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(54) Magnetic field inductor

Magnetfeldinduktor

Inducteur de champ magnétique

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Description

[0001] The present invention relates to a magnetic field inductor.

[0002] More particularly it relates to a magnetic field inductor for magnetotherapy devices.

[0003] Magnetic field inductors currently consist of solenoids formed from an electrical conductor (electric wire) wound in several coil turns to form a coil.

[0004] By stacking several turns, the magnetic field intensity at the centre is equal to the sum of that generated by each turn.

[0005] The induction value obtained by the coil will not be exactly the algebraic sum of that generated by each individual turn, but there will be a loss due to the fact that each coil turn has a physical thickness and withdraws from the centre in every direction with the progress of the winding and the superimposing of the layers. Moreover every coil composed of a large number of turns is provided with a plastic support (spool) on which the wire is wound.

[0006] This generates a further increment in the space between the coil centre and its exterior; at the coil centre, the magnetic field generated in a plane perpendicular thereto can be utilized without mechanical obstructions.

[0007] In addition, as each coil winding has its own thickness it withdraws increasingly more from the centre, both in the depth direction and by incrementing its starting radius.

[0008] As already stated, incrementing the induction level is mainly achieved by adding more turns to create a coil, however in this manner the distance from the centre continuously increases in all directions and the efficiency decreases, so incrementing the electrical resistance and incrementing the inductive level of the system, hence slowing down the system in the transient regime and increasing the coil weight and cost.

[0009] When a coil is powered by a direct current, it behaves exactly as a permanent magnet, i.e. it attracts or repels ferromagnetic materials and polar substances. Hence when powered by a direct current, the aforedescribed can also be defined as an "electromagnet".

[0010] If, instead of being powered by a direct current, a pulsating current is applied to the coil, an electromagnet is obtained which continuously and alternately attracts and repels any ferromagnetic material or polar substance positioned in proximity thereto.

[0011] This principle is utilized in the electro medical field and specifically in the magnetotherapy field. In this respect, as the human body is composed largely of water (which is a polar substance), the pulsating electromagnet stresses the cutaneous and subcutaneous zone with continuous attraction or repulsion actions, to provide therapeutic action.

[0012] Currently marketed electromedical appliances implement the electromagnet or LF (low frequency) emitter with frequencies which range up to a maximum of 200 Hz, using a coil of any size, power and final geometry, however this is always formed by winding a conductor to form a coil able to generate a determined size of pulsating magnetic field.

[0013] Known traditional coils used in the medical field are able to generate a magnetic field even of considerable size, but these are of large weight and dimensions. For example, a normal 100 Gauss coil (1 Gauss = 10^{-4} kg C^{-1} S^{-1}) used in the electromedical field has a weight of about 167 g for a diameter of 60 cm and a height of 16.5 cm.

[0014] Large dimensions and weights are not effective for use in mobile devices which have to be applied to various parts of the body and have therefore to be light and manageable.

[0015] Moreover, known coils provide a magnetic field which is not specifically suitable in magnetotherapy applications, in that this develops outside the solenoid in the axial direction from both sides of the coil, both from the side on which the treatment is to be carried out and on the opposite side, hence there is a loss of system efficiency and the result obtained does not exactly conform to that desired.

[0016] Other magnetic field inductors are also known from DE-U-8801879, EP-A-0 428 142, US-A-4 494 100, and FR-A-2 894 061.

[0017] An object of the present invention is therefore to provide a magnetic field inductor which represents an improvement over the known art.

[0018] A further object of the present invention is to provide an inductor which, for the same generated magnetic field, is lighter and of smaller dimensions than traditional coils, for the same generated magnetic field. The main size reduction regards the emitter thickness, which is further reduced by there being no need for the winding spool.

[0019] These and other objects are attained by providing an inductor in accordance with the technical teachings of the accompanying claims. Advantageously the present invention enables improved dissipation of the heat generated by the direct or pulsating electric current passing through the coil turns or through the constituent traces of the emitter.

[0020] A further advantage of the present invention is that of providing an inductor enabling a magnetic field to be obtained which develops mainly on a single side, being concentrated towards a single direction and a specific area of use.

[0021] Further characteristics and advantages of the invention will be apparent from the description of a preferred but non-exclusive embodiment of the inductor or emitter of arbitrary shape, not necessarily cylindrical, toroidal or defined by the winding support, which is illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a plan view of an emitter or inductor according to the present invention, integrated into a printed circuit on a printed circuit board (PCB);

Figure 2 is a simplified radiographic view of an emitter formed from ten mutually superimposed layers (5 plates) in which the electrical paths are joined together at each passage from one plane to another to form a single emitter able to add together the magnetic fields generated by the turns of each individual plane;

Figure 3 is a section through the emitter of Figure 1;

Figures 4A and 4B show schematically the electrical interconnections between the various sides with which the emitter is composed, in proximity to the central zone and in proximity to the outer edge of the emitter respectively;

Figure 5 is a graph showing the lines of force of the magnetic field generated by the emitter of the present invention; the presence of a specific ferromagnetic plate, of suitable dimensions and thicknesses, positioned resting on the emitter either directly or by interposing insulating and/or thermoconductive material has the double function of dissipating the heat generated by the emitter and of varying the generation geometry of the magnetic field, so directing it onto a single side, namely that of interest for the treatment function;

Figure 6 is a perspective view of an emitter or inductor of the present invention.

