



(11) **EP 1 536 436 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
25.01.2017 Bulletin 2017/04

(51) Int Cl.:
H01F 27/30 ^(2006.01) **H01F 41/02** ^(2006.01)

(21) Application number: **03761602.6**

(86) International application number:
PCT/ES2003/000309

(22) Date of filing: **23.06.2003**

(87) International publication number:
WO 2004/003947 (08.01.2004 Gazette 2004/02)

(54) **METHOD OF PRODUCING PLANAR TRANSFORMERS AND PLANAR TRANSFORMER THUS PRODUCED**

VERFAHREN ZUR HERSTELLUNG VON PLANARTRANSFORMATOREN UND SO
HERGESTELLTER PLANARTRANSFORMATOR

PROCEDE DE FABRICATION DE TRANSFORMATEURS PLANAIRES ET TRANSFORMATEUR
PLANAIRE FABRIQUE SELON LEDIT PROCEDE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR**

(30) Priority: **26.06.2002 ES 200201465**

(43) Date of publication of application:
01.06.2005 Bulletin 2005/22

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Description

[0001] This invention relates to a process for the manufacture of planar transformers and a planar transformer manufactured by means of said process.

[0002] The object of this invention is to provide planar transformers of very small size and with a large capacity for insulation between layers, in particular between windings, offering the further possibility that they may be manufactured economically.

[0003] In order to achieve its object this invention discloses the manufacture of planar transformers comprising solely of windings and insulating layers of variable thickness according to the insulation between integrated circuits and/or windings manufactured by the punching of copper sheets or wound copper, ensuring that there is dielectric strength in the vertical direction.

[0004] Document US 5,010,314 discloses a planar condenser of the type comprising separate insulating planar printed circuit layers and copper windings. This transformer, of the same type as the transformer to which this invention relates, does not resolve the problem of obtaining adequate insulation in the horizontal direction, while occupying the least space possible, in a wholly satisfactory way.

[0005] Document US 5,929,743 discloses a flat coil member formed from a plurality of printed circuits stacked one above the other in which pillars interconnect the conducting strips of the printed circuit along at least one of the edges and also have connections to the exterior. This document does not relate to the type of transformer to which this invention relates.

[0006] Document US 6,000,128 describes a process for the manufacture of a stack of flat printed circuits prepared for connection by pillars on two sides of the stack and with two cores which are located at the base and top of the stack of circuits. Again this document does not relate to the type of transformer to which this invention relates.

[0007] Document US 5,317,300 describes a wholly conventional non-planar transformer with a coil, windings and terminals and a core formed by retention plates. Therefore it relates in fact to a transformer which belongs to a wholly separate stage in the development of transformers. It is cited because unlike the documents mentioned above it describes the total or partial encapsulation of the transformer with a thermoplastic material by injection.

[0008] US 6 211 767 discloses an example of planar transferances according to the precharacterising portion of claim 1.

[0009] EP 0 267 822 discloses a flat transformer with a resin encapsulation. However, the transformer being of a different structure, therefore applicable in other fields.

[0010] Also, Document XP010265713 ISBN: 978-0-7803-3959-0 discloses a method for increasing the insulation in planar magnetics such as void-free en-

capsulation using an insulating resin.

[0011] Document US6380834 discloses planar transformers that comprise stacked circuit boards and windings with insulating layers between them.

5 **[0012]** The process of manufacture in accordance with this invention satisfactorily provides insulation in the horizontal direction in which the distance called "creepage" is conventionally defined as the minimum distance between the windings or winding and the core over the insulating surface area through air, occupying the least space possible.

