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(54) **MAGNETIC CORE WITH COOLING CAPABILITIES AND METHOD FOR ITS PRODUCING**

MAGNETKERN MIT KÜHLFÄHIGKEITEN UND VERFAHREN ZUR DESSEN HERSTELLUNG

NOYAU MAGNETIQUE PRESENTANT DES CAPACITES DE REFROIDISSEMENT ET SA METHODE DE FABRICATION

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- **PATENT ABSTRACTS OF JAPAN vol. 010, no. 272 (E-437), 16 September 1986 (1986-09-16) & JP 61 094310 A (KANSAI ELECTRIC POWER CO INC: THE; others: 01), 13 May 1986 (1986-05-13)**

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Description

Field of the invention

[0001] The present invention relates to magnetic cores having enhanced self-cooling capabilities and, in particular to magnetic cores comprising special elements for dissipating the heat internally produced.

Description of related art

[0002] Magnetic cores, as component of impedances, coils and transformers, are used in a number of electrical and electronic applications. In particular magnetic cores are used in the manufacturing of impedances, chokes, and transformers in many power or signal processing circuits for the purposes of impedance matching, frequency filtering, as energy tanks in voltage converters, for power factor correction and in numberless other cases.

[0003] More particularly, applications of magnetic cores in the construction of longitudinal coils and current-compensated coils are described in patent applications EP-A2-0 682 395 and EP-A2-1 096634 (closest prior art), in the name of the applicant.

[0004] US-A-5,768,113 discloses a high power and high voltage power supply is capable of charging one or more capacitors to high voltage. The power supply includes a current rectifier circuit for connecting to an AC source, a voltage step-up circuit including at least one controllable electronic switch and a voltage step-up transformer including a primary winding electrically connected to the electronic switch, and a control device for controlling the electronic switch. The power supply is organized to chop the current flowing through the primary winding in such a manner as to enable a high voltage to be taken from across the terminal to at least one secondary winding of the transformer. The step-up circuit is of a non-resonant type. The transformer core has heat dissipation features permanently fixed to its outer surface.

[0005] Magnetic coils and the associated cores are generally present in EMC filters, and in most noise-suppression filters. Due to their comparative bulk, Magnetic component contribute heavily to the size and cost of such filtering devices.

[0006] In many cases, and in particular in medium and high frequency applications with moderate or high core losses, it is customary to produce magnetic cores from magnetic metallic powders, typically iron or permalloy powders, or other magnetic powders, by a process of pressing a mixture of magnetic powder and an adequate binding and insulating phase, into a die of the desired form. The powder and the binding phase are compacted together by the action of heat and pressure into a solid core having the desired shape.

[0007] Alternatively magnetic cores can be produced by magnetic powder alone, by a sintering process.

[0008] In a further alternative process magnetic cores are cast at lower temperature and pressure, by adopting an appropriate resin binder, for example a two-component hardening compound, another chemically curable resin, or a low-temperature curing resin.

[0009] Other magnetic core types comprise laminated cores, mostly employed for applications at mains frequency, and ceramic ferrite cores.

[0010] In all these cases the problem arises of transferring the heat losses in the core to the outside of the coil. Core losses arise from hysteresis and eddy currents and are of course unavoidable, whenever the core is subject to a time-variable magnetic flux. In some cases, and particularly in filters, mains filters and EMC filters, core losses are a desired characteristic of the magnetic component, since dissipating unwanted portions of the signal in the core may reduce the load on resistive elements of the circuit.

[0011] Such shortcomings of the known core coils reflect in corresponding limitations of EMC filters and noise filters comprising those coils.

[0012] The internally produced heat must however be transferred to the outside to avoid that the temperature exceeds the thermal limit of the coil insulation or the Curie point of the magnetic material. Due to the finite core heat-transfer capability, core losses are often a major limiting factor in the power rating of a magnetic component.

[0013] Magnetic cores 10 are usually manufactured in a variety of shapes, some of which are represented on figure 1. Core shapes are generally designed with the aim of simplifying coil winding and/or of using the magnetic material in the most efficient way. The designer tries therefore to place the magnetic material in high flux zones, and regards regions of magnetic material in which the flux is sensibly lower then average as an unnecessary waste.