[0022] With reference to said figures, these show an emitter (or inductor) indicated overall by the reference numeral 1.

[0023] The emitter is formed from a plurality of individual superimposed layers (or plates) A, B, C, D, E which are adhesive-bonded and pressed together. Each emitter layer is substantially a printed circuit on a printed circuit board (PCB). The symbol PCB (printed circuit board) indicates an insulating material base (usually epoxy resin reinforced with glass fibre) on which connection lines of conductive material (usually copper) are formed between the circuit elements. The production processes, mainly of photographic, chemical and electrolytic nature, have been known in the electronic industry for decades, and will not be repeated here.

[0024] A PCB is known as mono- or single-face type when composed of a single layer of insulating resin and a single layer of conductive material which is the photographic image of the electrical connections to be obtained.

[0025] A PCB is produced starting from a plate of insulating resin on which a thin homogeneous sheet of copper has been applied to totally cover the insulating base. The part not involved in the image to be obtained is then eroded by a series of photographic and chemical processes, to obtain at the end of the process an insulating base with the photographic image of the desired circuit in conductive material.

[0026] Following this trace forming operation, the PCB in the form of a semifinished product is suitably bored with a specific numerically controlled drill to facilitate its connection to other components.

[0027] Following this first stage the PCB usually undergoes a series of enhancements to finish the product, including the application of an electrically insulating varnish known as "solder resist" by a masking process, implemented only at the points where the PCB must not have electrical access to the outside, by which the traces and the areas at voltage become totally insulated, on one side by the base resin and on the other side by the solder resist protective varnish, to leave uncovered only the trace ends, i.e. where normally soldering is carried out to connect a component or a wire or a connection towards the outside.

[0028] The PCB usually undergoes two further finishing processes, such as the application of a silk screen print by which an actual design is made with a non-conductive varnish to facilitate identification of the components or to print other information useful in recognizing the product.

[0029] A further process undergone by the PCB is the surface treatment of those areas exposed to the air (not covered by solder resist), to ensure their protection against the typical oxidation of bare copper, this treatment typically being a covering with tin alloy spread hot on the PCB, or a chemical or electrolytic deposition such as silver or gold plating if extreme planarity or very low contact resistances are required.

[0030] The present invention relates to a multi-layer double-face emitter.

[0031] A double-face circuit is composed of a single insulating resin support on which two copper sheets are applied, one on each side of the support, these being processed simultaneously as aforedescribed.

[0032] In this case the final circuit can be more complex, because in this case a wire connection is emulated at which the conductors can mutually cross and be superimposed, enabling a more complex scheme to be implemented.

[0033] This procedure requires a more well-organized production process to enable a connection present on one side to be able to also continue on the opposite side.

[0034] In this case a through hole is made at the point in which the two layers are to be connected together, then by means of an electrolytic process a conductive galvanic deposit is formed within the hole, the applied material cladding the walls of the hole to connect together the two traces present on the opposite sides. This connection type is known as a "metallized hole" or "metallization".

[0035] Reference will be specifically made to a multilayer PCB formed by superimposing double-face PCBs adhesive-bonded and pressed together to compose an even very complex circuit, in which the connections can pass from one side to the other through the metallization holes.

[0036] By studying those traditional coils wound in air or on a spool which have been used up to the present time as magnetic field emitters, it has been noted that

the greatest efficiency loss arises from the fact that the thickness of each winding is not ideally zero, this hence involving the problem of not being able to utilize the effect of the magnetic field in a point close to the coil centre where instead the magnetic field should be a maximum.

[0037] According to present invention, on each face of a first plate a trace of small thickness (usually from 30 to 100 μm) is formed extending as a spiral, in order to concentrate the magnetic field generated by the passage of electric current in a predefined single point, which is usually but not essentially the centre.

[0038] The present invention will be described in Figure 1. This shows a first face A1 of a plate A made of insulating resin. On the first face a trace 5 is formed of spiral shape. In the illustrated example there are 20 turns per plane extending about a common axis 6 corresponding to the plate centre. It should be noted that these traces forming the turns present on each layer must have suitable thicknesses, widths and insulations to generate in gauged manner the required magnetic result and to enable the necessary thermal dissipation.

[0039] The trace thickness is usually between 10 and 200 μm, preferably 70/100 μm, the plate width is between 0.1 and 20 mm, preferably 1 mm, and each side of the plate presents a number of turns between 1 and 200, preferably 20. In this specific example a base material is used in which the sum of the copper trace and of the insulating resin gives a total thickness of 0.25 mm for each individual layer.

[0040] The final shape of the product is totally arbitrary; in the present invention, the traces are of circular pattern, the outer profile of the emitter is square (of 58 mm side), but could be adapted to any convenient geometry. The trace extends from a first contact 12 to a second contact 7. These serve to electrically power the spiral. In this case, while the contact 12 represents one end of the emitter, the contact 7 represents an intermediate point thereof, namely a point which joins to the next side of the printed circuit.

