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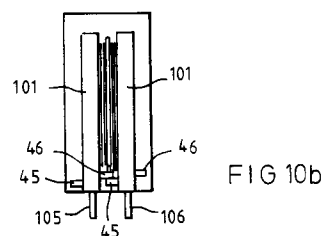
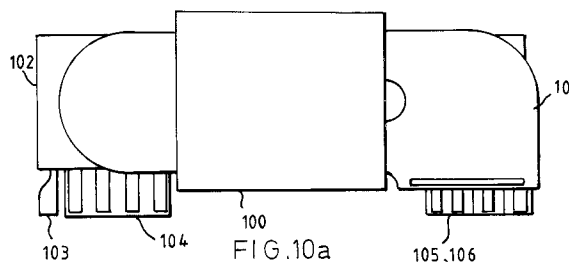
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(54) **Flat transformer.**

(57) A flat transformer comprising planar windings of which at least one is contained in an electrically-insulating flat box sealed everywhere except at the points that lead-out wires from the winding exit of the box.



This invention relates to a flat transformer, i.e. to a transformer in which each winding is generally planar, for example of spiral shape. Such transformers are particularly useful in electrical power conditioning equipment, particularly for switched mode power supplies.

The purpose of the invention is to provide sufficient insulation between the primary and secondary windings of a flat transformer to satisfy the requirements of the major International Safety Bodies, while maintaining simplicity of construction of the transformer.

Accordingly, the invention provides a flat transformer comprising planar windings of which at least one is contained in an electrically-insulating flat box sealed everywhere except at the points that lead-out wires from the winding exit of the box. Two such boxes may be provided for respective windings. While such a box could be used to enclose the secondary windings, in the preferred example the or each box is used to contain only a respective primary winding. This is because the transformer cores, which should be considered as electrical conductors, have in effect become "primary components" and electrical insulation is now needed between these cores and the output circuits or metal work of the power supply. The electrically-insulating flat box is conveniently made from a plastics material.

From another aspect, the invention provides a planar transformer winding for a flat transformer, the winding contained in an electrically-insulating flat box sealed everywhere except at the points that lead-out wires from the winding exit the box.

The invention is particularly advantageous because it represents a simple solution to the problem of electrical insulation in a flat transformer, and it still enables the transformer to be assembled from modular flat components in a very simple manner.

In order that the invention may be better understood, an example will now be described with reference to the accompanying drawings, in which:

Figure 1a is a section through a conventional transformer, and Figure 1b is a perspective view of the same transformer;

Figure 2 is an exploded view of a conventional flat transformer;

Figures 3a and 3b are a plan view and end view respectively of a core element of a flat transformer embodying the present invention;

Figures 4a and 4b are a plan view and side elevation of a plastics box for enclosing the or each set of primary windings of a flat transformer embodying the invention;

Figure 4c is an end elevation of two adjacent plastics boxes of the type shown in Figures 4a and 4b; Figure 4d is a schematic end elevation of one set of primary windings of the flat transformer of Figures 4a to 4c, showing the folded structure of the

various windings;

Figure 5a is a top plan view of a primary winding before it is folded in two, and Figure 5b is an underneath plan view of the same primary winding; Figure 6 is a plan view of a power back winding of the flat transformer of Figures 3 to 5;

Figure 7 is a plan view of a radio frequency interference screen for the flat transformer of Figures 3 to 6;

Figure 8a is a plan view of a single turn high current secondary winding for the flat transformer of Figures 3 to 7, before it is formed into the final shape;

Figure 8b is a plan view of the secondary winding of Figure 8a, after folding once about the line F1-F1;

Figure 8c is a view of the same secondary winding after it has been folded along the line F2-F2; Figures 8d and 8e are different elevations, to an enlarged scale, of terminal portions of the secondary winding of Figures 8a to 8c;

Figures 9a and 9b are top and underneath plan views of an auxiliary secondary winding for the flat transformer of Figures 3 to 8; and

Figures 10a, 10b and 10c are respectively a plan view, and elevation and side elevation of the complete flat transformer comprising elements shown separately in Figures 3 to 9.

By way of background information, a typical conventional electrical transformer consists of a number of windings wound onto a former. Insulation materials are commonly used between windings in order to provide electrical isolation. A magnetic core is used, to complete the magnetic circuit. This type of construction is shown in Figure 1a and Figure 1b, where the magnetic material is in the shape of two "E" pieces 11. There are two windings 13, 15 separated by insulation 14 and wound on formers 12. Electrical connection to the windings 13, 15 is made by means of lead-out wires 16 and 17.

The design of such transformers can become very complex, particularly if they are to be used as isolating components in high frequency switched mode power supplies. In such applications it is usually required to minimise the leakage inductance or to maximise the coupling between the windings, further complicating the windings, and further complicating the design and manufacturing aspects.

More recently, it has been realised that the use of "flat" transformers is beneficial because they are much easier to manufacture than their conventional counterparts and because they have a better electromagnetic coupling between windings. Instead of winding wires or foils onto formers, each winding consists of a disc or spiral of wire as illustrated in Figure 2. An inner core 21 slots into an outer core 25, holding between them first 22 and second 24 windings separated by insulation or electrical screens 23. It is most

convenient if each disc of wire is self supporting and, at the present moment, probably the best method of construction for multiple turn windings is to use double-sided flexible printed circuit materials, placing half the turns on one side and the remainder on the other side. In this manner this windings are "printed" onto a base material and electrical insulation may be applied over the printed pattern. A transformer may be assembled very easily by slotting an appropriate combination of these windings onto a pair of cores such as cores 21 and 25.