10 **[0013]** In accordance with the process in accordance with this invention manufacture of the planar transformer is effected through a series of successive operations which in total comprise:

a) successive stacking of the laminar members constituting the windings with interleaved insulating layers on both sides and including the laminar members of multilayer printed circuits or printed circuits with double printed circuits or circuits printed on only one side,

20 b) fitting of the connecting plugs or pins inserted into aligned openings in the laminar members forming the windings and the winding printed circuit boards (PCB), proceeding to attach the pins both to the terminals of the copper windings and those of the printed circuits, simultaneously making an electrical connection between the said pins and the spatial mounting of the printed circuits, imparting high rigidity to the assembly,

25 c) casting a mass of resin, for example using a reusable or shell mould, forming a block, or fitting the assembly comprising the different stacked windings together with the interleaved insulating layers within a box substantially matching the external shape of the said stacked and previously unified assembly, then proceeding to pour the insulating polyurethane resin at a very slow rate so as to allow it to enter between the windings until the desired depth within the box is reached, which might be the depth at which it is flush, after which and after the resin has hardened there is obtained a wholly compact assembly which is well insulated as a result of the resin's penetration between the layers of windings, providing great dielectric strength as well as small external dimensions.

30 **[0014]** In order to achieve good penetration by the resin between the windings, it is necessary for the interleaved insulating layers to be of sufficient size to permit such penetration, in order to leave a larger region for penetration by the insulating resin.

35 **[0015]** Finally the externally attached ferrites are incorporated with the assembly formed by the windings, interleaved insulating layers, printed circuits and connecting rods, all embedded in a mass of insulating polyurethane resin.

[0016] The box for moulding the assembly of windings, interleaved insulating layers and printed circuits may be incorporated in the transformer for the purpose of acting as an envelope for the assembly, although the transformer may be manufactured in the manner indicated within a metal or shell mould, in which case there is no outer box moulding the polyurethane resin.

[0017] For better understanding some drawings illustrating this invention are appended by way of an explanatory but not restrictive example.

Figure 1 illustrates the set of parts forming a planar transformer manufactured according to this invention, in which the relative position of a resin moulding box and the ferrite cores can be seen.

Figure 2 shows a cross-section of the planar transformer on a larger scale in which the moulding box is arranged in the form of a protective envelope.

Figure 3 illustrates a second cross-section of the planar transformer along a plane parallel to that in Figure 2.

Figure 4 shows a plan view.

[0018] As illustrated in these figures, a planar transformer according to this invention comprises a set of windings and interleaved insulating layers stacked into an assembly joined together by a set of connecting pins as seen in Figure 1, in which may be seen the printed circuit boards -1- and -2- and intermediate windings -3- and -4-, punched from copper sheet or wound from the same material, the interleaved insulating layers -5-, -6-, -7-, -8- and -9- being located on each side of the said members and having surface dimensions which are smaller than those of printed circuit windings -1- and -2-. The arrangement is that which may be seen in Figures 2 and 3, in which the arrangement of the windings, printed circuit boards and interleaved insulating layers can be seen, fixed in position through a variable number of through pins, with the pins represented by the numbers -10-, -10'-, -10"- ..., as may be seen in Figure 1, it being understood that their number and arrangement will depend on the circuits enclosed. These pins are inserted in the corresponding orifices in the printed circuit boards and winding boards as indicated for example by numbers -11-, -11'-, -11"- ... in printed circuit board -1- and numbers -12- and -12'- in winding -3-.

[0019] These pins are attached to the said panels and windings in ways which are known in the art, for example by cold welding, cementing masses or other means.

[0020] Once the set of windings with their interleaved insulating layers and fixing pins has been assembled, the assembly is embedded in a mass of insulating polyurethane resin which can be achieved by casting in an external or "shell" mould or using a box of appropriate structure -13-, which has an external shape matching that of the printed circuit boards, with lateral steps such as -14- and -15- to match lateral notches -16- and -17- of the said printed circuit boards and an extended central

core -18- designed to coincide with the central openings of the said stacked members, that is, printed circuit boards, windings and interleaved insulating layers.

[0021] In order to achieve a satisfactory result it is essential that the thickness of the interleaved insulating layers which form the passages for the resin must be adequate.

[0022] Once the insulating resin, preferably polyurethane resin, has been cured, ferrite cores -19- and -20- are attached, being joined by laminar insulating members fitted externally thereto or by any other means known in the art.

