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**(54) Title:** A WINDING FOR A MAGNETIC COMPONENT ASSEMBLY

**(57) Abstract**

A winding for a magnetic component assembly, the winding comprising at least one planar turn formed from a single piece of planar conductive material provided with an insulating powder coating, the or each turn being insulated by the insulating powder coating and a method manufacturing a winding for a magnetic component assembly comprising the steps of: providing a single piece of planar conductive material; forming at least one planar turn from the conductive material; and coating the or each turn with an insulating powder coating.

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**"A Winding for a Magnetic Component Assembly"**

THIS INVENTION relates to a winding for a magnetic component assembly and more particularly to a winding for a low profile high power planar transformer assembly to meet safety isolation requirements.

There have been a number of attempts to produce low profile transformers such as, for example, U.S. Patent No. 5,010,314 which discloses a low profile planar transformer for use at high power levels. The structure comprises a ferrite core surrounded by a stack of layers which include a first winding, various layers of insulation material and dielectric material, bobbins for insulating the respective layers and holding the layers in registration with one another and further layers for other windings. Each turn in the windings is produced from a stamped copper form, the forms being connected together by individually soldered or welded joints.

The use of bulky bobbins to insulate the transformer windings is disadvantageous since this impedes heat flow from the windings through the core. Additionally, bobbins require expensive tooling to manufacture and the resultant transformer assembly requires a large number of parts.

In order to be efficient in high power applications, it is important that the proportion of conductive material to insulation material is high in the window space of the transformer. The use of bobbins reduces the proportion of conductive material to insulation material in the window space thereby producing a less efficient transformer. Further, the use of bobbins and the other insulation materials in such low profile planar transformers increases the thickness of the resultant assembly.

U.S. Patent No. 5,381,124 discloses a low profile conductive film multi-pole transformer having a conductive film primary winding interleaved with a multi-turn conductive film secondary winding. The windings used are flexible printed wiring (FPW). This type of conductive film transformer is only suitable for low power applications in which power levels are below a few hundred Watts. If one attempts to use low profile conductive film transformers of this type in high power applications, then it is necessary for much thicker conductive film thicknesses to be used and overheating of the transformer assembly results. Additionally, the structure of this transformer requires the use of flexible conductive and insulating materials which are expensive to source and awkward to manufacture. The technique cannot be applied to a single pole transformer structure.

It should be appreciated that the conductive portion of flexible printed wiring windings, such as those used in US 5,381,124, are relatively thin, typically 0.001 to 0.005 inches (0.025 to 0.13 mm), such that they have a limited current capacity in the order of 5 to 10 Amps. A 30 Amp flexible printed wiring is known but it is more usual to resort to other manufacturing techniques when designing at such high current levels.

Further, it should be noted that conventional coil winding techniques do not meet safety isolation requirements in which isolation is required between windings. Conventional winding techniques such as those providing enamel or varnish coatings are specifically not recognised as constituting insulation for approval purposes (e.g. IEC950 International Standard on "Safety of Information Technology Equipment, including electrical business equipment") between windings as these only provide a level of insulation between respective turns in a winding where voltage differentials are much less than between windings. Typically, in high power applications, one might expect the voltage differentials between turns in a winding to be of the order of a few Volts to tens of volts whereas the voltage differentials between a Mains primary winding and a secondary winding would be tested to a voltage in the order of 3000 Volts RMS. Thus, it is important to provide insulation which meets safety approval requirements between windings and which still enables the provision of a low profile assembly.

It is an object of the present invention to seek to provide a low profile magnetic component assembly for use in high current, high power applications which does not suffer from the above-mentioned problems, which meets the necessary safety approval requirements for high power components and which provides good heat flow from the windings through the core into a heat sink, which runs cooler than component assemblies of similar size using existing construction techniques, thereby enabling smaller constructions to be used to run at the same temperature and allowing a high degree of interleaving between primary and secondary windings without contravening safety regulations in order to reduce leakage inductance.

Accordingly, one aspect of the present invention provides a winding for a magnetic component assembly, the winding comprising at least one planar turn formed from a single piece of planar conductive material provided with an insulating powder coating, the or each turn being insulated by the insulating powder coating.

Another aspect of the present invention provides a method of manufacturing a winding for a magnetic component assembly comprising the steps of: providing a single piece of planar conductive material; forming at least one planar turn from the conductive material; and coating the or each turn with an insulating powder coating.

In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic cross-section through a transformer assembly embodying the present invention;

FIGURE 2 is a plan view of a six turn winding in an unfolded condition for use with an embodiment of the present invention, fold lines being shown as dashed lines;

FIGURE 3 is a schematic circuit diagram of the transformer assembly of Figure 1;

FIGURE 4 is a plan view of the winding of Figure 2 in a folded condition;

FIGURE 5 is a perspective view of a transformer assembly embodying the present invention; and

FIGURE 6 is a plan view of an eight turn winding in an unfolded condition for use with an embodiment of the present invention, fold lines being shown as dashed lines and an E-core being shown cross-hatched.

Referring to Figure 1, a transformer assembly 1 embodying the present invention comprises a fourteen turn primary winding 2 and two six turn secondary windings 3,4. The secondary windings 3,4 sandwich the primary winding 2, a single turn earth screen 5,6 being located between each secondary winding 3,4 and the primary winding 2. A core (not shown but preferably a reduced height E65 core) passes through the windings 2,3,4 and the earth screens 5,6 to define a magnetic path which, in use, inductively links the primary winding 2 to the secondary windings 3,4.

Referring to Figure 2, one of the secondary windings 3 is shown in its basic unfolded form. The winding 3 comprises a conductive material, in this case a single piece of copper sheet, which has been formed by, for example, chemical etching or stamping from a single strip of copper sheet.