[0041] The plate A presents a second face A2 opposite the first. On the second face, a second trace (not shown) is formed having the shape, characteristics and axis 6 substantially identical to those of the first trace, the only difference being the on the second face the spiral turn is designed specularly such that the current path and the consequent magnetic field generation do not change direction and hence does not nullify that generated on the first layer but instead adds to it. This however is connected to the contact 7 and to the contact 13 in proximity to the axis 6. As already stated, the electrical connections between the trace on the first face and that on the second face, the geometry of the paths and the geometry of the connections ensure that the current circulates always in the same direction about the axis 6, hence enabling magnetic fields to be generated which are added together at the axis.

[0042] In the illustrated embodiment, a second plate B, a third plate C, a fourth plate D and a fifth plate E are adhesive-bonded and pressed on the first plate A.

[0043] All the plates A, B, C, D, E (five in all) and the traces formed on them (ten in all) are substantially identical in pairs (i.e. the turns present on the five upper sides and the turns present on the five lower sides of each plate are identical to each other with the exception of the contacts to which these are connected, which are those indicated by the numerals from 7 to 11, and from 12 to the final contact (not shown). In detail, listing the connections, these are: 12 (inlet conductor connection), 7 (joins side 1 to side 2 concerning the plate A), 13 (joins side 2 to side 3 concerning the plates A and B), 8 (joins side 3 to side 4 concerning the plate B), 14 (joins side 4 to side 5 concerning the plates B and C), 9 (joins side 5 to side 6 concerning the plate C), 15 (joins side 6 to side 7 concerning the plates C and D), 10 (joins side 7 to side 8 concerning the plate D), 16 (joins side 8 to side 9 concerning the plates D and E), 11 (joins side 9 to side 10 concerning the plate E), final contact at outlet.

[0044] All the electrical connections are obviously made such as to cause current to circulate in the same direction through the ten traces provided, such that the magnetic fields generated by them are added together at the axis 6.

[0045] It should be noted that even if superimposing a considerable number of plates (in this respect in other embodiments more than five double-face plates can be adhesive-bonded together), the total thickness can still be maintained small while maintaining the system efficiency high, given that the coil centre 6 nearly coincides with the point at which the generated magnetic field can be utilized.

[0046] Returning to the embodiment described here, as can be seen from Figure 3, the plate E (i.e. the last) can be positioned resting on (or fixed for example by glue or other manner to) a layer of electrically insulating but thermally conductive rubber. The rubber layer is then associated on the opposite side of the plate E to a sheet of ferromagnetic material 3.

[0047] The rubber positioned in contact with the lower side of the emitter (in this case the plate E) enables the active electric power to be dispersed, i.e. to dissipate in advantageous manner the heat produced by the current flowing through the traces, so transporting this heat from the active part of the emitter to the ferromagnetic backing plate which here also acts as a thermal dissipater.

[0048] Hence, in contrast to traditional coils, the planar shape of the product, the absence of winding spools, and the fact that the coil turns are not wound but are formed on the printed circuit by tracing any desired geometry, enable any regular or irregular final shape to be obtained.

[0049] A further innovation of the present invention is the already described application of a ferromagnetic material to compress the flux lines.

[0050] From Figure 5 it can be seen that the presence of the ferromagnetic plate 3 (which advantageously can project perimetrally with respect to the size of the plates A-E) modifies the flux lines of the magnetic field to give

this latter a preferential direction indicated by the arrow F in the figure.

[0051] It should be noted that this electromagnetic field modification is particularly useful for those emitters used in the electromedical field which utilize the magnetic flux generated by a single side. These are usually rested on the zone to be treated. The circular nature of traditional coils makes the emitter develop the flux lines symmetrically on both sides of the emitter, dispersing one half of the generated magnetic field which is hence not used for therapeutic purposes.

[0052] In contrast, in the solution proposed herein, nearly all the magnetic flux is directed onto the zone to be treated, with evident advantages.

[0053] Essentially, by resting or connecting the emitter (or a stack of emitters) implemented on a PCB above a resting surface of suitable shape and thickness, if this resting base consists of a strongly ferromagnetic material (for example ductile iron with very low steel residues), nearly all the generated flux previously dispersed by the part not adjacent to the surface to be treated "rebounds" and changes direction, to reinforce the induction value generated by the side of interest (arrow F).

[0054] The present invention also provides other advantageous advantages compared with traditional coils.

[0055] The absence of the winding spool means that the "centre - utilization plane" dimension of the magnetic field is further reduced.

[0056] Relative to the implementation on PBCs, if determined production expedients are followed, a repeatability and production homogeneity are enabled which the wound coil cannot guarantee. In other words, PCB technology enables the emitters to demonstrate performance differences between product units pertaining either to the same batch or to different batches which are much smaller than that which can generally be obtained on comparing the performance differences of several coils constructed to the same specification.

[0057] In this respect, in a wound coil the high confidence range is due mainly to the high packing geometry of the wire which at each revolution rests in the spool with a certain position tolerance, moreover the tension (winding torque) with which the wire is wound makes a considerable difference because the coil can become more or less compact, hence varying its final performance.

[0058] Another unknown is the number of actual turns, unverifiable if not sample-removing the wire from the spool.

[0059] A flat coil integrated on a PCB, given its flat geometry, also enables devices to be constructed of smaller dimensions, less bulky and lighter in weight.

[0060] The use of the present invention enables a pulsatingly controlled electromagnet or a pulsating magnetic emitter to be created, to obtain a determined magnetic induction value on its surface.