[0023] Figure 4 illustrates a plan view of an embodiment of a planar transformer manufactured in accordance with this invention, in which will be seen enclosing box -13- incorporated in the mass of polyurethane resin, forming end blocks -21- and -34- which are interconnected by portions -22- and -23- of which only the beginning can be seen in Figure 4, edging the central opening -25-. The ends of the connecting pins extend beyond the block of polyurethane resin, being represented by the numbers -26-, -27-, -28- and -29- in the case of block -34- and pins -30-, -31-, -32- and -33- in the case of block -21-, although it should be understood that the number and arrangement of the said pins may vary with the specific design of the planar transformer.

Claims

1. A planar transformer, of the type comprising a ferrite core (19, 20) and a succession of windings in a stack comprising a variable number of printed circuit boards (1, 2) and copper windings (3, 4), punched from sheet or wound, with interleaved insulating laminar members (5, 6, 7, 8, 9) in contact with all the surfaces of the windings and of variable thickness to adjust the gaps between the windings, said windings being connected together by connecting pins (10, 10', 10", 26-33) inserted there through, **characterized in that** the connecting pins are inserted in aligned orifices (11, 11', 11", 12) of the printed circuit boards (1, 2) and the copper windings (3, 4) and the transformer comprises a single preassembled block (21, 22, 23, 34) as a result of the stacking of the printed circuit boards and the copper windings with inserted connection pins and the interleaved insulating laminar members that are embedded in a single mass of insulating polyurethane resin which covers the assembly of said stacked elements externally and which enters the gaps between the windings, leaving the ferrite core outside and attached to the preassembled block.
2. A planar transformer according to Claim 1, **characterised in that** the resin block containing the windings, the interleaved insulating laminar members and the inserted connecting pins (10, 10', 10", 26-33)

of the transformer are incorporated within an open insulating box (13) which fits the base and the lateral profile of said block and its central opening.

3. A process for the manufacture of planar transformers according to Claims 1 and 2, proceeding through a first stage of vertically stacking the printed circuit boards, the copper windings and the interleaved insulating laminar members in both upper and lower parts of the stack, **characterised in that** these are fastened by inserting connecting pins fitted in aligned orifices of the windings, securing the pins with said windings and finally proceeding to pour a mass of polyurethane resin into a mould which surrounds the previously assembled stack comprising the windings, interleaved insulating laminar members and inserted connecting pins, pouring the resin at a suitable rate to permit the insulating resin to penetrate the gaps between the windings.
4. A process according to Claim 3, **characterised in that** the mass of polyurethane resin is poured within a surrounding box (13) which has a sealed bottom and is open at the top which externally matches the shape of the preassembled stack of the printed circuit boards, the copper windings and the interleaved insulating laminar members, filling with resin until flush with the upper surface in order to form a block.

Patentansprüche

1. Planartransformator, der Art umfassend einen Ferritkern (19, 20) und eine Reihenfolge von Wicklungen in einem Stapel, umfassend eine variable Anzahl von gedruckten Leiterplatten (1, 2) und Kupferwicklungen (3, 4), gestanzt aus einer Folie oder gewickelt, mit verschachtelten isolierenden flächigen Elementen (5, 6, 7, 8, 9) in Kontakt mit allen Oberflächen der Wicklungen und mit einer variablen Dicke, um die Lücken zwischen den Wicklungen einzustellen, wobei die genannten Wicklungen mittels Verbindungsstiften (10, 10', 10'', 26-33) miteinander verbunden sind, welche durch diese eingesteckt werden, **dadurch gekennzeichnet, dass** die Verbindungsstifte in ausgerichteten Löcher (11, 11', 11'', 12) der gedruckten Leiterplatten (1, 2) und der Kupferwicklungen (3, 4) eingesteckt werden, und der Transformator einen einzigen vormontierten Block (21, 22, 23, 34) umfasst, infolge der Stapelung der gedruckten Leiterplatten und der Kupferwicklungen mit eingesteckten Verbindungsstiften und den verschachtelten isolierenden flächigen Elementen, welche in einer einzigen Masse aus isolierendem Polyurethanharz eingebettet sind, welche die Baugruppe aus gestapelten Elementen äußerlich deckt und welche in die Lücken zwischen den Wicklungen eindringt, wobei der äußerliche Ferritkern außen und

an dem vormontierten Block befestigt bleibt.