The winding 3 shown in Figure 2 comprises six planar turns or frames of copper sheet connected to one another in pairs. The winding 3 is terminated at one end with a first electrical connector 7 having an aperture to which a terminal lead from external circuitry may be electrically connected and, in the present case, to allow the two secondary windings 3,4 to be connected in parallel with one another by appropriate wiring as shown in Figure 3.

The electrical connector 7 runs into a first planar turn 8 of a first pair of turns 8,9 of the copper strip. The first turn 8 defines a substantially rectangular elongate frame which turns back on itself towards the electrical connector 7. However, the frame is broken at this point so that the turn is not fully completed. The first turn can be viewed in Figure 2 as running anti-clockwise, starting from the electrical connector 7. The second turn 9 is connected in series to a lateral edge of the frame of the first turn 8 by a first fold line 10. The first fold line 10 runs substantially parallel to the lateral edge of the frame of the first turn 8 to which the second turn 9 is joined. Fold lines are shown in Figure 2 by dashed lines.

The second turn 9 runs clockwise from the lateral edge of the frame of the first turn 8 and is also in the form of a substantially rectangular frame similar to the first turn 8. The second turn 9 terminates adjacent to but spaced apart from a corner of the first turn 8 in a second fold line 11. This structure comprises the first pair of turns or frames. The second fold line 11 is perpendicular to the first fold line 10.

The first turn 8 is foldable along the first fold line 10 onto the second turn 9 such that the two turns 8,9 are registered with one another.

A first strap 12 connects the first pair of turns 8,9 to a second pair of turns, comprising a third turn 14 and a fourth turn 16. The strap 12 extends away from the second fold line 11 to a third fold line 13. The strap 12 has a length which is substantially the same as the width of the first and second turns 8,9 such that the strap 12 can be folded back onto the registered turns 8,9 by the second fold line 11 and then folded again back on itself along the third fold line 13 such that the third fold line 13 is located in the region adjacent to and above the start of the first turn 8 at the electrical connector 7. The third turn 14 comprising substantially a mirror image of the second turn 9 runs clockwise from the third fold line 13 and terminates in a fourth fold line 15. The fourth turn 16 extends from the fourth fold line 15 and comprises substantially a mirror image of the first turn 8. The third turn 14 is folded back along the third fold line 13 such that the third turn 14 also registers with the first and second turns 8,9. A subsequent fold along the fourth fold line 15 allows the fourth turn 16 to register with the first, second and third turns 8,9,14.

The fourth turn 16 terminates in a fifth fold line 17 substantially the same as the second fold line 11. A second strap 18 connects the second pair of turns 14,16 to a third pair of turns comprising a fifth turn 20 and a sixth turn

22. The strap 18 has the same width as the turns 8,9,14,16 and extends to a sixth fold line 19 from which extends, in an anti-clockwise fashion, the fifth turn 20 which terminates in a seventh fold line 21. The sixth turn 22 runs from the seventh fold line in a clockwise fashion. The sixth turn 22 terminates in a second electrical connector 23 of the same structure as the first electrical connector 7. The fold lines 10,11,13,15,17,19,21 are preferably partially etched, creased or scored so that an accurate fold always results.

Figure 4 illustrates the winding 3 of Figure 2 in a folded condition. The six turns 8,9,14,16,20,22 are registered with one another to define rectangular frames having a common window space 24 through which a ferrite core (not shown) can be inserted. The straps 12,18 lie adjacent a lateral edge of the frames and the electrical connectors 7,23 protrude from the frames to allow electrical contact to be made therewith.

Whilst the turns shown in Figure 2 are all substantially rectangular, other shapes and configurations of turns are also possible as are other folding techniques. Specifically, the accommodation of a circular centre pole is envisaged. It is, however, important that each winding is manufactured from a single sheet of conductive material and that the respective fold lines result in the turns being registered one on top of the other.

The other six turn secondary winding 4 is of identical construction to the first secondary winding 3 shown in Figure 2. The fourteen turn primary winding 2 is also of similar construction to the secondary windings 3,4 but includes more turns so that there are seven pairs of turns rather than the three pairs of turns 8,9,14,16,20,22 shown in Figure 2. Thus, it can be appreciated how windings can be fabricated from a single strip of copper to produce as many turns as are required.

The basic winding such as the six turn winding 3 shown in Figure 2, is subjected to a coating and curing process before folding. In a preferred embodiment, the coating is an epoxy powder coating such as 3M's Resin 5388 powder coating. Preferably, the coating is applied to both sides of the winding and the winding edges although it is possible to selectively coat respective sides of the winding. In the coating process, the windings 2,3,4 should be clean, dry and free of oils. Resin 5388 is first placed in an electrostatic fluid bed and charged (40 to 90kV), causing the epoxy resin particles to repel each other and move upward. This results in a cloud of charged particles above the surface of the bed. A grounded winding 2,3,4 is coated when passing through or placed in this cloud. Resin 5388 can be deposited in film thicknesses up to 25mils on windings at room temperature. Because it is applied to a room temperature winding, the powder can be selectively removed. Air used for fluidising should be dried to a 30-35°F dew point. The epoxy powder on the coated winding is then cured. Curing of Resin 5388 is accomplished by heating the coated part to a temperature above the melting point of the resin. The resin then melts, flows to a controlled extent, and coalesces into a smooth, continuous, thin, essentially uniform coating, which cures and bonds to the winding. The coating maintains uniformity on flat surfaces as well as in corners. Either convection oven or induction heating may be used as a heat source for curing the resin.

