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(54) **A METHOD OF MANUFACTURING AN ELECTRICAL COIL OR TRANSFORMER WINDING
HAVING AN INSULATION DEVICE**

VERFAHREN ZUM HERSTELLEN EINER ELEKTRISCHEN SPULE ODER
TRANSFORMATORWICKLUNG MIT EINER ISOLIERANORDNUNG

PROCEDE DE FABRICATION D'UNE BOBINE ELECTRIQUE OU D'UN ENROULEMENT DE
TRANSFORMATEUR AYANT UN DISPOSITIF D'ISOLATION

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Description

The invention relates to a method of manufacturing an electrical coil or transformer having at least one winding with a substantially rectangular winding cross-section, in which an insulation layer made from a flexible foil material of a predetermined thickness is provided to extend on the internal side and the end faces of said winding.

In particular in transformer primary and/or secondary windings such insulation layers are used to perform an insulation barrier between the mains voltage, e.g. 220V, and the user-touchable components of electrical appliances, and the electrical energy authorities make specific demands on the insulation properties for different application purposes.

For the insulation between the primary and secondary windings of the transformer a creepage distance of at least 6 to 8 mm between any part of the primary winding and any part of the secondary winding is thus frequently required, together with a minimum thickness of the insulation barrier which in dependence on the use may vary between 0.4 and 1.0 mm. In cases where an insulation barrier is composed of a number of thinner layers it is normally required that at least one layer can withstand a prescribed test voltage.

To comply with said requirements the following methods have traditionally been practised.

1. Arranging the windings in coaxial alignment, e.g. by using coil forms divided into compartments. This method results in a too high stray inductance and is not applicable in connection with high-frequency pulse transformers (switch-mode transformers).

2. Coaxially placing the windings one over the other with an intermediary three-layer insulation, the necessary creepage distance being obtained by winding on a smaller width and completing with edging tape or plastic blocks and by use of insulated supply lines. Due to the unfavourable ratio between effective copper cross-section and insulation cross-section this method is in particular inappropriate in smaller transformers, in which a high stray inductance also arises.

3. Wrapping or bandaging the individual windings in a three-layer tape. In particular when using round field spools this method is troublesome and gives rise to a vast productional unreliability since, due to the incomplete overlapping of the taping, considerable local variations or holes may occur in the insulation thickness.

4. Using special coil forms allotted to a confined concrete product; application or a corresponding particular design of the coil structure supplemented with encapsulation technique. From an economic point of view such methods are merely relevant in connection with series productions on a larger scale that may justify the comparatively high costs of tools

etc.

From GB 2 125 227 A and GB 2 125 228 A it is known to insulate concentric primary and secondary windings in a transformer from one another by means of a layer of extremely stretchable insulation tape which after taping the primary winding placed in a coil form is wound on its external side and is stretched so that its longitudinal edges are made to cover the end walls of the coil form up over and around their peripheral edges. The stretching of the tape entails, however, an uncontrollable reduction of the thickness of the insulation layer and the method is not appropriate for coil forms with a non-circular cross-section, e.g. square forms or coil forms with terminal blocks. This method further necessitates a completing embedment.

From GB 170 052 A an electromagnetic transformer is known having overlapping primary and secondary windings separated by an insulation applied in the form of a layer of insulating tape wound around the external side of the innermost winding and having a width such that edges of the tape may be deformed by outwards bending to extend radially outwards over the inner faces of end-cheeks of coil form, whereby a tray is formed in which the outer secondary winding may be located. By this deformation the edges of the tape will be stretched so that the thickness of the parts of the insulation covering said end-cheeks will be reduced in an uncontrollable manner.

On this background it is the object of the invention to eliminate the drawbacks of the above-mentioned prior art devices and provide a new design of an insulation layer of the type concerned which may be used both in coreless coils and transformers independent of the transformer type and which without encapsulation may also be used with and without the use of a coil form while preserving a favourable ratio between the effective copper area and the insulated winding cross-section and with an effective control of the thickness of all parts of the insulation layer to meet the requirements stipulated by authorities.

With a view to obtain this, the method according to the invention is characterized in that following shaping of the insulation layer into a substantially tubular form corresponding to the external side of said winding, the layer is deformed to provide a substantially U-shaped axial sectional profile corresponding to said inner side and end faces.

The method according to the invention may in principle be used both for coreless coils and for any winding on a transformer of the type concerned, i.e. the primary winding or the secondary winding alone or both of them, and it may as well be used for each of the primary or secondary windings in a transformer with a number of primary and/or secondary windings.

The obtained insulation barrier is appropriate in connection with windings disposed in standard as well as in special coil forms but may further be used with no

coil form in that the winding is effected on a special mandrel and is supported by the encircling insulation barrier.

With a composition of the insulation material determined in consideration of the actually valid requirements stipulated by the authorities a high degree of security is obtained as to permanently complying with demands on creepage distances and minimum insulation thickness and to the fact that in the method according to the invention the deformation does not entail any uncontrolled thickness reduction.