Although the flat transformer shown in Figure 2 is very easy to manufacture, it is very difficult to make such a transformer meet the rigorous input to output isolation required to meet International Safety Standards. For example, creepage distances between primary and secondary windings of a converter transformer used in a typical off-line switched mode power supply may need to be 12.6mm according to standard EN60950. This problem is made worse by the trend towards higher operating frequencies and smaller transformers.

The conventional solution to this problem is to vacuum impregnate all the transformer windings with a suitable substance, typically an epoxy resin. It is now no longer necessary to consider creepage and clearance paths between primary and secondary windings within the transformer, but care must still be taken to ensure that the requirements are met where the lead-out wires exit the windings. Meeting these requirements is in fact very difficult and expensive in practice: very strict control must be exercised over cleanliness and process control to ensure that the potting compound adheres correctly to the windings and to ensure that no voids are present.

By enclosing the primary winding or windings or each set thereof, in a respective plastics box sealed everywhere except at the points where the lead-out wires exit the box, in accordance with the present invention, it is possible to satisfy the safety standard requirements. For example, standard EN60950 stipulates that a layer of solid insulation of at least 0.4mm in thickness may be used to separate primary and second windings in the example given above. A preferred embodiment of the invention will now be described with reference to the Figures 3 to 10 of the accompanying drawings.

This flat transformer is designed around two "E" cores 31, of which one is shown in Figures 3a and 3b. Many different core shapes could however be used as alternatives, ranging from circular ones of the type shown in Figure 2 to rectangular ones, of which the core shown in Figure 3 is an example, so long as they are substantially flat.

The two sets of primary windings are contained inside two identical moulded plastics boxes 41 and 42, as shown in Figure 4c. The construction of one such box is shown in Figures 4a and 4b. The primary

winding 491, 492 itself consists of an etched double-sided copper-polyester-copper laminate joined from one side to the other and folded as described below with reference to Figure 5. Two further windings are associated with the primary winding: a power back winding 481, 482, described below with reference to Figure 6, and radio frequency interference screens 471, 472, described below with reference to Figure 7. These windings are folded one inside the other, together with a single insulator 40 in the centre, this "primary build-up" being shown in Figure 4d. Each primary box 41 or 42 is moulded in two parts: a flat lid and a hollow "lunch-box" style container. The primary stack of windings, as shown in Figure 4d, is placed into the "lunch-box" half, and the lid is then welded in place. In principle, any method of welding could be used, or the two halves could be bonded by adhesive; the preferred method is ultrasonic welding.

With reference to Figures 4a to 4c, the plastics box 41 has a central elongate aperture for receiving part of the core; otherwise, the box is generally an elongate rectangle with three rounded corners, the fourth corner allowing the lead-out wires to exit. Elongate rectangular ribs 45 and 46 project normally from the major surfaces of the box 41 at the fourth corner: as can be seen in Figures 4c and 10b, these ribs are intended to be staggered so as to interlock when identical boxes are placed adjacent one another in the stack. The ribs increase the length of the electrical creepage path between primary and secondary conductors in the vicinity of the primary winding lead-outs.

It will be seen from Figure 4b that the box 41 is thin in relation to its width and length, and that the walls of the box are also very thin. By way of example, the overall length of the box may be 94mm, the overall width 27mm, the overall thickness 3.2mm and the air space between the major walls 1.6mm, with the walls themselves being 0.8mm thick. The material thickness must not be less than 0.5mm at all points including any weld lines; there are no rivets.

The primary winding 491, 492 is shown in Figures 5a and 5b. Copper tracks 53 and 54, with terminals 531 and 541, are provided on one side of the plastics lamina 51, and a corresponding copper track 55 is provided on the opposite side of the same lamina 51. Copper track 53 is connected electrically to copper track 55 through the plastics lamina 51 at the point indicated "x" in the drawing, by the technique described below as an embodiment of the second invention. At the other end, copper track 54 is bonded through the lamina 51 to copper track 55, at the point shown as "*" in the drawing. The double-sided laminate is folded along the F1-F1, to assume the position shown in Figure 4d for assembly into the plastics box 41.

With reference to Figure 6, the power back winding 481, 482 of Figure 4d comprises a single-sided laminate having a plastics lamina 61 on which copper

tracks 62 and 63 are printed. The power back winding is folded along the line F1-F1 to adopt the configuration shown schematically in Figure 4d.

Similarly, with reference to Figure 7, the radio frequency interference screen layer 471, 472 of Figure 4d is constituted by a single-sided plastics-copper laminate with a copper "winding" 72 on a plastics lamina 71; the laminate is folded about the line F1-F1.

The secondary windings consist of a single turn high current winding 81 with terminals 86 and 87, as shown in Figures 8a to 8e, plus up to four auxiliary windings of the type shown in Figures 9a and 9b. The high current winding 81 is formed from a planar copper element cut as shown in Figure 8a, having mounting holes 84, 85 as shown. The element 81 is generally U-shaped, with relatively long 82 and relatively short 83 end pieces. The end pieces 82, 83 are folded through 90° about the line F1-F1 to assume the position shown in Figure 8b, and then the longer end piece 82 is folded about the line F2-F2 through 180° so as to lie adjacent the shorter end element 83. The ends of these pieces 82, 83 are formed into cylindrical terminals 86, 87, as shown in Figures 8c, 8d and 8e.

One of the auxiliary secondary windings 90 is shown in Figures 9a and 9b, in the form of a double-sided copper-polyester-copper laminate. Copper tracks 91 and 92 are formed on one side of the laminate, and are connected electrically through the plastics intermediate layer at respective points "x" and "*" to different ends of a spiral copper track 93 on the other side.