[0014] The known cores 10 represented on figure 1 are an example of this way of designing. While these cores use a minimal amount of magnetic material, the outer surface available for the heat exchange is necessarily very low. These cores are therefore easily overheated, because the heat dissipation of the core losses is very inefficient in this design. As a consequence, in many applications where core losses are moderate or high, the core dimensioning factor will be the power dissipation rather than the maximum available magnetic flux.

[0015] When such magnetic cores are employed in the manufacturing of a filter, for example an EMC-filter or a mains filter for noise disturbance suppression, the large size of the magnetic elements contribute to the size and cost of the final device.

Summary of the invention

[0016] An object of the present invention is to provide a magnetic core in which the heat losses are efficiently transferred to the outside, and therefore a magnetic core allowing the construction of more compact, more powerful coils and magnetic components.

[0017] A further object of the present invention is to provide a filter, and a coil therefore, exhibiting smaller size and lower cost.

[0018] Such object is attained by the coil, the core and the circuit having the characteristics of the claims 1-7 in the corresponding categories. The core is produced by a method according to claims 1-10.

Brief Description of the Drawings

[0019] The invention will be better understood with the aid of the description of an embodiment given by way of example and illustrated by the figures, in which:

Fig. 1	represent a series of views of magnetic cores according to the prior art.
Fig. 2a, b	represent a magnetic core according to a first embodiment of the present invention.
Fig. 3	represents a magnetic core according to a second embodiment of the present invention.
Fig. 4a,b	represent a variant embodiment of the first embodiment of figures 2a and 2b and
Fig. 5, 6a,b	represent further embodiments.

Detailed Description of the Invention

[0020] According to a first embodiment of the invention, the shape of the core is chosen in order to enhance heat dissipation.

[0021] According to a first embodiment of the invention, the outer surface of the core 10 is equipped with fin-like structures in order to increase heat dissipation. Figures 2a and 2b represent an example of an E-core 10 provided with a series of heat fins 40 on the other surface. The heat fins 40 are integrally realized together with the core 10, by appropriately shaping the die or the mould in which the metal powder is pressed or cast.

[0022] The magnetic material in the heat fins 40 may play little or no role as far as the magnetic circuit is concerned, yet the fins 40 significantly improve heat convection and radiation from the core 10 to the outside. The cores of figure 2a will often lead, in presence of core losses, to a more compact and economical construction than the known cores 10 of the figure 1.

[0023] This invention is limited to powder cores, but the fins 40 could equally be added to ferrite cores, or to laminated cores, or to magnetic elements of other magnetic materials with which radiating fins can be integrally realized.

[0024] According to a variant of this first embodiment of the invention, represented on figures 4a and 4b, the same heat-dissipating fins 40 are realized on the outer surface of a pot-shaped core 10. It is clear that similar variant embodiments are also possible for any other usual core shape, for example for C-cores, ring, flat, drum or rod cores, and for all variations and combinations thereof.

[0025] It is also to be understood that the present invention should not be limited to the provision of parallel fins as described in the above non-limitative examples, but comprises as well other geometrical structures like ribs, slots, protrusions, nooks, combs, fingers, and in general any shape providing cavities and protrusions for increasing the available external surface of the core and the heat dissipation therefrom.

[0026] According to a second embodiment of the present invention, and with reference now to figure 3, the magnetic core according to the invention comprises heat-conductive inserts 50, permanently attached to or inserted in the core 10, for conducting and dissipating the heat generated in the core 10 as a consequence of the magnetic losses therein. Such heat conductive inserts 50 can for example be realized from pre-punched metal sheets, inserted in the die or in the mould before the magnetic powder is added and which become then permanently incorporated in the powder core. The protruding part of the metal inserts 50 acts as radiating fins, thus increasing the heat dissipation from the core 10.

[0027] Alternatively the metal inserts 50 can be inserted and integrated in the core 10 after the constitution of the core 10, for example by gluing, pressing, screwing, or by any other assembly technique.

[0028] Preferably the shape of the sheets will be chosen in order to achieve a large contact area with the core material, and the sheet orientation and thickness will be adapted in order to minimize the induced eddy currents. In this case the sheets may be realized of high thermal conductivity material, like aluminium or copper.

[0029] Other alternative variants of this embodiment are also possible, in which the heat-conductive insert 50 consists of metal rods or of metal wires or of a metallic mesh.

[0030] Figures 6a and 6b represent an alternative embodiment of the present invention according to which a ring core 10 comprises metallic bushes 90 for fixing the wound core 10 to a heat sink. The metallic bushes 90 are permanently inserted in the core 10, and produce three ear pads, by which the core 10 can conveniently be mounted on the heat sink. The internally generated heat flows therefore from the core 10 through the bushes 90 to the heat sink, by thermal conduction.

