.2		Pending
IPT55	146623NZ	NZ	7/9/2012	593764	593764	Granted

Interoperability of Magnetic Structures for Inductive Power Transfer Systems – Inventors: Covic

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT57	121491NZP1	NZ	7/8/2011	593977		Expired
IPT57	121491NZP2	NZ	12/23/2011	597367		Expired
IPT57	121491WO	PCT	7/9/2012	PCT/NZ2012/000121		Expired
IPT57	121491JP	JP	7/9/2012	2014-518475		Pending
IPT57	121491EP	EP	7/9/2012	12820784.2		Pending
IPT57	121491US	US	7/9/2012	14/131,138		Pending
IPT57	121491CN	CN	7/9/2012	201280037549.7		Pending
IPT57	121491KR	KR	7/9/2012	10-2014-7003472		Pending
IPT57	121491NZD1	NZ(Div)	3/31/2014	623198		Abandoned
IPT57	121491NZ	NZ	10/8/2012	593977		Abandoned

Magnetic Structure Interoperability for IPT Systems – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT62	123495NZ1	NZ	9/16/2011	595251		Cognated with IPT57

Multiple Coil Flux Pad – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT63	123496NZP1	NZ	2/16/2012	598253		Expired
IPT63	123496WO	PCT	2/15/2013	PCT/NZ2013/000016		Expired
IPT63	123496KR	KR	2/15/2013	10-2014-7025625		Pending
IPT63	123496JP	JP	2/15/2013	2014-557594		Pending
IPT63	123496IN	IN	2/15/2013	7034/DELNP/2014		Pending
IPT63	123496CN	CN	2/15/2013	201380019993.0		Pending
IPT63	123496US	US	2/15/2013	14/379,068		Pending
IPT63	123496EP	EP	2/15/2013	13749300.3		Pending
IPT63	123496NZ	NZ	4/19/2013	609482	609482	Granted

VAR Control for IPT System – Inventors: Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No	Grant Number	Status
IPT64	123497NZP11	NZ	2/2/2012	597987		Expired

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IPT64	123497WO	PCT	2/1/2013	PCT/NZ2013/000009		Expired
IPT64	123497EP	EP	2/1/2013	13813549.6		Pending
IPT64	123497US	US	2/1/2013	14/376,401		Pending
IPT64	123497CN	CN	2/1/2013	201380017845.5		Pending
IPT64	123497JP	JP	2/1/2013	2014-555521		Pending
IPT64	123497KR	KR	2/1/2013	10-2014-7024432		Pending
IPT64	123497NZ	NZ	4/16/2013	609519		Abandoned

Design Considerations for Variable Coupling Lumped Coil Systems– Inventors: Chang-Yu and Covic

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT66	131923NZP1	NZ	8/31/2012	602184		Expired
IPT66	131923NZP2	NZ	9/14/2012	602543		Expired
IPT66	131923WO	PCT	9/2/2013	PCT/NZ2013/000154		Expired
IPT66	131923NZ	NZ	11/29/2013	618318		Abandoned
IPT66	131923KR	KR	9/2/2013	10-2015-7008302		Pending
IPT66	131923EP	EP	9/2/2013	13833528.6		Pending
IPT66	131923US	US	9/2/2013	14/424,390		Pending
IPT66	131923JP	JP	9/2/2013	2015-529721		Pending
IPT66	131923CN	CN	9/2/2013	201380055662.2		Pending

Wiring Harness and Wireless Power Transfer System– Inventors: Keeling, Beaver, van Boheemen, Kissin, Covic and Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT68	120822P1	US	3/20/2012	61/613,420		Expired
IPT68	120822WO	PCT	3/20/2013	PCT/NZ2013/000045		Expired
IPT68	120822EU	EP	3/20/2013	13764869.7		Pending
IPT68	120822	US	3/20/2013	14/386,206		Pending
IPT68	120822KR	KR	3/20/2013	10-2014-7029391		Pending
IPT68	120822CN	CN	3/20/2013	201380024923.4		Pending
IPT68	120822JP	JP	3/20/2013	2015-501611		Pending

Winding Arrangements in Wireless Power Transfer Systems– Inventors: Keeling, van Boheemen, Kissin, Beaver, Boys Covic, et al.