The complete transformer constructed from the parts shown in Figures 3 to 9 is shown in Figures 10a to 10c, and is constructed simply by slotting the appropriate components over the core halves and holding the core halves together by clamping or gluing. Thus, each primary stack is assembled into its plastics box 101, two such boxes being provided in this example. The secondary windings, consisting of the high current winding and four auxiliary windings, are assembled as at 102 between the plastics boxes 101. The leadout wires 105 and 106 from the respective primary windings emerge at one end of the transformer, while the leadout wires 104 from the auxiliary secondary windings, and the leadout wires 103 from the high current secondary winding, are located at the opposite end, for maximum electrical isolation.

there are at least two such flat boxes for respective windings.

3. A flat transformer according to Claim 1, in which the or each said flat box is used to contain only a respective primary winding.
4. A flat transformer according to Claim 1, in which the or each said flat box is made from a plastics material.
5. A planar transformer winding for a flat transformer, the winding contained in an electrically-insulating flat box sealed everywhere except at the points that lead-out wires from the winding exit the box.
6. A winding according to Claim 5, the said flat box which contains the winding being made from a plastics material.

Claims

1. A flat transformer comprising planar windings of which at least one is contained in an electrically-insulating flat box sealed everywhere except at the points that lead-out wires from the winding exit of the box.
2. A flat transformer according to Claim 1, in which