2. Planartransformator nach Anspruch 1, **dadurch gekennzeichnet, dass** der Harzblock, welcher die Wicklungen, die verschachtelten isolierenden flächigen Elemente und die eingesteckten Verbindungsstifte (10, 10', 10'', 26-33) des Transformators enthält, innerhalb eines offenen Isolierkastens (13) eingegliedert wird, welcher in die Basis, das seitliche Profil des genannten Blocks und dessen zentrale Öffnung einpasst.
3. Verfahren zur Herstellung von Planartransformatoren nach den Ansprüchen 1 und 2, ausgeführt durch einen ersten Schritt des vertikalen Stapelns der gedruckten Leiterplatten, der Kupferwicklungen und der verschachtelten isolierenden flächigen Elementen sowohl in oberen als auch in unteren Teilen des Stapels, **dadurch gekennzeichnet, dass** diese mittels des Einsteckens von Verbindungsstiften, welche in ausgerichtete Löcher der Wicklungen einpassen, fixiert werden, wobei die Stifte mit den genannten Wicklungen befestigt werden und schließlich eine Masse aus Polyurethanharz in eine Form eingegossen wird, welche den zuvor montierten Stapel umfassend die Wicklungen, die verschachtelten isolierenden flächigen Elemente und die eingesteckten Verbindungsstifte umgibt, wobei das Harz bei einer geeigneten Geschwindigkeit eingegossen wird, um zu ermöglichen, dass das isolierende Harz in die Lücken zwischen den Wicklungen eindringt.
4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** die Masse aus Polyurethanharz in einen umgebenden Kasten (13) eingegossen wird, welches einen versiegelten Boden aufweist und im oberen Teil offen ist, welcher äußerlich der Gestalt des vormontierten Stapels der gedruckten Leiterplatten, der Kupferwicklungen und der verschachtelten isolierenden flächigen Elementen entspricht, so dass er mit Harz gefüllt wird, bis es bündig mit der oberen Oberfläche ist, im einen Block zu bilden.

Revendications

1. Un transformateur planaire du type comportant un noyau de ferrite (19, 20) et une suite de bobinages dans une pile comportant un nombre variable de cartes de circuit imprimé (1,2) et des bobinages en cuivre (3, 4), découpés dans une lame ou enroulés ayant des éléments laminaires isolant entrelacés (5, 6, 7, 8, 9) en contact avec toutes les surfaces des bobinages et ayant une grosseur variable pour régler les écarts entre les bobinages, ces bobinages étant reliés entre eux par des broches de raccordement (10, 10', 10'', 26-33) insérées à travers eux, **caractérisé en ce que** les broches de raccordement sont

insérées dans des trous alignés (11, 11', 11", 12) des cartes de circuit imprimé (1,2) et les bobinages en cuivre (3, 4) et le transformateur comporte un seul bloc pré-assemblé (21, 22, 23, 34) suite à l'empilement des cartes de circuit imprimé et des bobinages en cuivre ayant des broches de raccordement insérées et les éléments laminaires isolants entrelacés qui sont incorporés dans une seule masse de résine de polyuréthane isolante qui couvre l'ensemble de ces éléments empilés et qui entre dans les écarts entre les bobinages, en laissant le noyau en ferrite à l'extérieur et attaché au bloc pré-assemblé.