[0031] This embodiment of the present invention lends itself to several variants, in which the cylindrical bushes 90 are replaced by other mounting and heat-conduction inserts, like for example metallic profiles or fixation plaques.

[0032] According to another embodiment, described with reference to figure 5, a pot core 10, on which a winding 20 is realized, has permanently inserted a heat pipe 80. The heat pipe 80 is in thermal contact with the core 10, and comprises an internal conduit (not represented) partially filled with a volatile liquid, for example water in a low-pressure tight chamber. The heat contact between the heat pipe 80 and the core 10 can be enhanced for example by providing a series of ribs on the former (not represented).

[0033] The volatile liquid continuously evaporates in the part of the heat pipe 80 in contact with the hot core 10 and condensates in the cold outer part thermally connected with the large radiator 81. From the cold end of the pipe 80 the liquid drips back to the core in a continuous cycle.

[0034] In other words, the heat transfer along the heat pipe 80 comprises the four following processes, all taking place in a continuous cycle:

1. (evaporation) the liquid evaporates in the hot end of the heat pipe 80, inside the core 10, thereby subtracting from the core 10 a latent evaporation heat;

2. (vapour transfer) the hot vapour fills the cavity in the heat pipe 80 and reaches the cold end, transporting the heat subtracted from the core in the evaporation phase;

3. (condensation) the vapour condensates on the cold end of the heat pipe 80, connected with the radiator 81. The heat subtracted from the core 10 is delivered to the radiator 81 as condensation latent heat;

4. (liquid transfer) the condensate return, usually by gravity, to the hot end of the heat pipe 80 in the core 10, wherein a new evaporation takes place.

[0035] In this way large heat transfers can be achieved from the hot core 10 to the colder radiator 81.

[0036] Also in the case of this embodiment the heat pipe 80 can be permanently integrated in the core 10 during its fabrication, or permanently mounted to it in a further fabrication phase.

[0037] In an alternative non represented variant of this embodiment, the radiator 81 could be substituted by a heat sink. In this case the heat pipe 80 provides efficient conduction of the heat to the heat sink.

[0038] In a variant of the present invention, one or more conductors are wound around one of the magnetic cores described above, and the resulting coil is incorporated in a filter circuit, for example a power filter for electromagnetic compatibility, or another sort of filter or noise-suppression circuit. The coil so produced, thanks to its small size and high loss tolerance is particularly suitable for such filtering applications, particularly for EMC filters at mains voltage.

[0039] According to the necessity, the coil thus fashioned may comprise multiple windings, for example in the case of a filter for a multiphase power system. The present invention also provides longitudinal coils and current-compensated coils with improved cooling capability.

Reference Numbers

[0040]

10	Core
20	Winding coil
40	Heat fin, fin
50	Heat-conductive insert
80	Heat-pipe
81	Radiator
90	Metallic bushes

Claims

1. Magnetic core (10) for a power electromagnetic compatibility filter, wherein said core (10) consists of a metal powder,
characterized in that
the core (10) comprises an outer surface and has heat dissipation features (40, 80, 81, 90) integrally formed with said powder core (10) or heat conductive inserts (50) permanently incorporated in said powder core (10) for increasing the heat dissipation there from.

2. The magnetic core (10) of claim 1, wherein said dissipation features increase said outer surface of the core (10) and comprise at least one of the following shapes: ribs, protrusions, fins (40), fingers, slots, nooks and combs or any shape providing cavities and protrusions.

3. The magnetic core (10) of claim 1, wherein said heat conductive inserts (50) comprises pre-punched material, metal rods, metal wires or a metallic mesh.

4. The magnetic core of claim 1, wherein said heat dissipating features protrude to the outside of said core (10) for dissipating heat by convection and radiation.

5. An inductive electric component, comprising at least a magnetic core (10) according to one of the preceding claims.

6. A power filter for electromagnetic compatibility, comprising an inductive component according to claim 5.

7. The power filter of claim 6, wherein said filter is adapted for filtering a noise superimposed to a mains supply line.