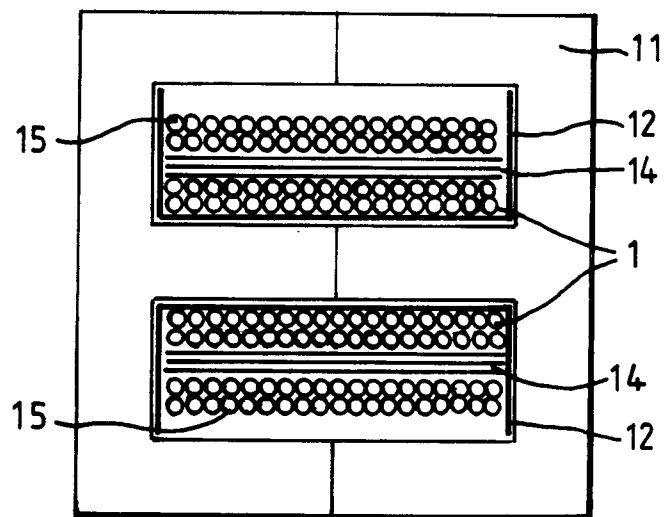


FIG. 1a

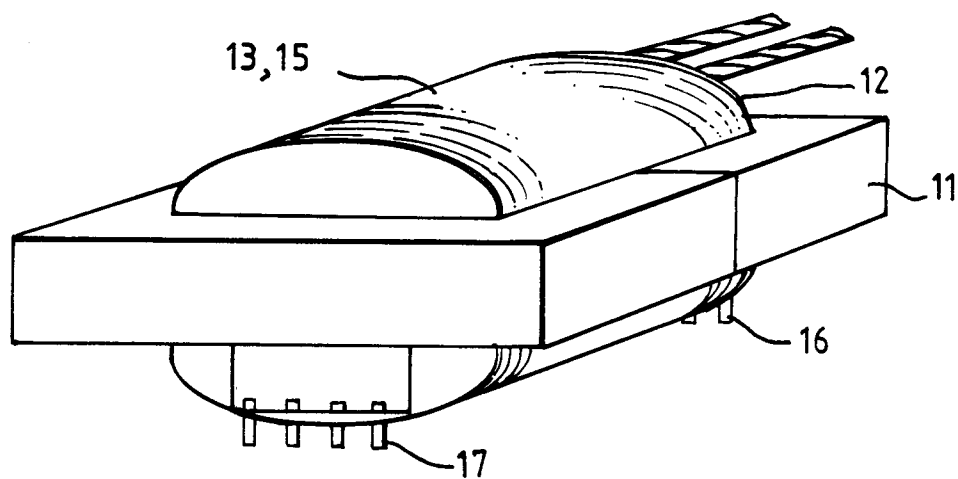


FIG. 1b

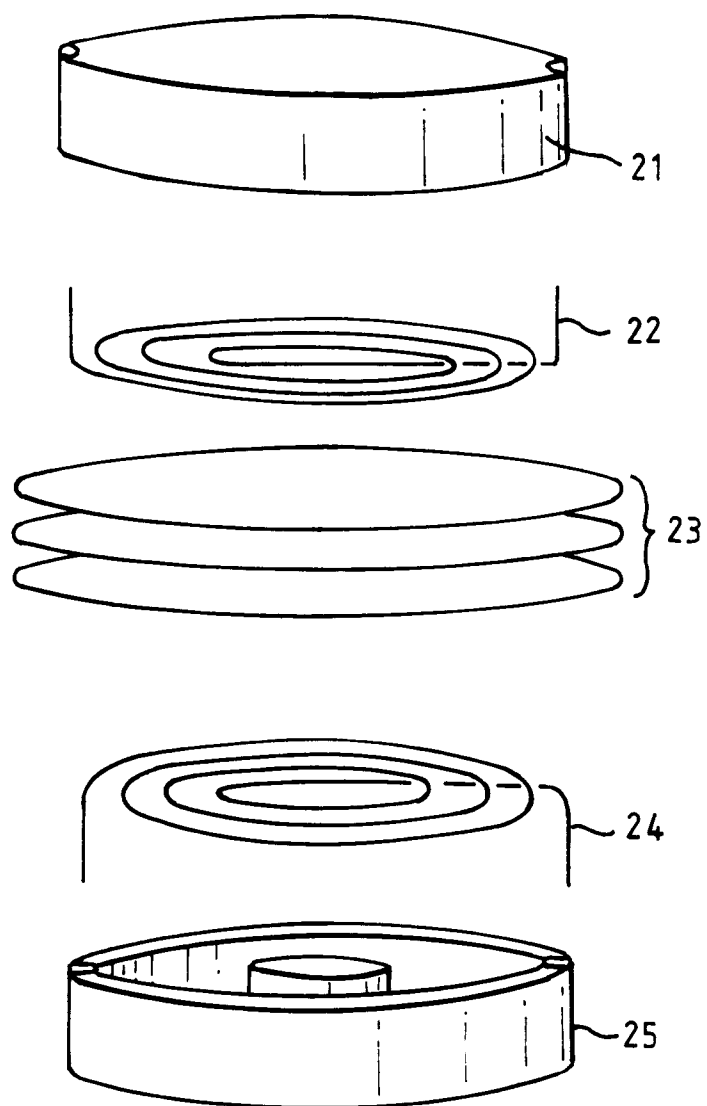


FIG. 2

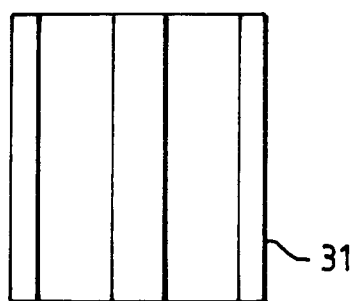
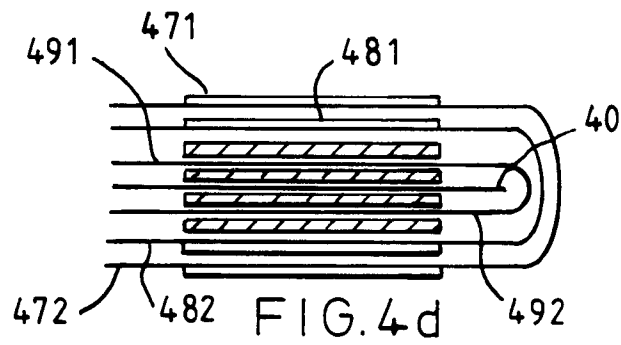
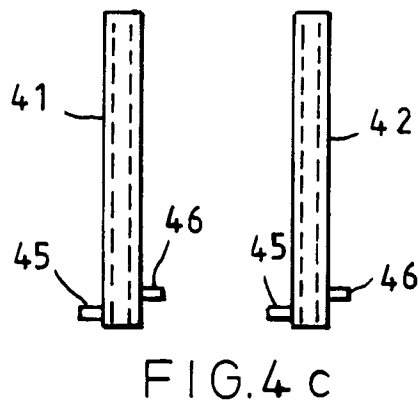
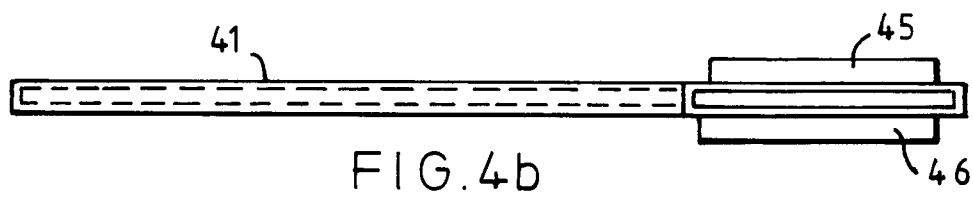
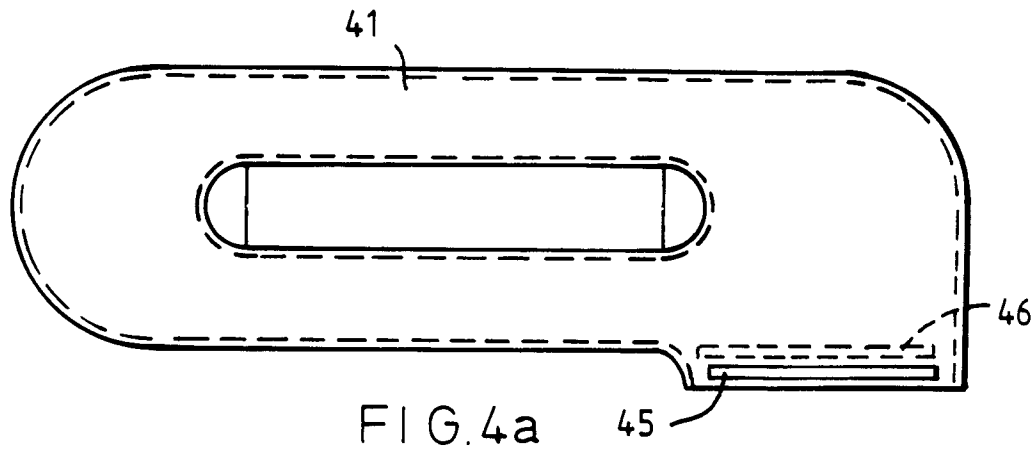
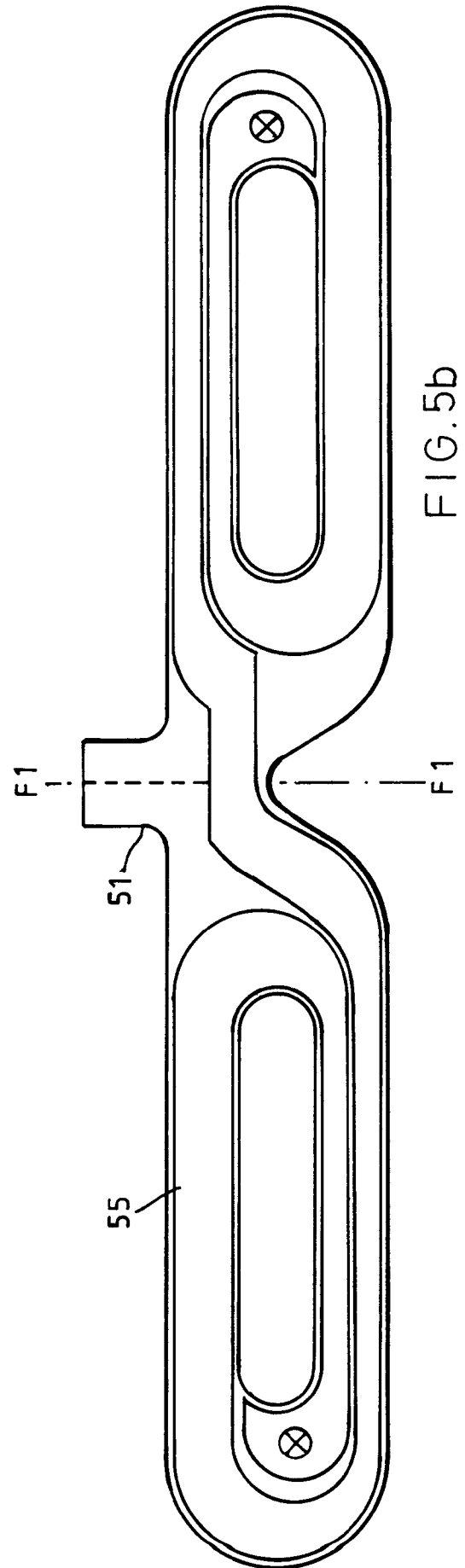
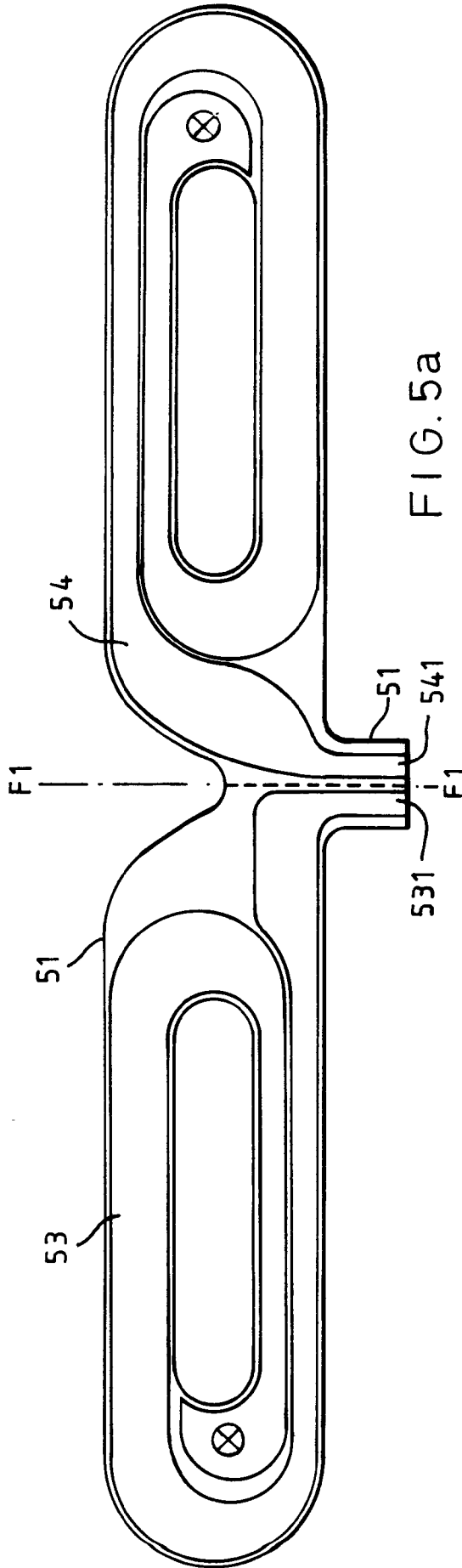