[0061] The figures show by way of example an emitter implemented on a PCB of 10 layers.

[0062] Figure 1 shows how the turn geometry is visible at the surface on one of the two outer sides (a ten-layer PCB presents eight internally hidden sides and two surface visible sides). In the substantially radiographic Figure 2, the ten superimposed layers are shown together with the metallized holes used to connect each side to the next in order to simulate a continuously wound wire, i.e. to emulate a coil.

[0063] A further advantage achieved by implementing such pulsating magnetic field inductors on a PCB support lies in the fact that because of the small thickness several inductors can be stacked to still achieve an acceptable efficiency. If in contrast several air-wound coils were stacked, seeing the considerable thickness, the emissions of the first coil would be nullified before reaching the outer surface of the second and so on.

[0064] It should also be noted that the geometry of the spirally wound copper trace present on each side of the PCB possesses a flat and wide geometry, presenting a contact surface to the outside which is much larger than that achievable with an enamelled conductor of circular cross-section used in forming traditional coils, this fact aiding the dispersion of the heat generated by the passage of electric current.

[0065] In an alternative embodiment of the present invention, not shown, a radiofrequency transmission antenna can be integrated into at least one side of the emitter, usually the most outer side towards the treatment area, to hence enable combination emitters to be implemented in which the therapeutic effects of low frequency (pulsating magnetic field) and of high frequency (radio waves) can be added together.

[0066] This implementation or the extension of this concept enables electronic measurement and control circuits to be integrated into the same emitter, making the device intelligent and reducing costs and dimensions.

[0067] Hence summarizing, the innovations and advantages obtained compared with traditional coils by means of the present invention are:

* Greater confidence range in mass production.
* Lesser weight.
* Lesser thickness.
* Facility to decide on more complex geometries compared with a normal coil wound in air or on spool
* Greater electromagnetic efficiency.
* Greater thermal efficiency.
* Greater control response speed (low inductance)
* Facility to stack several finished emitters (for example superimposing two or more aforedescribed emitters 10 by resting them one on the other on a single ferromagnetic backing plate) to obtain an emission proportional to the number of stacked emitters.
* Ability to dissipate the active power by conduction by the use of thermally conducting rubber to hence transfer the heat onto the ferromagnetic backing plate.

* Ability to use the ferromagnetic backing plate to compress the flux lines, hence incrementing the induction on the side of interest.
* Facility to integrate on one and the same PCB electronic control and measurement circuits or to integrate other antennas to provide multiple LF + HF therapy (LF = magnetism with frequency between 6 and 120 Hz + HF = radio waves with carrier frequency between 20 and 30 MHz and pulse repetition range between 0.1 and 5 KHz).

[0068] In the aforedescribed embodiment, the spiral turns of the traces present on the various constituent plates of the inductor present a substantially circular path, however alternative embodiments can assume any shape, regular or irregular (square, rectangular, elliptical, composite geometries of any extent and type).

[0069] As already explained, although the aforedescribed inductor taken as an example to described the invention is formed from five double layer plates adhesive-bonded and pressed together (ten layers in total), this number can obviously be increased or decreased or more finished figures can be stacked with or without the use of the ferromagnetic backing plate, to form emitters of adequate power capable of enabling emission of a magnetic flux of required extent and geometry.

Claims

1. A magnetic field inductor presenting a first plate (A) of insulating material provided with a first face (A1) on which a first trace (5) of electroconductive material is formed, said first trace (5) presenting a spiral shape extending about an axis (6), the first plate (A) presenting a second face (A2) on which a second trace of electroconductive material is present, the second trace also presenting a spiral shape extending about an axis (6) substantially identical to that of the first trace, the first (5) and second trace being connected together electrically such that, when a current passes therethrough, the first (5) and second trace generate magnetic fields which are added together on said axis (6), **characterized in that** only one of the external plates is coupled to a sheet of ferromagnetic material (3) adapted to compress the flux lines and improve the dissipation of heat generated by the current passing through the traces.

2. An inductor as claimed in claim 1, **characterised by** comprising a plurality of plates (A, B, C, D, E) each provided with a first face on which a first trace of electroconductive material is formed, said first trace presenting a spiral shape extending about an axis (6) common to all the plates, a second face of said first plate presenting a second trace of electroconductive material, the second trace also presenting a spiral shape extending about said axis common to all the plates, the traces of each plate being connected together electrically such that, when a current passes therethrough, they generate magnetic fields which are added together on said axis common to all the plates.

3. An inductor as claimed in one or more of the preceding claims, wherein a layer of electrically insulating but thermally conductive rubber is provided between the external plate and the sheet of ferromagnetic material.

4. An inductor as claimed in one or more of the preceding claims, wherein at least the plate traces are covered by insulating varnish.

5. An inductor as claimed in claim 2, wherein a further trace is provided on at least one of said plates for the emission of radio waves.

6. An inductor as claimed in one or more of the preceding claims, wherein each plate has a thickness between 0.1 and 2.0 mm, preferably 0.25 mm.

7. An inductor as claimed in one or more of the preceding claims, wherein five plates (A, B, C; D, E) are provided adhesive-bonded together, for a total of ten traces.