An essential advantage obtained by the invention is in particular an improved distribution between effective copper area and insulated winding cross-section, which offers the possibility of reducing the transformer dimensions or of lower operating temperatures. Owing to the possibility of increasing the effective coil width an improved coupling between the windings is obtained as a substantial advantage for the transformer, which is in particular of importance as regards high-frequency pulse transformers of the switch-mode type.

The invention further provides for a productional relief because it is possible to a higher degree to avoid insulated supply lines through sufficient encapsulation of the individual windings.

In an embodiment of the invention appropriate for practical purposes, the insulation material consists of a shrinkable material and the deformation is effected by shrinking. Such shrinkable material may be available in the form of an extruded tubular blank (shrink-flex) or in the form of tape.

The invention will now be explained in detail with reference to the schemtical drawings, in which

Fig. 1 as an embodiment of the invention illustrates a transformer with concentric primary and secondary windings manufactured according to the method of the invention,

Figs 2 to 4 illustrate the manufacture of the insulation device according to the invention,

Figs 5 and 6 illustrate the forming of an insulation layer in a tubular form in connection with a circular and a square coil form, and

Figs 7 to 11 show various examples of coil and transformer windings with an insulation device according to the invention.

In the transformer illustrated in Fig. 1 the primary winding 1 and the secondary winding 2 are disposed coaxially one over the other in a common coil form 3 so that the two windings in their full length overlap each other. The coil form 3 surrounds on its side an iron core 4.

Each of the windings 1 and 2 consists in a known manner of a considerable number of turns of lacquered copper wire wound in such a manner that each of the windings is imparted a mainly rectangular winding or copper cross-section.

In the illustrated example the primary winding 1 as

well as the secondary winding 2 are provided with an insulation device according to the invention in the form of insulating layers 5 and 6 completely covering in the illustrated Example the internal side of each winding facing the core 4, and the end faces of the winding, and are further bent in over and cover at least part of the external side of the winding.

As it appears from Figs 2 to 4 the insulation layer is obtained in that a layer of foil material is firstly shaped to a tubular form 7 corresponding to the outer dimension of the end walls 8 of the coil form 3 or, if no coil form is used, the outer dimension of the coil itself or the winding.

The foil layer 7 shaped to a tubular form is subsequently deformed to a substantially U-shaped cross-sectional profile 7a as illustrated in Fig. 3, corresponding to the coil form 3 or, if no coil form is used, to the winding cross-section of the coil. The U-shaped cross-sectional profile is provided with end portions 7b, 7c with such a radial width that they project so much beyond the intended winding width that after winding they may be bent in over the external side of the coil or winding and cover a substantial part of or possibly the entire of this side.

Producing the insulation layer with the tubular form 7 prior to deforming it to the U-shaped cross-sectional profile may be effected by cutting from a blank extruded in a tubular form a suitable insulation material or, as illustrated in Figs 5 and 6, by any other method that is more appropriate for a practical production in that the coil form 10, 10' is wound with a webshaped insulation material 9, 9' to constitute the tubular form 7.

In an embodiment appropriate in practical use the insulation material is a shrinkable material and the deformation to the U-shaped cross-sectional profile is effected by a shrinking process, preferably by controlled thermal stress.

As illustrated in Figs 7 to 11, there is by the use of insulation devices according to the invention in connection with transformers as illustrated in Fig. 1, a considerably free choice as regards designing and arranging the insulation device.

In the embodiment illustrated in Fig. 7 which corresponds to the embodiment illustrated in Fig. 1, insulation devices 11 and 12 are thus arranged both around the primary winding 13 and the secondary winding 14 in such a manner that they cover the internal sides and end faces of both windings and further cover part of the external sides of the windings.

Figs 8 and 9 show designs in which only the primary winding 13' and the secondary winding 14', respectively, have an insulation device 11' and 12', respectively, designed in the same manner as in Fig. 7.

Fig. 10 illustrates an embodiment in which an insulation device 15 around a primary winding 16 completely encapsulates the winding also on its external side.

Finally, Fig. 11 illustrates an insulation device 17 encapsulating a single coil winding 18.

Figs 12 and 13 illustrate alternative embodiments forming for each of the illustrated primary and secondary

windings 19, 19' and 20, 20', respectively, two separate insulation layers each from their respective foil material shaped to a tubular form as described in the foregoing and afterwards deformed to a substantially L-shaped cross-section covering part of the internal side of the winding and one end face thereof and of which an end portion is folded in over part of the external side of the winding.

In the embodiment in Fig. 12 there are in this manner for each of the windings 19 and 20 provided two separate insulation devices 21, 22 and 23, 24, respectively, covering only end portions of the windings whereas, in the embodiment in Fig. 13 there are for each of the windings 10' and 20' provided two separate insulation devices 25, 26 and 27, 28 overlapping each other on the internal side of the winding.