8. Method for producing a magnetic core (10) for a power electromagnetic compatibility filter according to any of the claims 1 to 4, wherein said core (10) consists of a metal powder, the method comprising the steps of

• providing a die or mould;
• adding metal powder and
• pressing or casting the metal powder, whereby the method is **characterized in** the steps of
• appropriately shaping the die or the mould in the form of heat dissipation features (40, 50, 80, 81, 90) or inserting in the die or mould heat conductive inserts (50) and
• integrally forming said heat dissipation features (40, 50, 80, 81, 90) with said powder core (10) or permanently incorporating said heat conductive inserts (50) in said powder core (10) in the step of pressing or casting the metal powder.

9. Method according to claim 8, comprising the step of shaping the die or mould in the form of ribs, protrusions, fins (40), fingers, slots, nooks and combs or any shape providing cavities and protrusions.

10. Method according to claim 8, comprising the step of realizing said heat conductive inserts (50) from prepunched material, of metal rods, of metal wires or of a metallic mesh.

Patentansprüche

1. Magnetischer Kern (10) für einen leistungselektromagnetischen Kompatibilitätsfilter, in welchem besagter Kern (10) aus einem metallischen Pulver besteht,
dadurch gekennzeichnet, dass
der Kern (10) eine äussere Oberfläche umfasst und Wärmedissipationsmerkmale (40, 80, 81, 90) hat, die integral mit besagtem Pulverkern (10) geformt sind, oder wärmeleitende Einsätze (50) hat, die permanent in besagtem Pulverkern (10) inkorporiert sind, um die Wärmedissipation davon zu erhöhen.

2. Magnetischer Kern (10) gemäss Anspruch 1, in welchem besagte Wärmedissipationsmerkmale besagte äussere Oberfläche des Kerns (10) vergrössern und mindestens eine der folgende Formen umfassen: Rippen, Vorsprünge, Flossen (40), Finger, Schlitze, Ecken und Waben oder in irgendeiner anderen Form, die Hohlräume oder Vorsprünge bereitstellt.

3. Magnetischer Kern (10) gemäss Anspruch 1, in welchem besagte wäremeleitende Einsätze (50) vorgestanztes Material, Metallstangen, Metalldrähte, oder ein metallisches Netz umfassen.

4. Magnetischer Kern (10) gemäss Anspruch 1, in welchem besagte Wärmedissipationsmerkmale aus der Aussenseite des besagten Kerns (10) herausstehen, um Wärme durch Konvektion und Strahlung zu abzugeben.

5. Eine induktive elektrische Komponente, umfassend mindestens einen magnetischen Kern (10) gemäss einem der vorhergehenden Ansprüche.

6. Einen Leistungsfilter für eine elektromagnetische Kompatibilität, umfassend eine induktive Komponente gemäss Anspruch 5.

7. Der Leistungsfilter gemäss Anspruch 6, in welchem besagter Filter angepasst ist, um eine Störung, die in einer Hauptversorgungsleitung überlagert ist, zu filtern.

8. Verfahren zur Herstellung eines magnetischen Kerns (10) für einen elektromagnetischen Kompatibilitätsfilter gemäss einem der Ansprüche 1 bis 4, in welchem besagter Kern (10) aus einem metallischen Pulver besteht, das Verfahren umfasst die folgenden Schritte

• Bereitstellen einer Gussform oder Pressform;
• Hinzufügen von metallischen Pulver und
• Pressen oder Giessen des metallischen Pulvers, wobei das Verfahren durch die Schritte **gekennzeichnet** ist
• Formen der Gussform oder Pressform in der Form von Wärmedissipationsmerkmalen (40, 50, 80, 81, 90) oder Einfügen von wärmeleitenden Einsätzen (50) in die Gussform oder Pressform und
• integriertes Formen besagter Wärmedissipationsmerkmale (40, 50, 80, 81, 90) mit besagtem Pulverkern (10) oder permanentes Einfügen besagter Wärme leitender Einsätze (50) in dem Schritt von Pressen oder Giessen des metallischen Pulvers.

9. Verfahren gemäss Anspruch 8, umfassend das Formen der Gussform oder Pressform in der Form von Rippen, Vorsprüngen, Flossen (40), Finger, Schlitze, Ecken und Waben oder in irgendeiner anderen Form, die Hohlräume oder Vorsprünge bereitstellt.

10. Verfahren gemäss Anspruch 8, umfassend den Schritt Verwirklichen besagter Wärme leitender Einsätze (50) aus vorgestanztem Material, aus Metallstangen, aus Metalldrähten, oder aus einem metallischen Netz.