2. Un transformateur planaire conformément à la revendication 1, **caractérisé en ce que** le bloc en résine contenant les bobinages, les éléments laminaires isolants entrelacés et les broches de raccordement insérées (10, 10', 10", 26-33) du transformateur sont incorporés à l'intérieur d'un boîtier isolant ouvert (13) qui s'adapte à la base et au profil latéral de ce bloc et de son ouverture centrale.
3. Une méthode pour la fabrication de transformateurs planaires conformément aux revendications 1 et 2, et passant par une première étape d'empilage vertical des cartes de circuit imprimé, des bobinages en cuivre et des membres laminaires isolants entrelacés sur les deux parties supérieure et inférieure de la pile, **caractérisé en ce qu'**ils sont fixés en insérant des broches de raccordement adaptées dans les trous alignés des bobinages, en assurant les broches avec ces bobinages et finalement en versant une masse de résine de polyuréthane dans un moule qui entoure la pile préalablement assemblée comportant les bobinages, les éléments laminaires isolants entrelacés et les broches de raccordement insérées, en versant la résine à un débit adapté pour permettre que la résine pénètre dans les écarts entre les bobinages.
4. Une méthode conformément à la revendication 3, **caractérisée en ce que** la masse de résine de polyuréthane est versée à l'intérieur d'un boîtier enveloppant (13) qui possède une base scellée et qui est ouvert en haut qui s'adapte à l'extérieur à la forme de la pile pré-assemblée de cartes de circuit imprimé, de bobinages de cuivre et d'éléments laminaires isolants entrelacés, en remplissant avec la résine jusqu'à ce qu'elle soit au même niveau que la surface supérieure afin de former un bloc.