The figures in the table below represent nominal guidelines for obtaining the resin's adhesion, impact and chemical resistance characteristics.

| Cure Temperature | Time |
|---|---|
| 177°C (350°F) | 15 minutes |
| 204°C (400°F) | 6 minutes |
| 232°C (450°F) | 3 minutes |

The times mentioned above do not include the time required to reach the cure temperature. The time required for the coated winding to reach the cure temperature must be determined separately.

As mentioned in the description of curing, parts of the powder can be selectively removed by, for example, suction means or parts of the winding can be masked to prevent powder deposition over selected areas. Such selected removal or masking of areas of the winding is important for the areas immediately adjacent the fold lines since cracking of the coating can occur along the fold lines when a winding is folded. By not coating the areas immediately adjacent the fold lines, this problem can be obviated. Also, powder deposition is prevented over the electrical connectors 7,23. Preferably, the exposed (i.e. non-coated) parts of the winding, when the winding is fully folded, are staggered from one another so that there is no possibility of exposed parts coming in contact with one another or of there being any arcing between exposed parts.

Using epoxy powder coatings, one can obtain a homogenous powder coating layer using a minimum coating thickness of 120 μm. At low voltage applications, it is, however, possible to use a coating thickness in the order of 30 to 40 μm. The thickest single coating which can be applied would be in the region of 500 μm although multiple coatings are possible. Thus, the thickness of the coating can be varied depending upon the application to which the winding is to be put, be it a high or a low voltage specification.

It is preferred that the copper windings are created using a copper etching process. Part of this process is the immersion of the winding in an acid bath before applying the epoxy powder coating. An advantage of this step is that it rounds the edges of the winding which improves the edge coverage of the powder from an unsatisfactory 35-40% which is obtained without rounded edges. The figure of 35-40% means that the thickness of the powder around a square edge is 35-40% of the thickness obtained when the powder is applied to a flat surface.

Turning now to Figure 5, the resultant coated and folded windings 2,3,4 are provided with an earth screen 5,6 between each secondary winding 3,4 and the primary winding 2. An E type ferrite core 25 has a middle leg 26 and two outer legs 27,28. The middle leg 26 is located through the window 24 defined by the registered turns 8,9,14,16,20,22 and the outer legs 27,28 straddle opposite sides of the windings 2,3,4 so as to enclose the windings 2,3,4. The electrical connectors 7A of the primary winding 2 are located at the opposite end of the transformer to the electrical connectors 7B of the secondary windings 3,4. The resultant structure may be sealed using a suitable varnish although this is not essential, and care should be taken not to coat a face of the ferrite core which would contact a heat sink as this would impede heat flow from the core.

Referring now to Figure 6, this shows another winding 3 embodying the present invention. It will be appreciated that the winding 3 of Figure 6 is similar to that shown in Figure 2 but comprises two strips 29,30 of planar conductive material laid side by side. In this manner, two turns are provided in a single layer as opposed to the single turn in a single layer of the winding provided in Figure 2. The E-core 25 and its legs 26,27,28 are shown cross-hatched. When folded along the illustrated dashed lines, one end 31 of the first strip 29 comprises an input terminal, the other end 32 of the same strip 29 is connected to the end 33 of the second strip 30 adjacent the input terminal 31 and the other end 34 comprises an output terminal for the winding 3. In order to compensate for any path length differences between the two strips 29,30, the widths of the strips can be tailored at specific areas along the strips so that both turns have equal resistance.

Whilst Figure 6 shows a winding with two turns in each layer, it is envisaged that windings with more than two turns into each layer can be provided by using further adjacent strips 29,30 and connecting the ends thereof to produce multiple consecutive turns in a single layer.

The use of powder coatings is especially advantageous owing to the thin and uniform film thicknesses which can be achieved while still providing the necessary insulation between respective turns in a winding. The good thermal conductivity of the powder coatings is especially advantageous as this allows a good heat flow from the heat generating windings to an appropriate heat sink through, for example, the core for the transformer assembly. Instead of using an epoxy powder coating, it is also possible to use a ceramic powder coating. A homogenous ceramic powder coating can be applied more thinly than an epoxy powder coating. Coating thicknesses of tens of microns are most likely although much thinner coatings are practical. The thickness of the coating can be varied depending upon the application to which the winding is to be put, be it a high or a low voltage specification.

The use of planar turns of a conductive material insulated with a powder coating advantageously provides a very high conductive material to insulation ratio sometimes termed the Overall Copper Factor, see "Soft Ferrites and Applications", E.C. Snelling, Butterworth & Co. 1988, where the Overall Copper Factor is given as $F_c$ = total cross sectional area of copper in winding/actual window area in the core.

In one particular example, for a 1,100 Watt phase modulated inverter with current doubler output stage designed for supplying a nominal 54.5 volts d.c. output at 20 amps, the specification is as follows: an operating frequency of 150 kHz; input voltage of 380 to 450 Volts DC; dissipation at less than 10 Watts; the core geometry is E64 planar; the core material is Philips 3F3; and safety isolation is provided between primary and secondary windings to meet International Safety Standards. The primary and secondary windings each comprise a series of copper frames from a single copper sheet having a thickness of 300 μm coated with a 200 μm layer of 3M's Resin 5388 epoxy powder coating, each of the secondary windings 3,4 being separated from the primary winding 2 by earth screens 5,6 which each comprise a single turn of uncoated 50 μm thick phosphor bronze.

The safety isolation mechanism described above makes use of earth screens 5,6. Other approaches are possible which also meet International Safety Standards such as the use, between primary and secondary windings - either alone or in combination, of: a specified minimum thickness of insulator material (e.g. 0.4 mm); two discrete dielectric layers meeting a specified dielectric strength test; and a minimum specified creepage path distance between exposed/uncoated portions of windings. The selection of one or more safety isolation methods is determined by the specific application and the safety standards to be met.