8. An inductor as claimed in one or more of the preceding claims, wherein each trace presents a thickness between 10 and 200 μm, preferably 70/100 μm, a width between 0.1 and 20 mm, preferably 1 mm, and a number of turns between 1 and 200, preferably 20.

9. An inductor as claimed in one or more of the preceding claims, wherein at least one of the plates presents a trace acting as an antenna for radiofrequency emission, and/or additional piloting, control and/or measurement circuits being implemented on at least one of the plates.

10. An inductor as claimed in one or more of the preceding claims, wherein said trace has a substantially circular and/or square and/or rectangular and/or elliptical development.

Patentansprüche

1. Magnetfeld-Induktor, welcher eine erste Platte (A) eines isolierenden Materials aufweist, welche mit einer ersten Fläche (A1) versehen ist, auf welcher eine erste Spur (5) eines elektrisch leitenden Materials ausgebildet ist, wobei die erste Spur (5) eine Spiralform aufweist, welche sich um eine Achse (6) erstreckt, wobei die erste Platte (A) eine zweite Fläche (A2) aufweist, auf welcher eine zweite Spur eines

elektrisch leitenden Materials vorhanden ist, wobei die zweite Spur auch eine Spiralform aufweist, welche sich um eine Achse (6) erstreckt, die im Wesentlichen identisch mit derjenigen der ersten Spur ist, wobei die erste (5) und die zweite Spur miteinander elektrisch verbunden sind, so dass, wenn ein Strom dort hindurchfließt, die erste (5) und die zweite Spur Magnetfelder erzeugen, welche bei der Achse (6) zusammenaddiert werden,
dadurch gekennzeichnet,
dass nur eine der äußeren Platten mit einer Schicht eines ferromagnetischen Materials (3) gekoppelt ist, welches ausgestaltet ist, um die Flusslinien zu komprimieren und das Abführen von Wärme, welche durch den Strom, der durch die Spuren fließt, erzeugt wird, zu verbessern.

2. Induktor nach Anspruch 1, **dadurch gekennzeichnet, dass** der Induktor mehrere Platten (A, B, C, D, E) umfasst, welche jeweils mit einer ersten Fläche versehen sind, auf welcher eine erste Spur eines elektrisch leitenden Materials ausgebildet ist, wobei die erste Spur eine Spiralform aufweist, welche sich um eine für all die Platten gemeinsamen Achse (6) erstreckt, wobei eine zweite Fläche der ersten Platte eine zweite Spur eines elektrisch leitenden Materials aufweist, wobei die zweite Spur auch eine Spiralform aufweist, welche sich um die für all die Platten gemeinsame Achse erstreckt, wobei die Spuren jeder Platte elektrisch zusammen verbunden sind, so dass sie, wenn ein Strom dort hindurchfließt, Magnetfelder erzeugen, welche bei der für all die Platten gemeinsamen Achse zusammenaddiert werden.

3. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Schicht eines elektrisch isolierenden, aber thermisch leitenden Gummis zwischen der äußeren Platte und der Schicht aus ferromagnetischen Material vorhanden ist.

4. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** zumindest die Platten-Spuren durch isolierenden Klarlack abgedeckt sind.

5. Induktor nach Anspruch 2, **dadurch gekennzeichnet, dass** eine weitere Spur auf zumindest einer der Platten zur Ausstrahlung von Funkwellen vorhanden ist.

6. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jede Platte eine Dicke zwischen 0,1 und 2,0 mm, vorzugsweise 0,25 mm, aufweist.

7. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** fünf Platten (A, B, C, D, E), welche mit Klebstoff zusammen verbunden sind, für insgesamt zehn Spuren vorhanden sind.

8. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jede Spur eine Dicke zwischen 10 und 200 μm, vorzugsweise 70/100 μm, eine Breite zwischen 0,1 und 20 mm, vorzugsweise 1 mm, und eine Anzahl von Windungen zwischen 1 und 200, vorzugsweise 20, aufweist.

9. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** mindestens eine der Platten eine Spur aufweist, welche als eine Antenne zur Ausstrahlung einer Radiofrequenz wirkt, und/oder dass zusätzliche Führungs-, Steuerungs- und/oder Mess-Schaltungen auf mindestens einer der Platten implementiert sind.

10. Induktor nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Spur eine im Wesentlichen kreisförmige und/oder quadratische und/oder rechteckförmige und/oder elliptische Ausprägung aufweist.

Revendications

1. Bobine d'induction de champ magnétique présentant une première plaque (A) de matériau isolant munie d'une première face (A1) sur laquelle une première trace (5) de matériau électro-conducteur est formée, ladite première trace (5) présentant une forme de spirale s'étendant autour d'un axe (6), la première plaque (A) présentant une seconde face (A2) sur laquelle une seconde trace de matériau électro-conducteur est présente, la seconde trace présentant également une forme de spirale s'étendant autour d'un axe (6) sensiblement identique à celui de la première trace, la première (5) et la seconde trace étant connectées ensemble électriquement de telle sorte que, quand un courant les traverse, la première (5) et la seconde trace génèrent des champs magnétiques qui s'additionnent ensemble sur ledit axe (6), **caractérisée en ce que** seule l'une des plaques extérieures est couplée à une feuille de matériau ferromagnétique (3) agencée pour comprimer les lignes de flux et pour améliorer la dissipation de la chaleur générée par le courant qui traverse les traces.