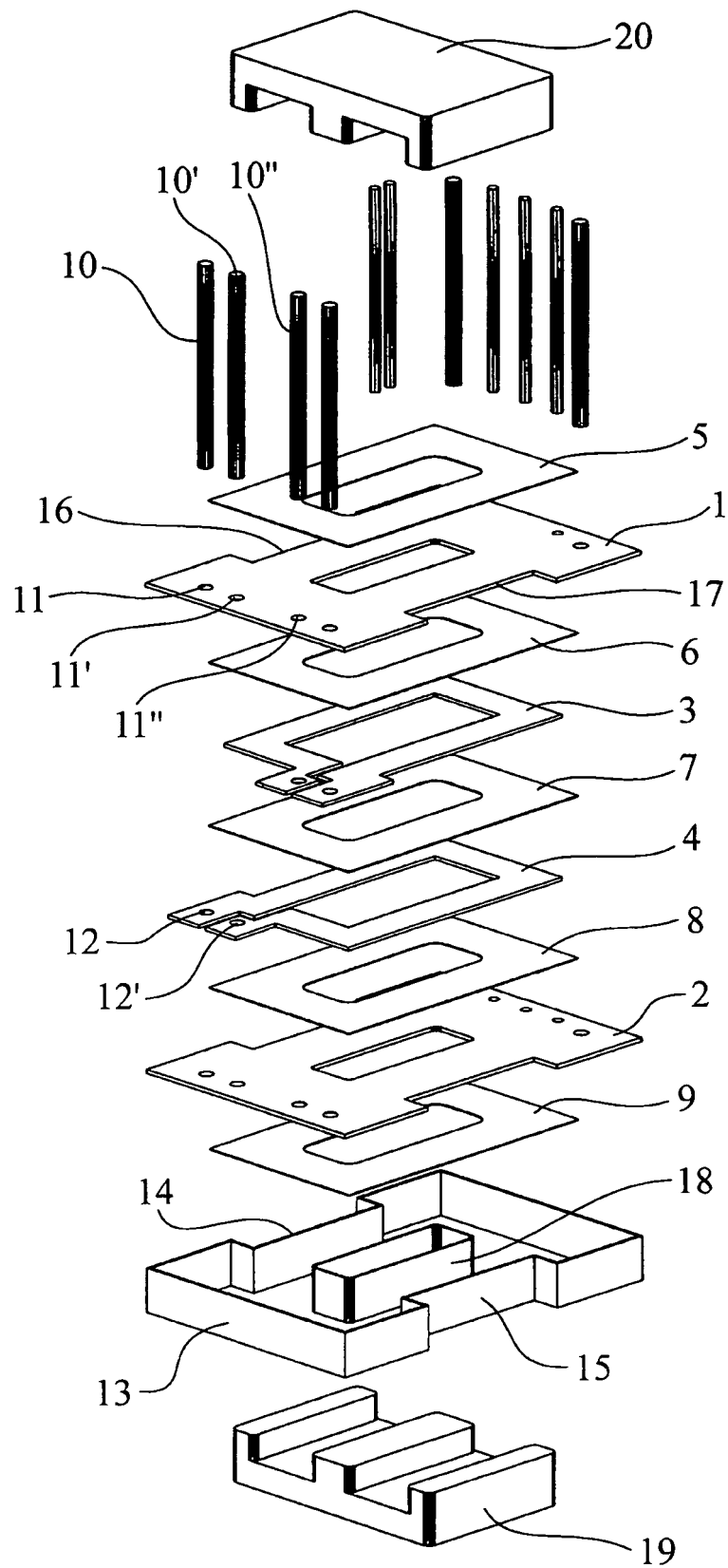
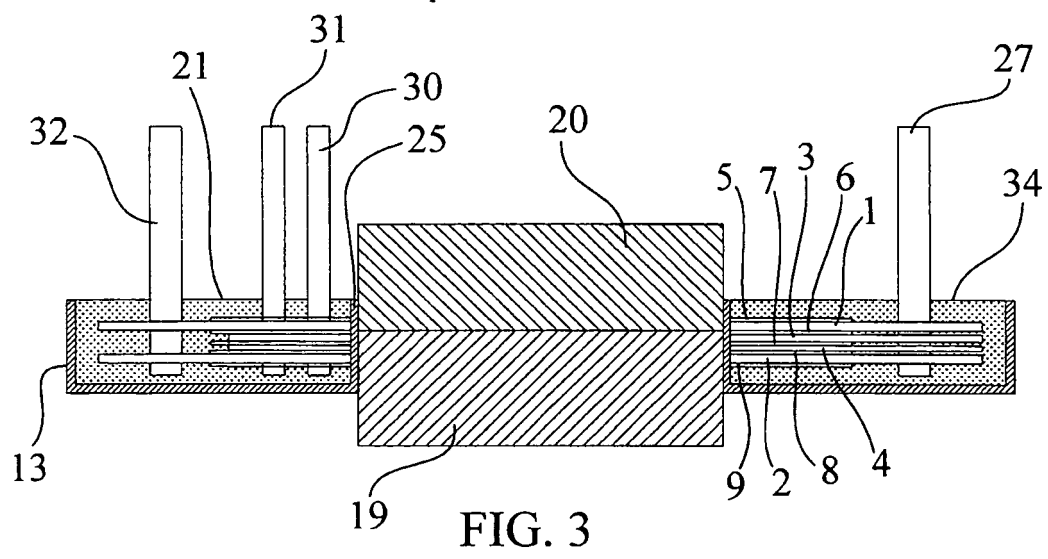
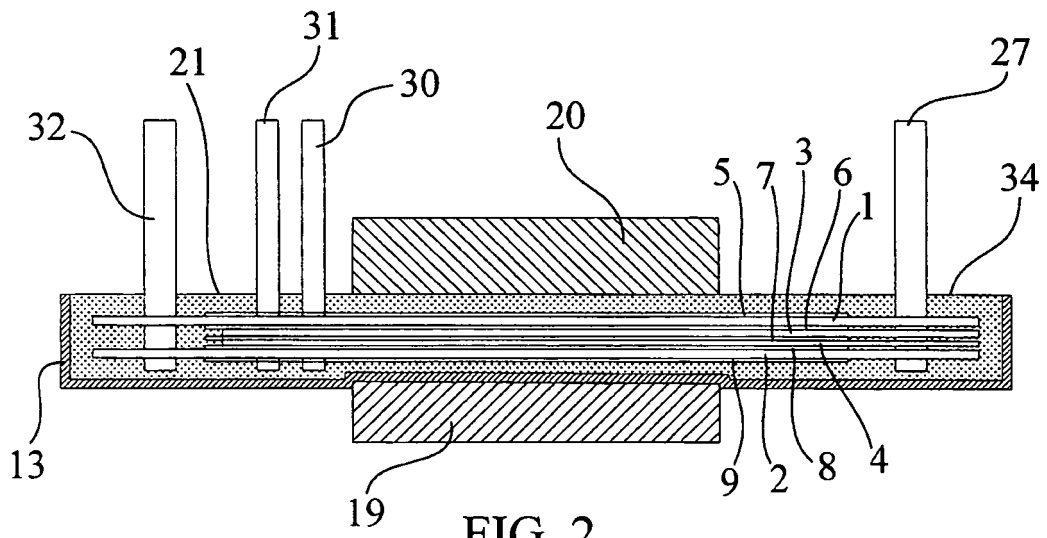