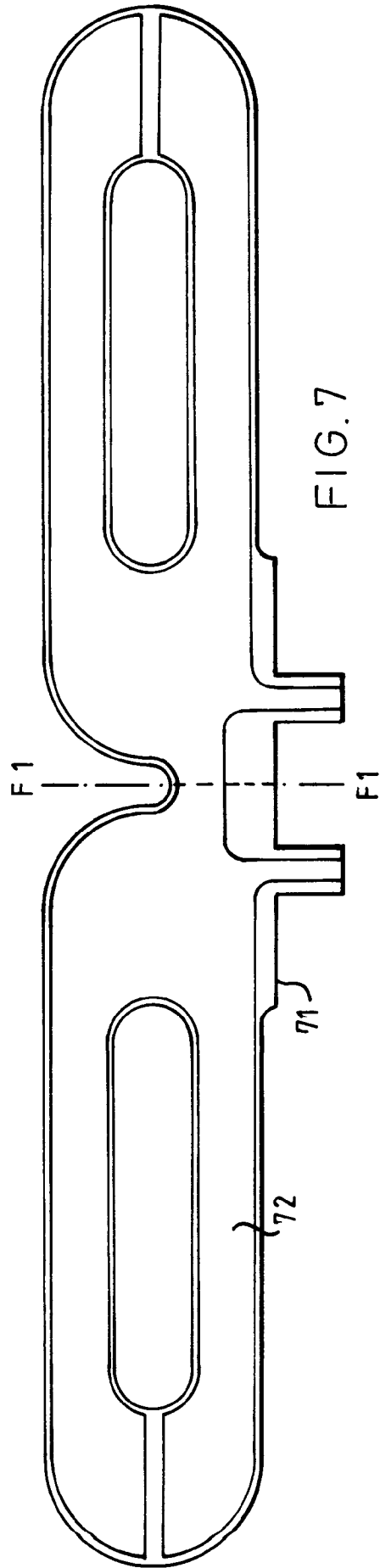
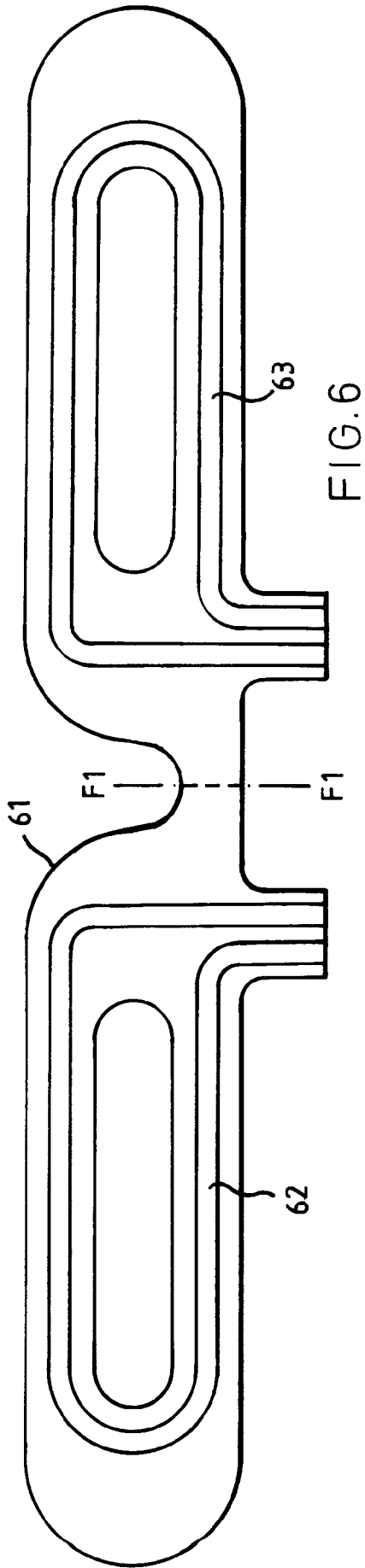
FIG. 3a