Revendications

1. Noyau magnétique (10) pour un filtre de compatibilité électromagnétique de puissance, ledit noyau (10) consistant en une poudre de métal,
caractérisé en ce que
le noyau (10) comprend une surface externe et a des caractéristiques de dissipation de chaleur (40,

80, 81, 90) formées intégralement avec ledit noyau de poudre (10) ou des insertions conductrices de chaleur (50) incorporées de façon permanente dans ledit noyau de poudre (10) pour en augmenter la dissipation de chaleur.

2. Le noyau magnétique de la revendication 1, dans lequel lesdites caractéristiques de dissipation augmentent ladite surface externe du noyau (10) et comprennent au moins une des formes suivantes: des nervures, protrusions, des ailerons (40), des doigts, des fentes, des alcôves et opercules, ou n'importe quelle forme fournissant des cavités et des protrusions.

3. Le noyau magnétique de la revendication 1, dans lequel les insertions conductrices de chaleur (50) comprennent du matériau préperforé, des tiges en métal, des fils en métal ou une maille métallique.

4. Le noyau magnétique de la revendication 1, dans lequel lesdites caractéristiques de dissipation s'étendent (10) vers l'extérieur dudit noyau pour dissiper la chaleur par convection ou radiation.

5. Un composant électrique inductif, comprenant au moins un noyau magnétique (10) selon l'une des revendications précédentes.

6. Un filtre de puissance pour compatibilité électromagnétique, comprenant un composant inductif selon la revendication 5.

7. Le filtre de puissance selon la revendication 6, dans lequel ledit filtre est adapté pour filtrer un bruit superposé à une ligne d'alimentation principale.

8. Procédé pour produire un noyau magnétique (10) pour un filtre de compatibilité électrique de puissance selon l'une des revendications 1 à 4, dans lequel ledit noyau (10) contient une poudre de métal, la méthode comprenant les étapes de

• fournir un moule à coulée sous pression ou compression;
• ajouter de la poudre métallique, la méthode étant **caractérisée par** les étapes de
• façonner le moule à coulée ou de pressage dans la forme des caractéristiques de dissipation de chaleur (40, 50, 80, 81, 90) ou insérer dans le moule à coulée ou de pressage des insertions conductrices de chaleur (50) et
• former intégralement lesdites caractéristiques de dissipation de chaleur (40, 50, 80, 81, 90) avec ledit noyau en poudre (10) ou incorporer de manière permanente lesdites insertions conductrices de chaleur (50) dans ledit noyau en poudre (10) dans l'étape de presser ou verser la poudre métallique.

9. Procédé selon la revendication 8, comprenant l'étape de façonnage du moule à coulée ou de pressage dans la forme de nervures, protrusions, ailerons (40), doigts, alcôves ou opercules ou n'importe quelle forme fournissant des cavités et protrusions.

10. Procédé selon la revendication 8, comprenant l'étape de réaliser lesdites insertions conductrices de chaleur (50) à partir de matériau préperforé, de tiges en métal, de fils en métal ou une maille métallique.