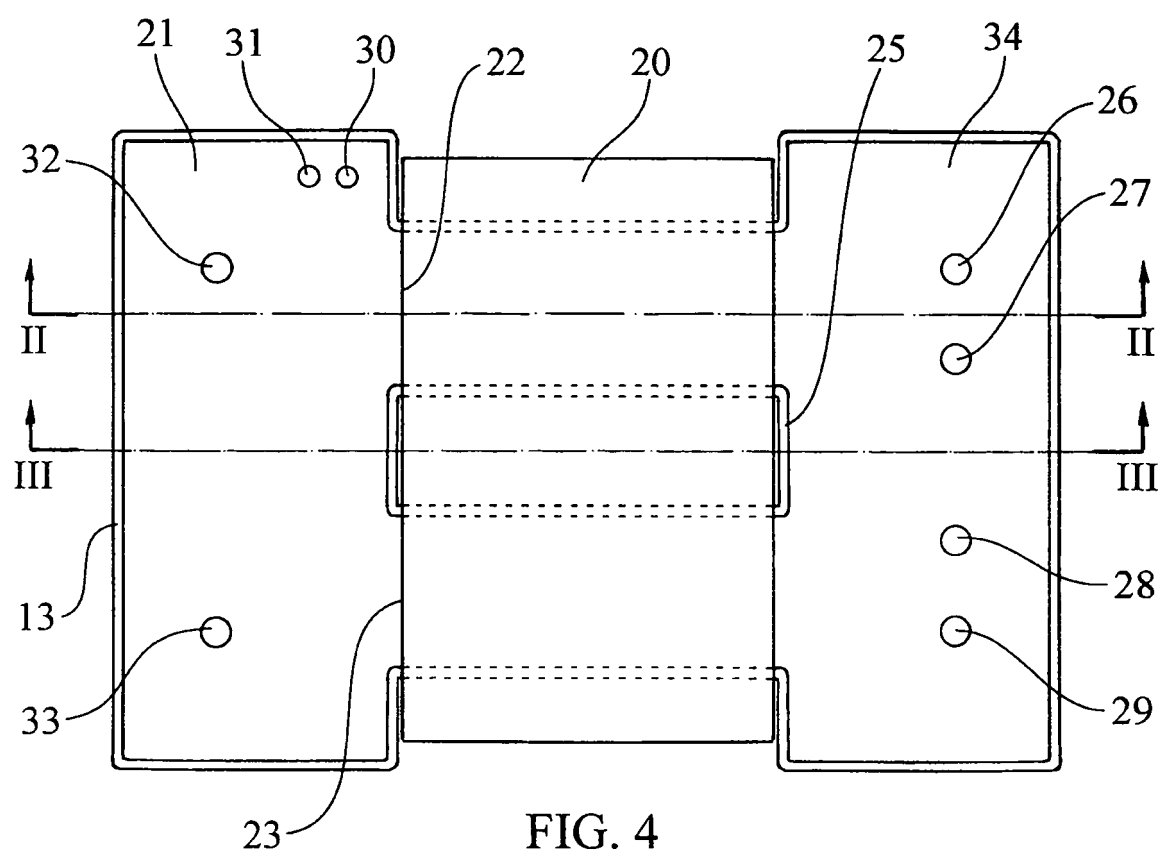


FIG. 1





REFERENCES CITED IN THE DESCRIPTION

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