It should be appreciated that, in many applications, a winding embodying the present invention can be used without additional insulation to produce a safety isolation mechanism meeting International Safety Standards either on the basis that the two insulating powder coatings on adjacent primary and secondary windings are selected to meet the specified dielectric strength test or that each insulating powder coating is selected to have a minimum thickness such that, when taken together, the two layers of insulating powder coating meet the specified minimum insulator material thickness.

Compared to a transformer winding such as that disclosed in US 5,010,314, a winding embodying the present invention would run cooler because a wider copper winding could be used in the absence of a bobbin. The winding would therefore have a lower resistance, by approximately 10%. There would also be better heat transfer from the winding to the core, enabling a transformer embodying the present invention to operate at a lower temperature. Further, an assembly embodying the present invention would have fewer parts than a transformer assembly built in accordance with US 5,010,314. Additionally, once the turns of a winding embodying the present invention have been stacked on top of one another, all connections to electrical connectors 7,23 are made. With the existing technology, another manufacturing step is required to connect the turns.

Thus, it can be appreciated that there are numerous advantages of the invention over existing technology. For a transformer assembly of comparable size, embodiments of the invention would demonstrate lower resistance, lower operating temperature, lower parts count and eliminate the need for a separate manufacturing process to connect turns.

In contrast to conductive film windings, powder coated windings embodying the present invention can have virtually unlimited maximum power handling capability whilst maintaining a low profile and a lower operating temperature than that which is available using the same size transformer manufactured with presently available technology. The higher the power handling capability required, the wider the copper frames can be made.

Since no bobbins are required in the manufacture of the present transformer assembly, significant thickness reductions can be achieved and significant benefits are realised because of the improved heat transfer through the transformer assembly.

It should be appreciated that other conductive materials can be used for the windings but copper is most preferred. Core materials other than ferrite including iron laminations or tape wound amorphous materials can also be used.

In the winding shown in Figure 2, the straps 12,18 are described as being folded outside the boundaries of the folded turns but within the boundaries of the transformer assembly. This arrangement is advantageous over existing winding techniques since the bridging straps 17,18 are not sandwiched between respective turns thereby allowing the turns to lie flat on one another. In this manner, a single turn is provided by each layer of the structure thereby minimising the stack height of the winding. Additionally, since the respective turns of the winding lie flat on one another, there is no spacing between respective turns, which spacing would otherwise provide an area of structural weakness. Whilst it is also possible for the straps 12,18 to be formed within the boundaries of the folded turns, this method is not preferred since the straps 12,18 form an intermediate layer between turns adding to the stack height of the winding.

Whilst the above-mentioned application describes the invention in relation to transformers, other magnetic component assemblies such as inductors and coupled inductors are also envisaged using windings with planar turns insulated with powder coatings. Further, it should be noted that the present invention is not limited to single pole structures but is also applicable to multi-pole structures.

It may also be desirable in some applications to add additional insulation material between core and winding for abrasion resistance. This might involve partial powder coating of the core, sheet material, or a moulded plastic part. This last option would significantly reduce heat flow from winding to core.

CLAIMS:

1. A winding for a magnetic component assembly, the winding comprising at least one planar turn formed from a single piece of planar conductive material provided with an insulating powder coating, the or each turn being insulated by the insulating powder coating.

2. A winding according to Claim 1, wherein a plurality of turns are provided in the winding and each turn of the winding is folded onto another turn of the winding such that the respective turns are registered with one another.

3. A winding according to Claim 1 or 2, wherein the or each turn is in the form of a frame which defines a window for receiving at least a part of a core.

4. A winding according to Claim 3, wherein one frame is connected to another frame by respective edges of the frames.

5. A winding according to Claim 3 or 4, wherein one frame is connected to another frame by an elongate strip of material, the strip having a length substantially equal to a width or length of a frame.

6. A winding according to any one of Claims 3 to 5, wherein the frames are of substantially the same shape.

7. A winding according to any preceding claim, wherein the powder coating is an epoxy powder coating.

8. A winding according to Claim 7, wherein the coating has a minimum thickness of approximately 30 to 40 μm.

9. A winding according to Claim 7 or 8, wherein the coating has a thickness of at least 120 μm to provide a homogenous coating.

10. A winding according to any one of Claims 1 to 6, wherein the powder coating is a ceramic powder coating.

11. A winding according to Claim 10, wherein the coating has a minimum thickness of approximately 1/100 μm.

12. A winding according to Claim 10 or 11, wherein the coating has a thickness of at least tens of μm.

13. A winding according to any preceding claim, wherein only predetermined areas of the winding are coated with the powder coating.

14. A winding according to any preceding claim, wherein the conductive material is copper.

15. A winding according to any preceding claim, wherein the conductive material has a minimum thickness of 100 μm.

16. A winding according to any preceding claim, wherein a scored, etched or creased line is provided at an area of the winding to be folded.

17. A winding according to any preceding claim, wherein a plurality of turns are provided in the winding and each turn of the winding is folded onto another turn of the winding such that the respective turns are registered with one another, means being provided to interconnect those turns, the interconnecting means being folded outside the boundaries of the folded turns but within the boundaries of the winding.

18. A magnetic component assembly comprising one or more windings according to any preceding claim.

19. A transformer comprising a primary winding and a secondary winding according to any one of Claims 1 to 17.

20. A transformer according to Claim 19, comprising a further secondary winding according to any one of Claims 1 to 17.

21. A method of manufacturing a winding for a magnetic component assembly comprising the steps of: providing a single piece of planar conductive material; forming at least one planar turn from the conductive material; and coating the or each turn with an insulating powder coating.