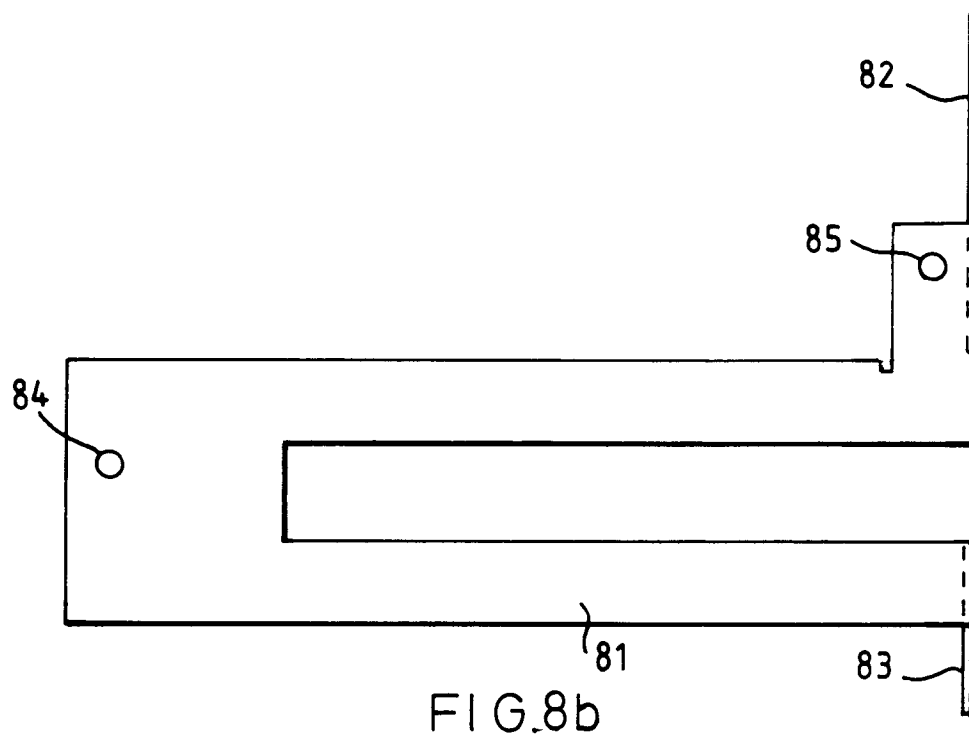
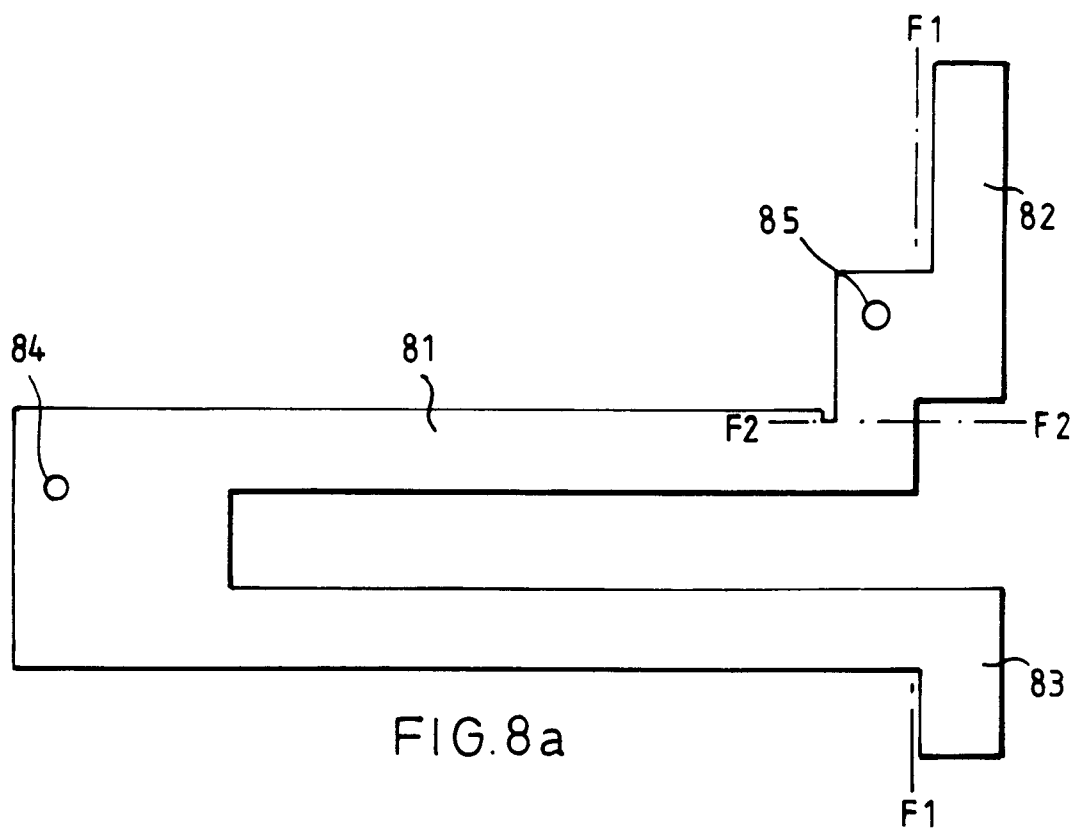