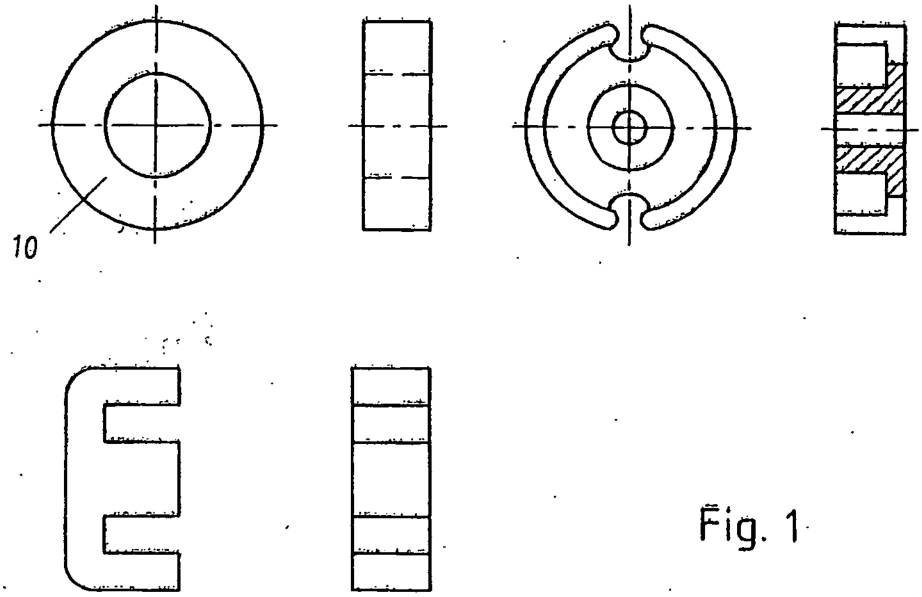

Fig. 1

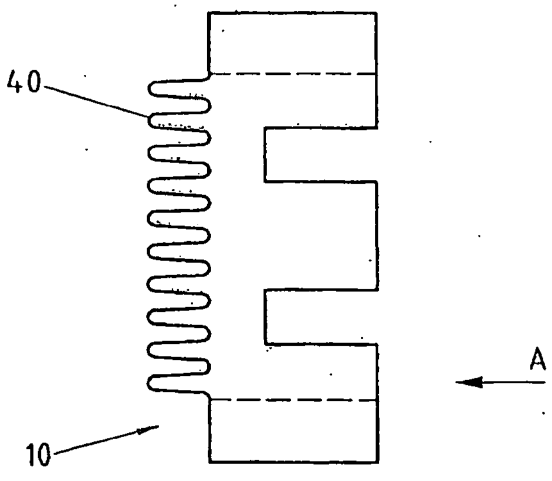

Fig. 2a

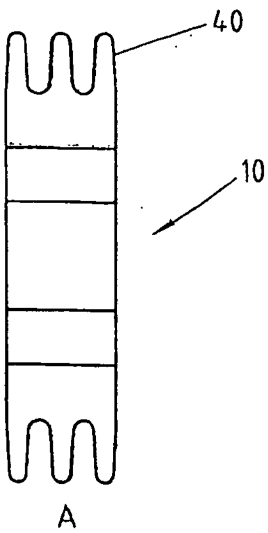

Fig. 2b

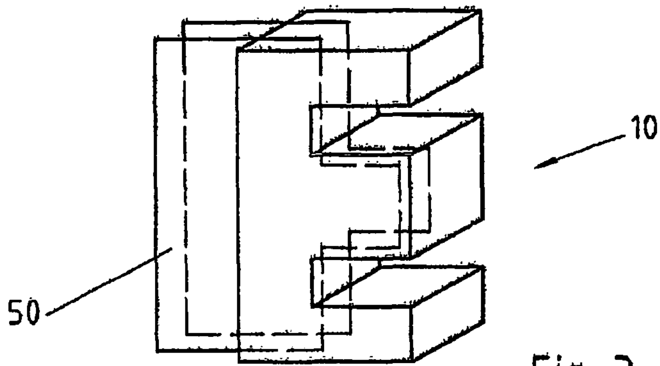

Fig. 3

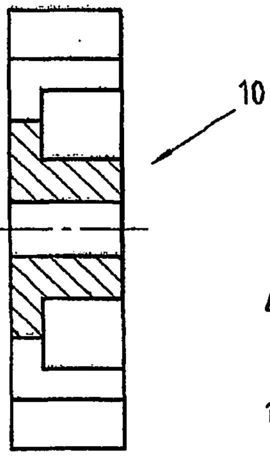

Fig. 4a