22. A method according to Claim 21, wherein a plurality of turns are provided, the method comprising the further step of folding the turns on top of one another such that the individual turns are registered with one another.

23. A method according to Claim 21 or 22, wherein the or each turn is formed from the conductive material by etching or stamping.

24. A method according to any one of Claims 21 to 23, wherein all of the winding is coated.

25. A method according to Claim 24, wherein the powder coating is selectively removed from one or more predetermined areas prior to curing the powder coating.

26. A method according to any one of Claims 21 to 23, wherein one or more predetermined areas are masked to prevent deposition of the powder coating on the predetermined areas.

27. A method according to Claim 25 or 26, wherein the predetermined areas comprise electrical contact regions of the winding and areas of the winding to be folded.

28. A method according to any one of Claims 25 to 27, wherein the turns are folded on top of one another so as to be staggered such that the predetermined areas do not come into contact with one another or into proximity with one another to prevent arcing between predetermined areas.

29. A method according to any one of Claims 21 to 28, wherein the winding has a plurality of turns and means interconnecting those turns, the method comprising the further step of folding the turns on top of one another such that the individual turns are registered with one another, the interconnecting means being folded outside the boundaries of the folded turns but within the boundaries of the winding.

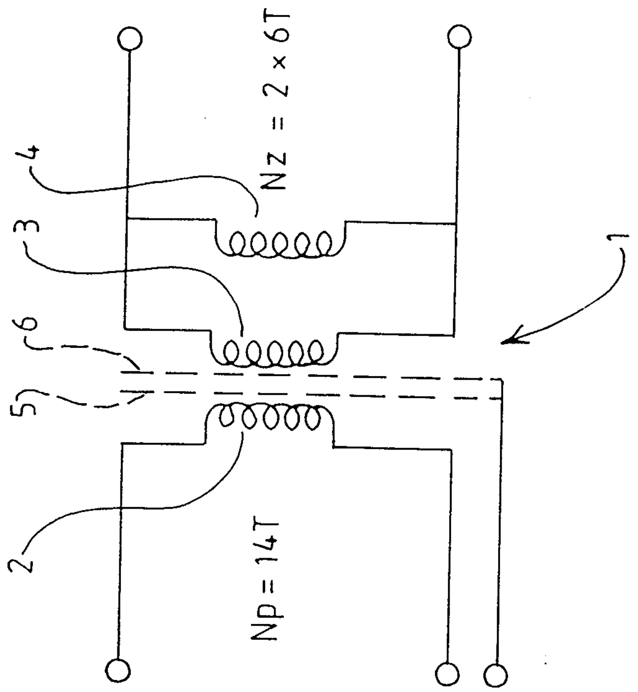



FIG 3

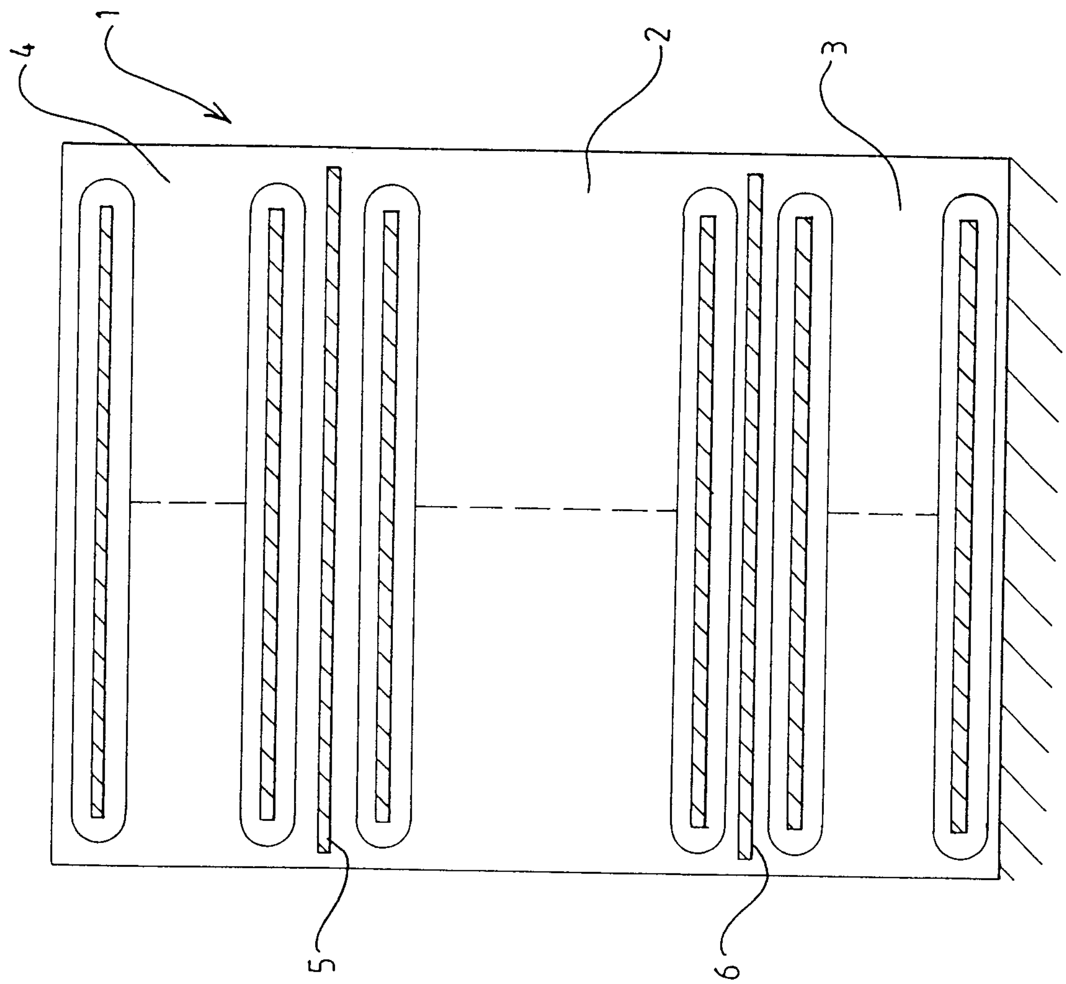



FIG 1

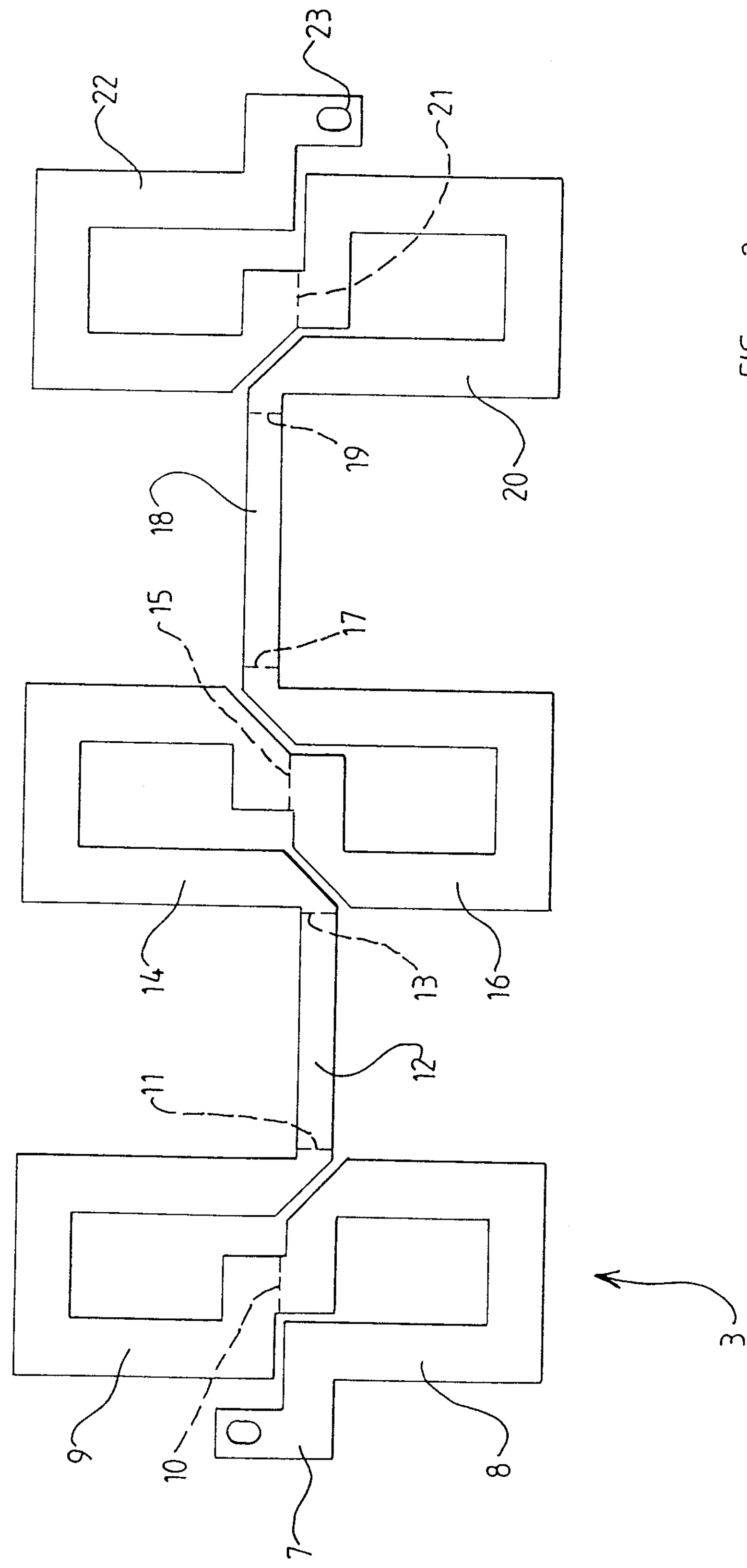



FIG 2

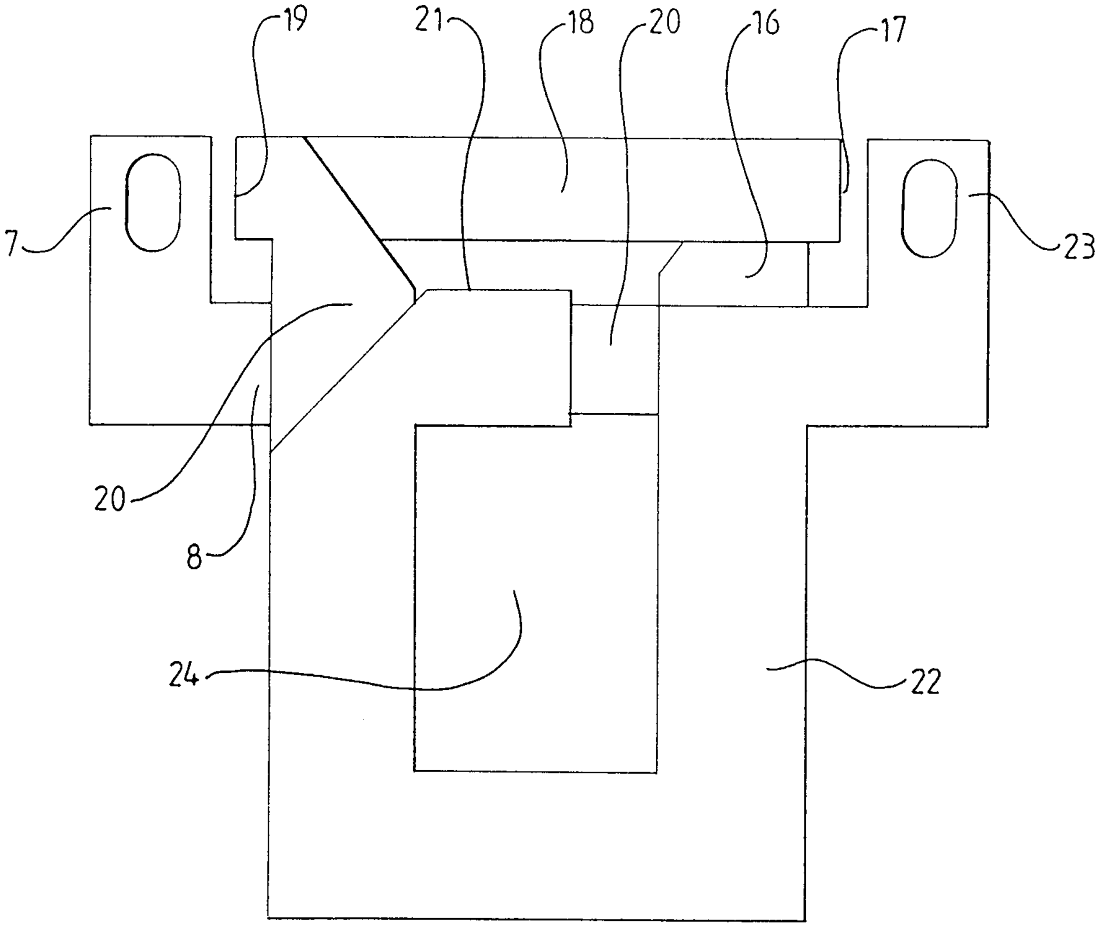
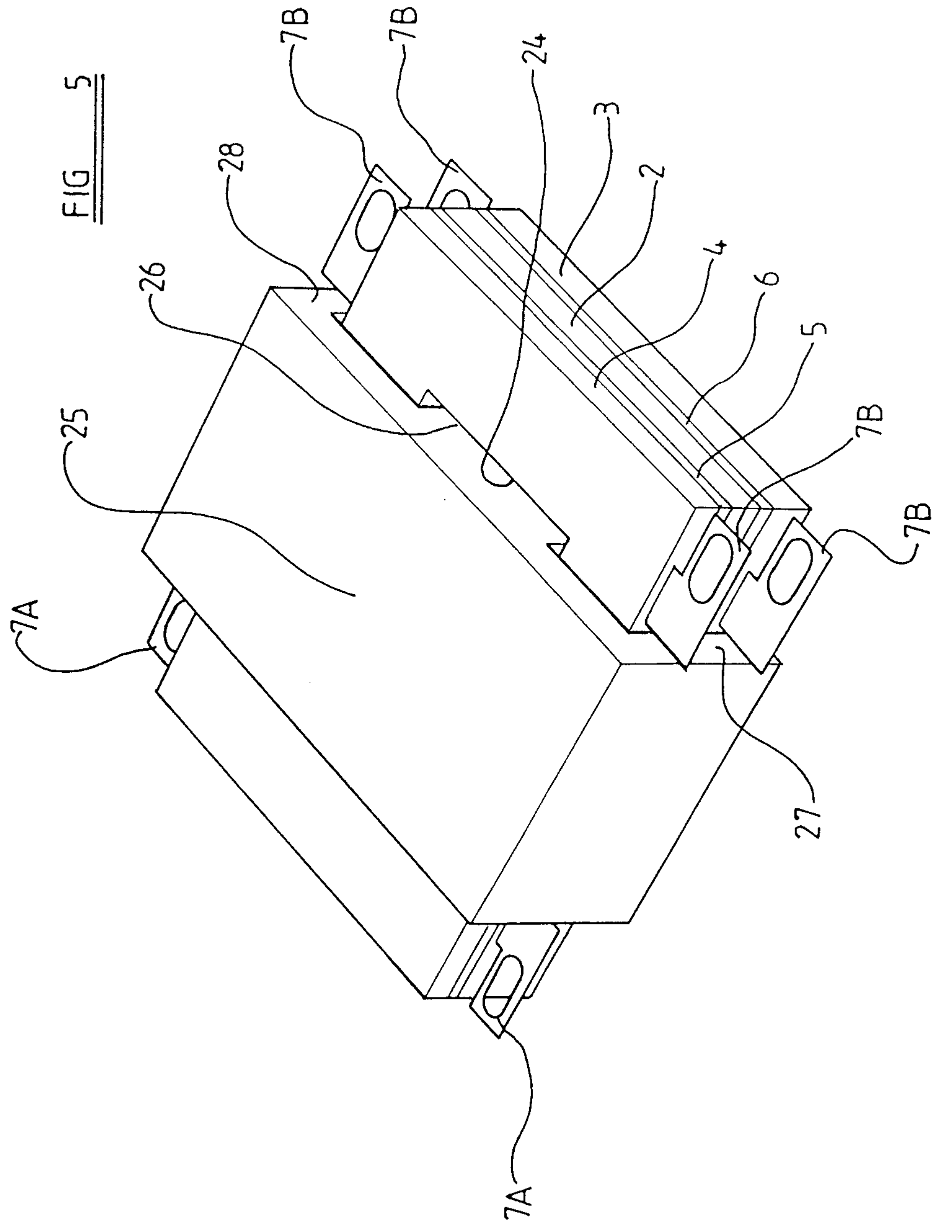