FIG. 3b









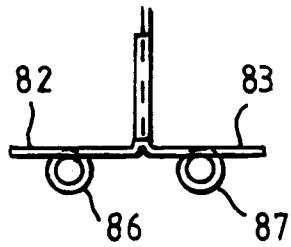
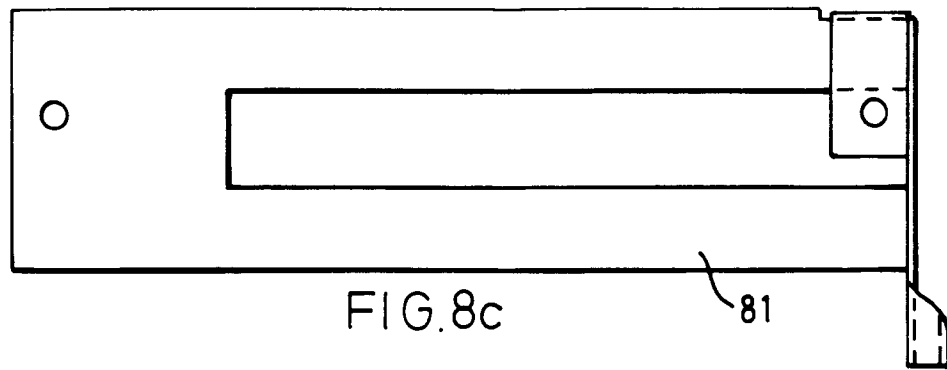