2. Bobine d'induction selon la revendication 1, **caractérisée en ce qu'**elle comprend une pluralité de plaques (A, B, C, D, E), chacune pourvue d'une première face sur laquelle une première trace de matériau electro-conducteur est formée, ladite première

trace présentant une forme de spirale s'étendant autour d'un axe (6) commun à toutes les plaques, une seconde face de ladite première plaque présentant une seconde trace de matériau électro-conducteur, la seconde trace présentant également une forme de spirale s'étendant autour dudit axe commun à toutes les plaques, les traces de chaque plaque étant reliées entre elles électriquement de telle sorte que, lorsqu'un courant les traverse, elles génèrent des champs magnétiques qui s'additionnent ensemble sur ledit axe commun à toutes les plaques.

3. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle une couche de caoutchouc électriquement isolant mais thermiquement conducteur est prévu entre la plaque extérieure et la feuille de matériau ferromagnétique.

4. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle au moins les traces des plaques sont recouvertes par du vernis isolant.

5. Bobine d'induction selon la revendication 2, dans laquelle une trace supplémentaire est prévue sur au moins l'une desdites plaques pour l'émission d'ondes radio.

6. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle chaque plaque a une épaisseur comprise entre 0,1 et 2,0 mm, de préférence de 0,25 mm.

7. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle cinq plaques (A, B, C, D, E) sont prévues assemblées par collage, pour un total de dix traces.

8. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle chaque trace présente une épaisseur comprise entre 10 et 200 μm, de préférence de 70/100 μm, une largeur comprise entre 0,1 et 20 mm, de préférence de 1 mm, et un nombre de spires compris entre 1 et 200, de préférence de 20.

9. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle au moins l'une des plaques présente une trace qui agit comme une antenne pour une émission de radiofréquence et / ou des circuits de pilotage, de commande et / ou de mesure supplémentaires qui sont mis en oeuvre sur au moins un des plaques.

10. Bobine d'induction selon l'une ou plusieurs des revendications précédentes, dans laquelle ladite trace a un développement sensiblement circulaire et /ou carré et / ou rectangulaire et / ou elliptique.