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT69	120823PI	US	3/20/2012	61/613,414		Expired
IPT69	120823WO	PCT	3/20/2013	PCT/NZ2013/000046		Expired
IPT69	120823	US	3/20/2013	14/386,311		Pending

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IPT69	120823KR	KR	3/20/2013	10-2014-7029392		Pending
IPT69	120823CN	CN	3/20/2013	201380024920.0		Pending
IPT69	120823EU	EP	3/20/2013	13763812.8		Pending
IPT69	120823JP	JP	3/20/2013	2015-501612		Pending

Vehicle or Moving Object Detection– Inventors: Boys

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT77	146626NZP1	NZ	11/12/2012	603566		Expired
IPT77	146626NZ	NZ	11/12/2013	617614		Abandoned
IPT77	146626WO	PCT	11/12/2013	PCT/NZ2013/000202		Expired
IPT77	146626CN	CN	11/12/2013	201380058928.9		Pending
IPT77	146626EP	EP	11/12/2013	13854136.2		Pending
IPT77	146626KR	KR	11/12/2013	10-2015-7015221		Pending
IPT77	146626JP	JP	11/12/2013	2015-541736		Pending
IPT77	146626	US	11/12/2013	14/441,682		Pending

Pick-Up Apparatus for Inductive Power Transfer Systems– Inventors: Covic and Boys; IPT 23 Re-Issue Applications

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT81	121462R1	US	5/2/2007	13/930,505		Pending (Re-issue, see IPT23)
IPT81	121462R1D1	US	10/31/2014	14/529,939		Pending (Re-issue, see IPT23)

Magnetic Flux Coupling Structures with Controlled Flux Cancellation– Inventors: Tejeda, Covic, Gawith, Boys and Pearce

Case	QC Ref No.	Country	Filing Date	Application No.	Grant Number	Status
IPT82	150715NZP1	NZ	9/11/2014	631149		Expired
IPT82	150715NZP2	NZ	3/16/2015	706024		Expired
IPT82	150715NZP3	NZ	4/1/2015	706620		Pending
IPT82	150715WO	PCT	9/10/2015	PCT/NZ2015/050139		Pending

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FOURTH AMENDMENT

THIS FOURTH AMENDMENT is made to the Amended and Restated License Agreement dated October 14, 2011, as amended by that certain letter agreement last signed on July 31, 2012, by the Second Amendment effective October 14, 2011 and by the Third Amendment effective October 14, 2011 (collectively, the "**Agreement**") between Auckland UniServices Limited, a company incorporated and registered in New Zealand with company number 373821 ("**UniServices**") and QUALCOMM Incorporated, a Delaware corporation ("**Qualcomm**"), and is entered into effective as of May 1, 2017 (the "**Fourth Amendment Date**"). UniServices and Qualcomm may be referred to individually as a "**Party**" and collectively as the "**Parties**" in this Fourth Amendment.

FOURTH AMENDMENT:

NOW, THEREFORE, the Parties hereby agree as follows:

1. **Headings; Definitions.** Headings used in this Fourth Amendment are inserted for the purpose of convenience only and are not intended to affect the meaning or interpretation of any provision of this Fourth Amendment. For the purpose of the construction and interpretation of this Fourth Amendment, the word "**including**" (and variations thereof such as "**include**" and "**includes**") will not be deemed to be a term of limitation, but rather will be deemed to be followed by the words "**without limitation,**" and the words "**herein,**" "**hereof,**" and "**hereunder**" will refer to this Fourth Amendment as a whole. Unless otherwise specified herein, capitalized terms used in this Fourth Amendment given to such terms in the Agreement.

2. **Clause 1.1 Definitions.**
   a. The definition of "Road Vehicle" in the Agreement is deleted and replaced by the following
   "Road Vehicle" means any vehicle, scooter, motorcycle, bicycle, tricycle, Segway, wheelchair, or other similar apparatus or machine (whether controlled directly or indirectly through remote or autonomous means (and with or without human input)) having one or more wheels that is designed primarily: (i) for use on a public or private road, trail, pathway, driveway, pavement, race track and its surrounding areas (e.g., race pit, entrance and exit area to race track), garage surface, or parking lot (whether located indoors or outdoors); and (ii) to transport, or provide any service to or for, any person (or persons) or goods.

3. 

4. No Other Amendment. Except as expressly set forth in this Fourth Amendment, the Agreement shall remain in full force and effect without any modification. The terms and conditions of this Fourth Amendment and the Agreement supersedes all prior and contemporaneous oral or written understandings between the Parties with respect to their subject matter, and constitute the entire agreement of the Parties with respect to such subject matter. The terms and conditions of this Fourth Amendment and the Agreement shall not be modified or amended, except by a writing signed by the authorized representatives of both UniServices and Qualcomm.

IN WITNESS WHEREOF, the Parties have, through their duly authorized representatives, caused this Fourth Amendment to be entered into effective as of the Fourth Amendment Date. This Fourth Amendment may be signed in counterparts.

Auckland UniServices Limited	QUALCOMM Incorporated
By: _____	By: _____
Printed Name: W.H.H. CHARLES	Printed Name: John Han
Title: GENERAL MANAGER	Title: Sr Vice President & General Manager
Date: 4th May 2017.	Date: 5/30/2017

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