FIG 4

FIG 5



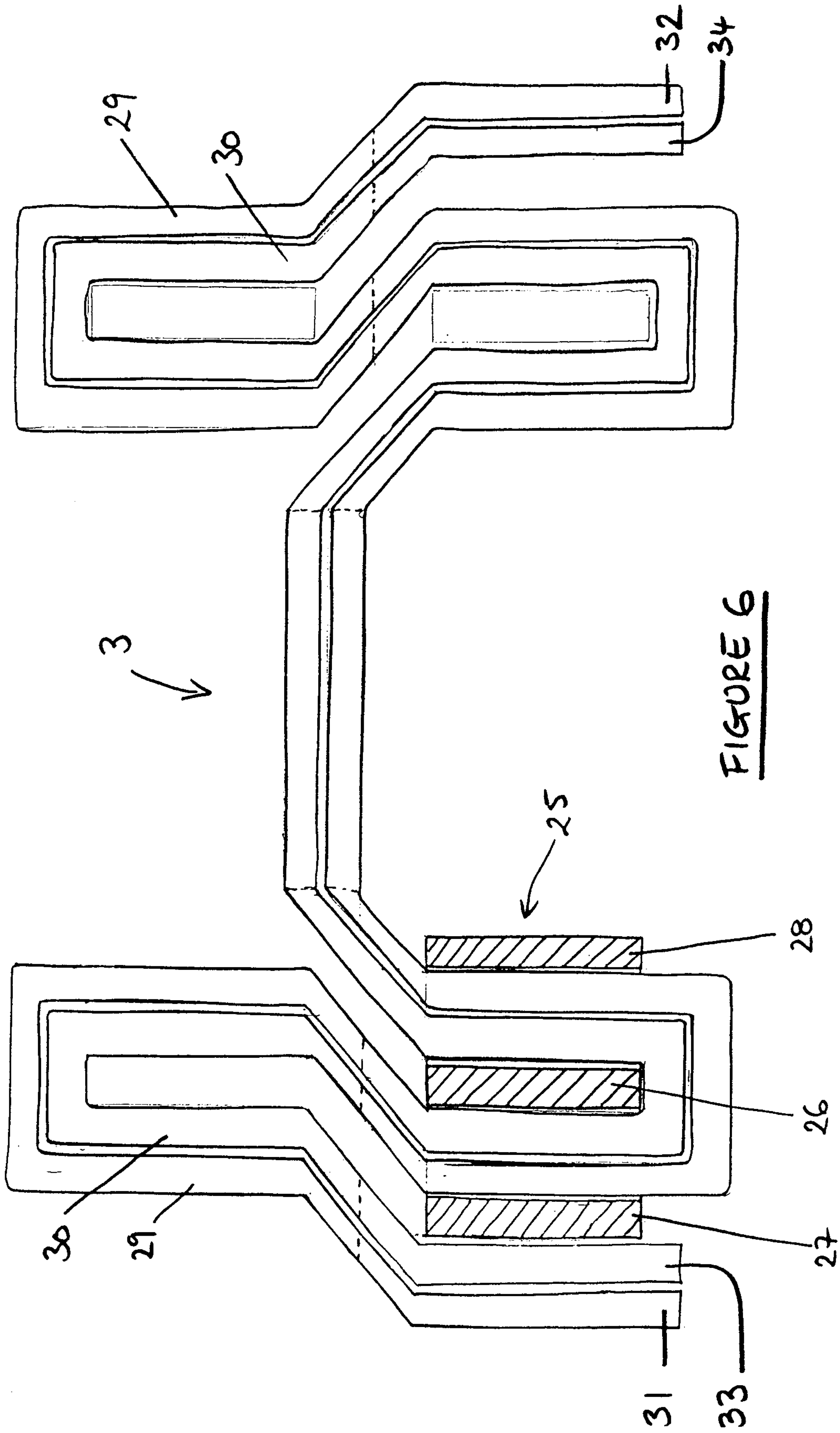



FIGURE 6

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/03584

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 H01F5/00 H01F27/28 H01F27/32 H01F41/06 H01F41/04

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01F

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 practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | EP 0 310 396 A (TOKYO SHIBAURA ELECTRIC CO) 5 April 1989 | 1,14,18, 21 |
| A | see column 9, line 44 - column 10, line 5; claims 1,12; figure 3A | 2,17, 22-24 |
| | --- | |
| Y | US 5 528 820 A (COLLIER HOWARD I J) 25 June 1996 | 1,14,18, 21 |
| A | see column 2, line 65 - column 3, line 6 | 7,8,11, 12,15,24 |
| | see column 3, line 48 - line 62; claim 1 | |
| | --- | |
| A | PATENT ABSTRACTS OF JAPAN vol. 007, no. 170 (E-189), 27 July 1983 & JP 58 075818 A (TOKYO SHIBAURA DENKI KK), 7 May 1983 see abstract | 1,10,18, 19 |
| | --- | |
| | -/-- | |

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 12 February 1999 | 19/02/1999 |
| Name and mailing address of the ISA<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Authorized officer<br><br>Decanniere, L |

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International Application No
PCT/GB 98/03584

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 5 381 124 A (ROSHEN WASEEM A)<br>10 January 1995<br>cited in the application<br>----- | |

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Information on patent family members

International Application No
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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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