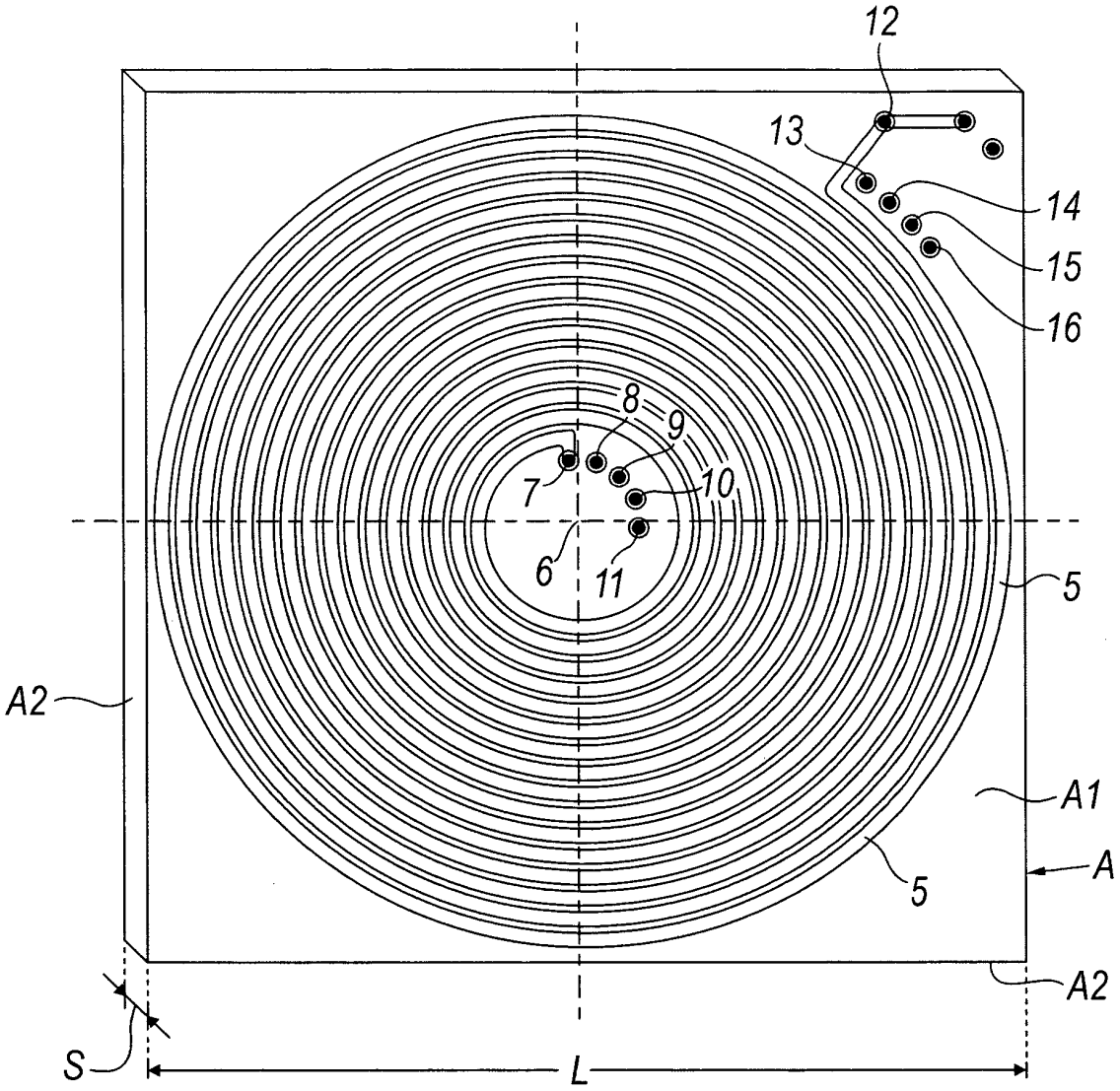


Fig. 1

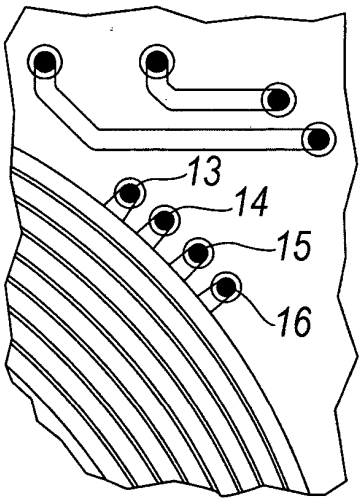


Fig. 4A

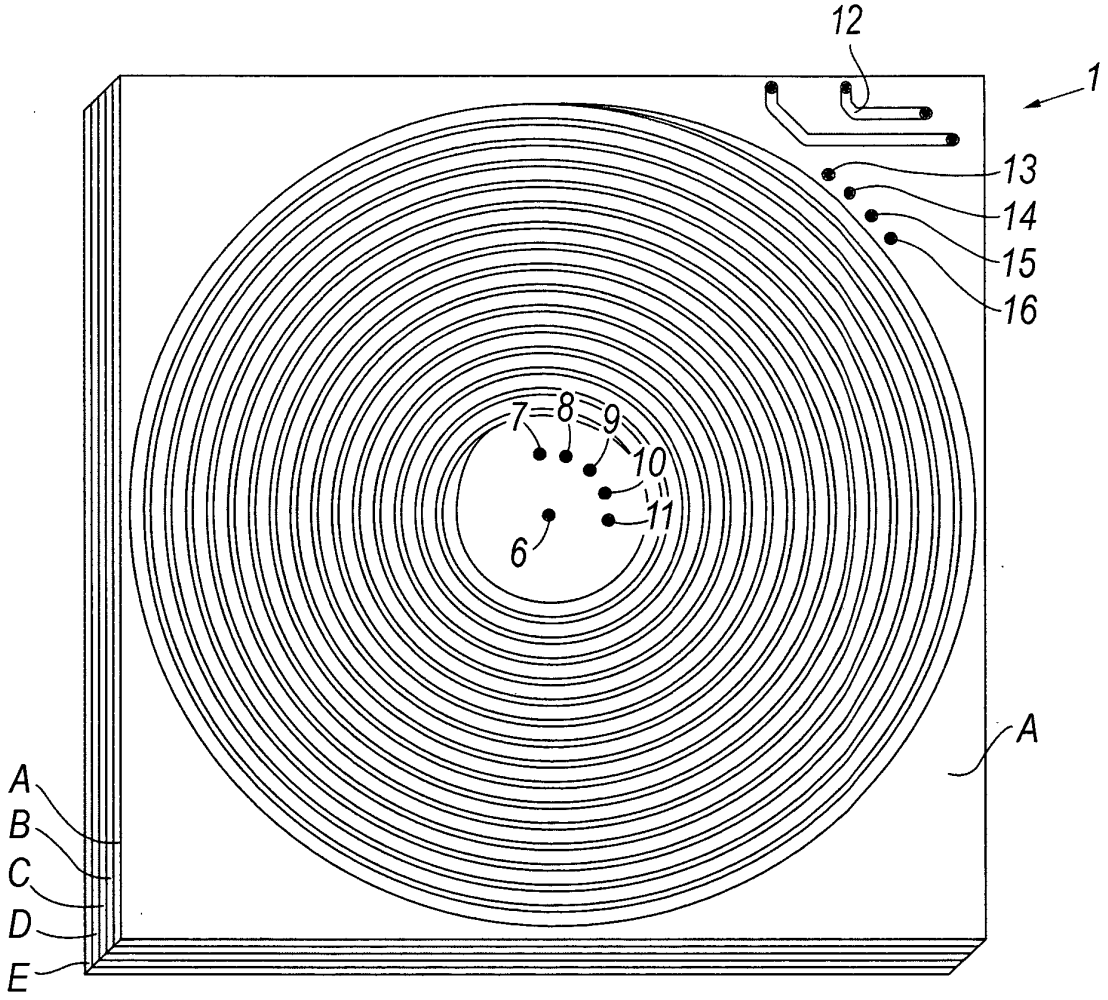


Fig. 2

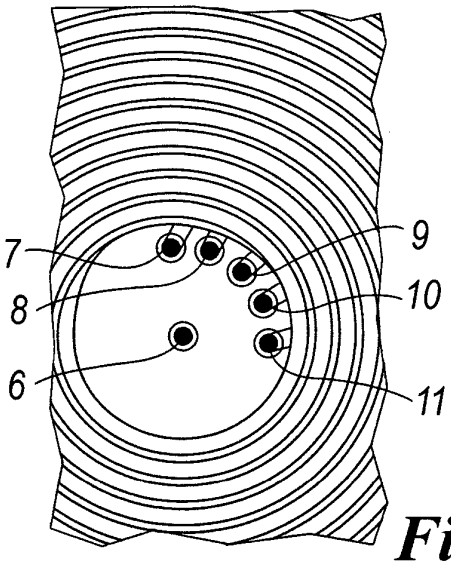


Fig. 4B

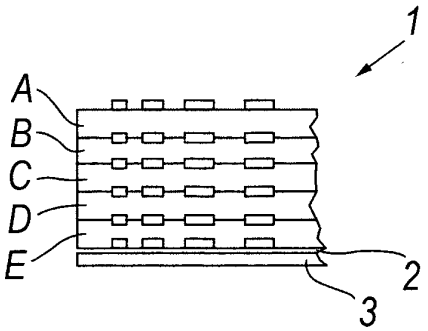