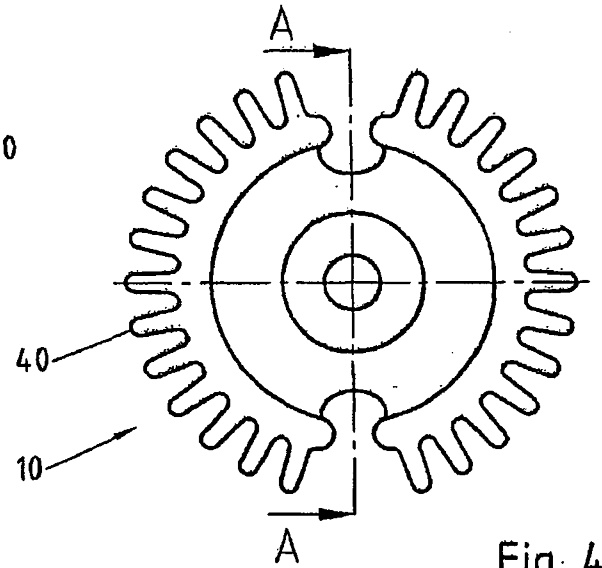

Fig. 4b

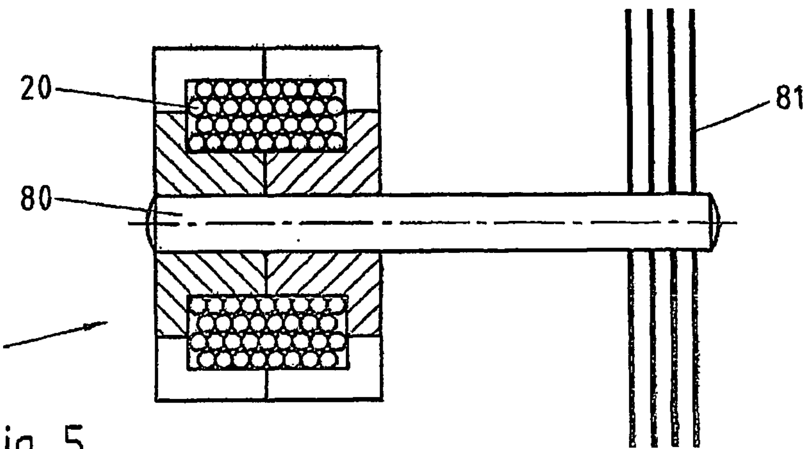

Fig. 5

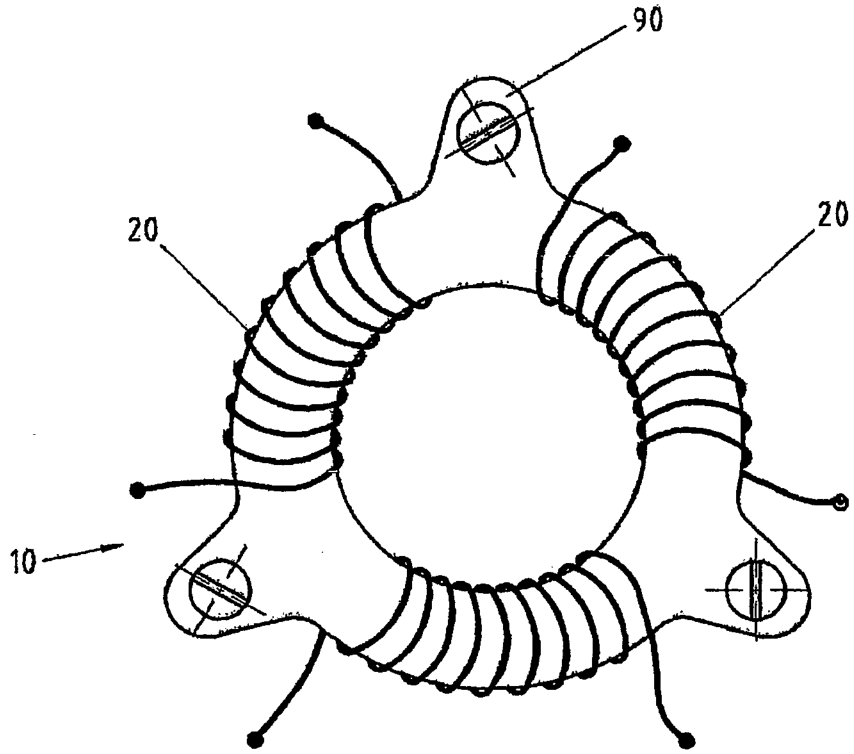

Fig. 6a

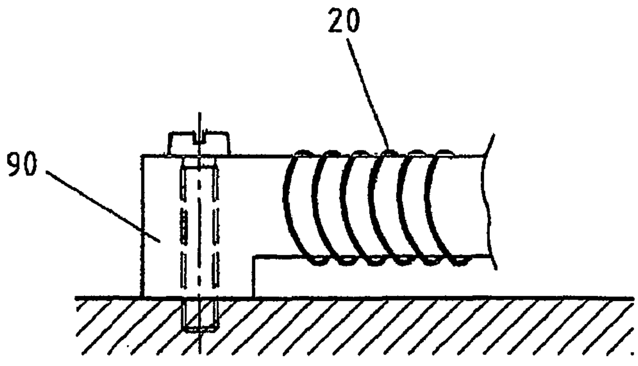

Fig. 6b

REFERENCES CITED IN THE DESCRIPTION

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