FIG. 8d

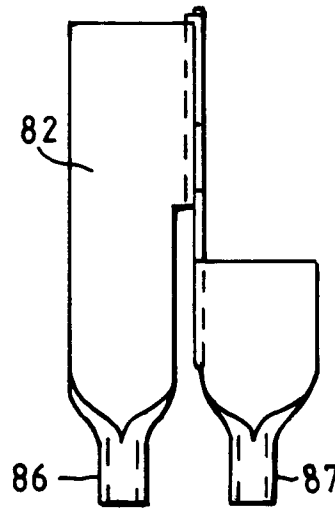


FIG. 8e

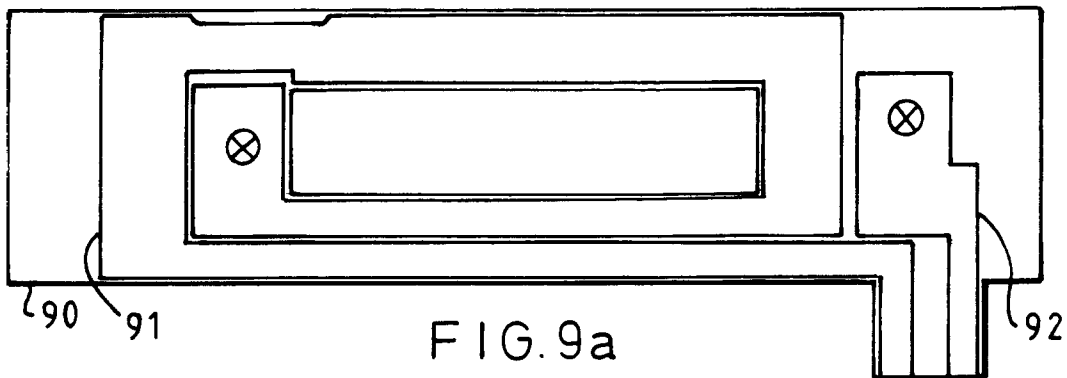


FIG. 9a

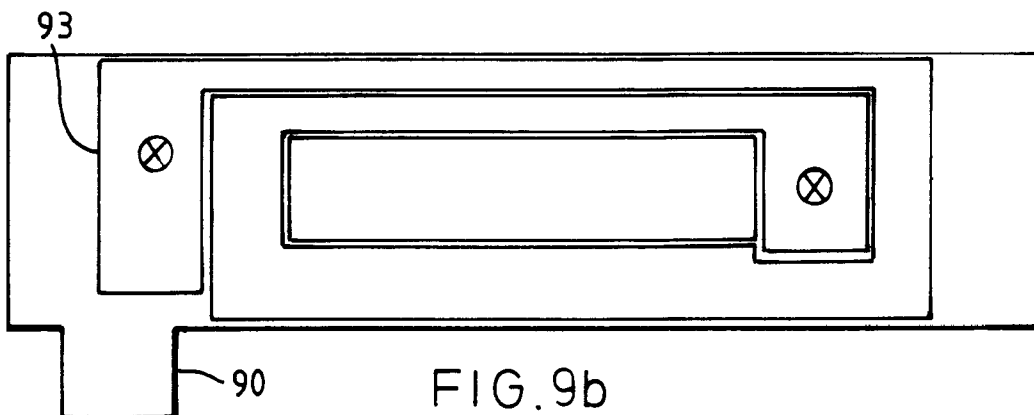
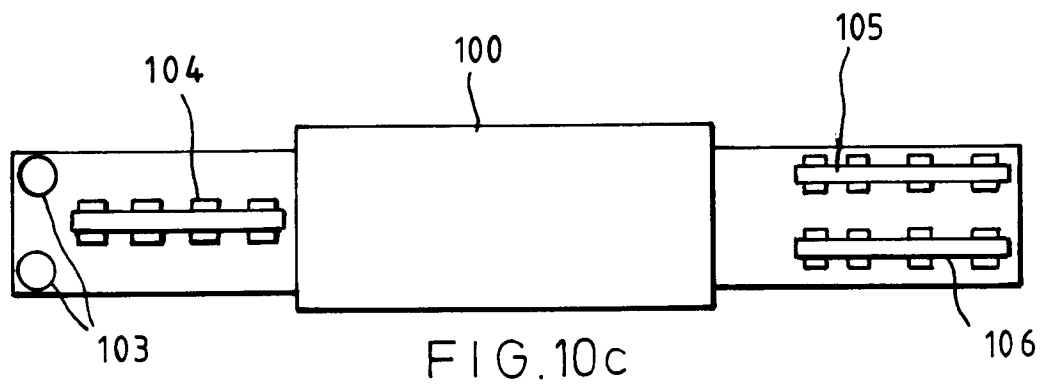
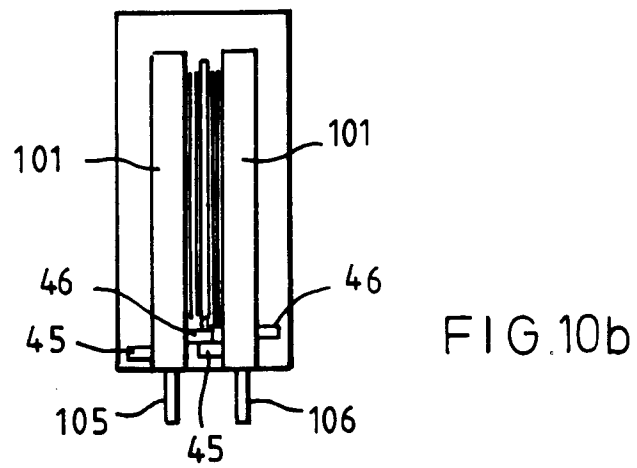
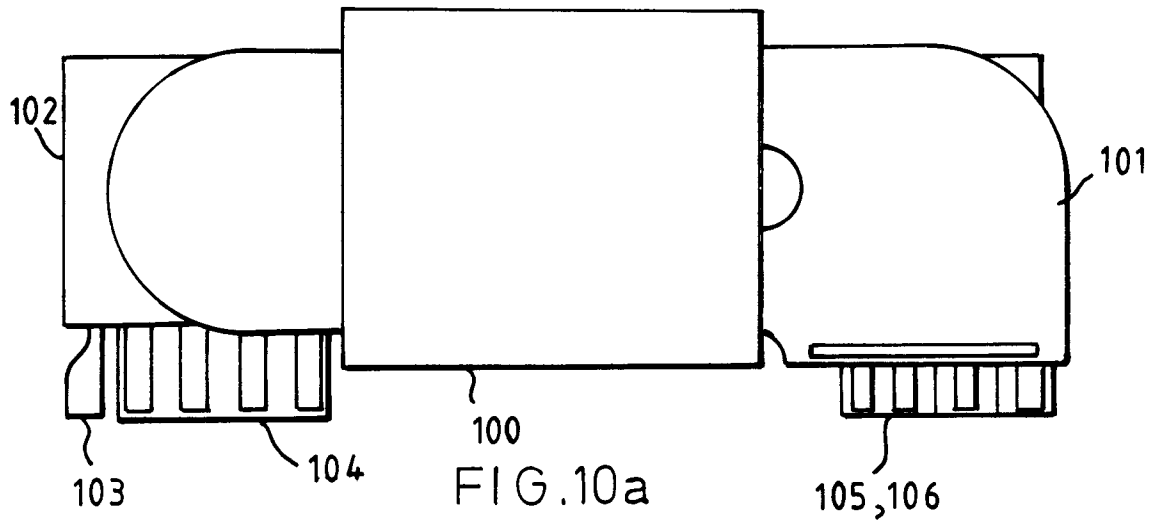


FIG. 9b





European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 9786

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-2 086 527 (CLAUSIN PIERRE) * page 2, line 16 - line 22 * ---	1,3,4,5,6	H01F27/32
A	US-A-3 868 766 (FORD MOTOR COMPANY) * figures 5,6,7 * ---	1,5	
A	US-A-3 964 009 (BEL FUSE INC.) * figures 1,2 * ---	1,5	
A	GB-A-845 530 (THE BRITISH THOMSON HOUSTON CO.) * figures 1,2,3 * ---	1,5	
A	GB-A-954 795 (PHILIPS ELECTRICAL INDUSTRIES) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5) H01F
Place of search THE HAGUE		Date of completion of the search 22 FEBRUARY 1993	Examiner VANHULLE R.
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