Fig. 3

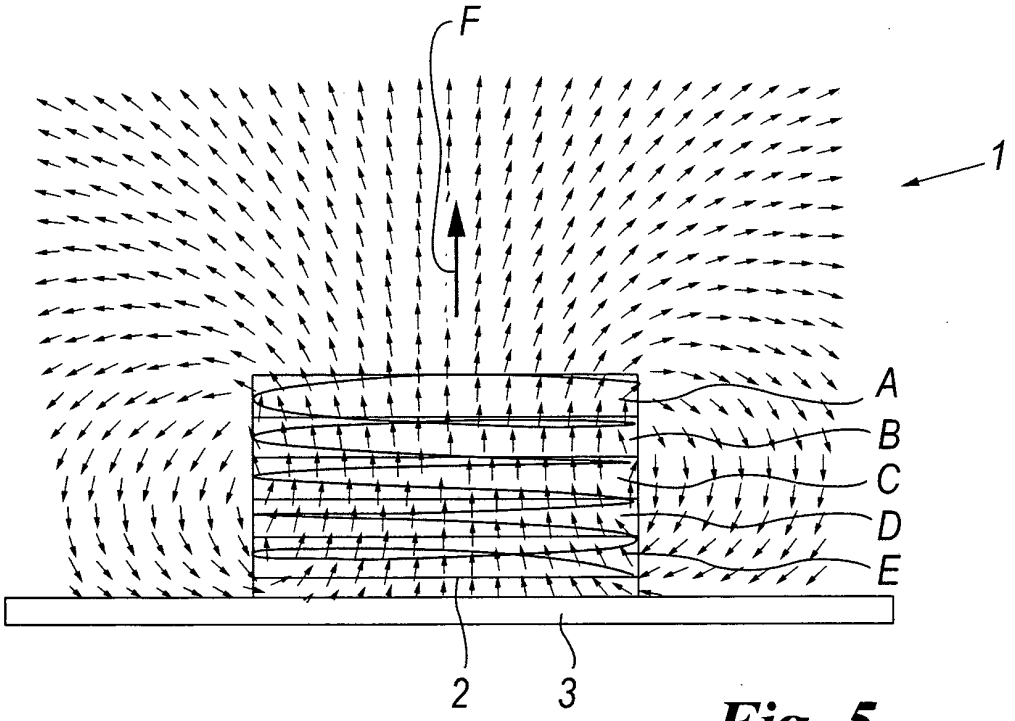


Fig. 5

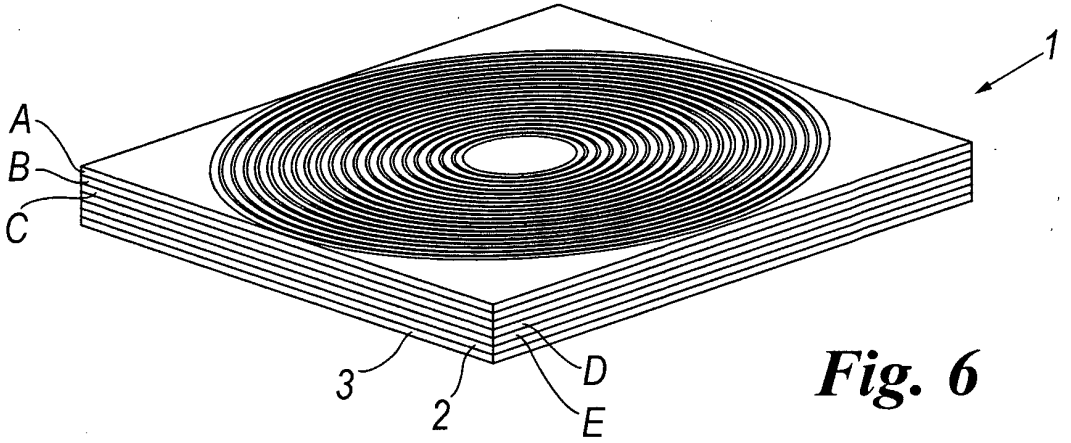


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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