Claims

1. A method of manufacturing an electrical coil or transformer having at least one winding (1, 2) with a substantially rectangular winding cross-section, in which an insulation layer (5, 6) made from a flexible foil material of a predetermined thickness is provided to extend on the internal side and the end faces of said winding, characterized in that following shaping of the insulation layer into a substantially tubular form (7) corresponding to the external side of said winding, the layer is deformed to provide a substantially U-shaped axial sectional profile (7a) corresponding to said inner side and end faces.
2. A method as claimed in claim 1, characterized in that the insulation layer is applied in two parts each having a substantially L-shaped axial sectional profile to cover a part of said inner side and one of said end faces.
3. A method as claimed in claim 1, characterized in that said substantially tubular form is provided with an axial length exceeding the sum of the axial length of said winding and the radius of both of said end faces.
4. A method as claimed in claim 1, 2 or 3, characterized in that a shrinkable material is used for said foil material, and that the deformation into said axial sectional profile is effected by shrinking.
5. A method as claimed in claim 1 or 3, characterized in that the shaping into said tubular form is effected by initial flexible expansion of a substantially tubular member of said foil material with a cross-section corresponding to the inner side of said winding and that the deformation into said axial sectional profile is effected by flexible deformation back to said initial form.

6. A method as claimed in any of claims 1 to 5, characterized in that the insulation layer is formed from a number of thin layers of foil material providing together said predetermined thickness.

Patentansprüche

1. Verfahren zum Herstellen einer elektrischen Spule bzw. eines Transformers umfassend zumindest eine Wicklung (1, 2) eines im wesentlichen rechteckigen Querprofils, in welcher auf der Innenseite und den Endflächen eine aus einem flexiblen Folienmaterial vorgewählter Dicke bestehende Isolierbeschichtung (5, 6) vorhanden ist, dadurch **gekennzeichnet**, dass die Isolierbeschichtung, nach deren im wesentlichen rohrförmigen Ausbildung (7) entsprechend der Aussenseite der erwähnten Wicklung, derart verformt wird, ein im wesentlichen U-förmiges axiales Querprofil (7a) entsprechend erwähneter Innenseite und erwähnten Endflächen darzustellen.
2. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, dass das Isolierbeschichten zweiteilig erfolgt, indem die beiden Beschichtungen im Hinblick auf Verkleiden eines Teils der erwähnten Innenseite bzw. einer der erwähnten Endflächen je ein im wesentlichen L-förmiges axiales Querprofil haben.
3. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, dass die erwähnte im wesentlichen rohrförmige Ausbildung eine der Summe der erwähnten axialen Wicklungslänge und des Halbmessers der beiden erwähnten Endflächen überschreitende axiale Länge hat.
4. Verfahren nach Anspruch 1, 2 oder 3, dadurch **gekennzeichnet**, dass als erwähntes Folienmaterial ein schrumpfbares Material verwendet wird, und dass das Verformen in das erwähnte axiale Querprofil durch Schrumpfen erfolgt.
5. Verfahren nach Anspruch 1 oder 3, dadurch **gekennzeichnet**, dass das Formen der rohrförmigen Ausbildung durch einleitende flexible Expansion eines im wesentlichen rohrförmigen Folienmaterials eines Querschnittes entsprechend der Wicklungsinnenseite erfolgt, und dass das Verformen des erwähnten axialen Querprofils durch flexibles Verformen in die ursprüngliche Form zurück erfolgt.
6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch **gekennzeichnet**, dass die Isolierbeschichtung mittels einer Anzahl dünner Folienmaterialschichten geformt wird, welche gemeinsam die erwähnte vorgewählte Dicke bilden.

Revendications

1. Procédé de fabrication d'une bobine électrique ou d'un enroulement de transformateur comportant au moins un enroulement (1, 2) à section transversale d'enroulement essentiellement rectangulaire, procédé dans lequel une couche d'isolement (5, 6) constituée par une feuille de matériau flexible d'épaisseur prédéterminée est prévue pour s'étendre sur la face interne et les faces d'extrémité dudit enroulement, caractérisé par le fait qu'après conformation de la couche d'isolement en une forme (7) essentiellement tubulaire correspondant à la face externe dudit enroulement, la couche est déformée pour donner, en coupe axiale, un profil (7a) essentiellement en forme d'U, correspondant auxdites faces interne et d'extrémités. 5
10
15
2. Procédé selon la revendication 1, caractérisé par le fait que la couche d'isolement est appliquée en deux parties, dont chacune présente, en coupe axiale, un profil essentiellement en forme d'un L pour couvrir une partie de ladite face interne et l'une desdites faces d'extrémité. 20
25
3. Procédé selon la revendication 1, caractérisé par le fait que ladite forme tubulaire est prévue avec une longueur axiale supérieure à la somme de la longueur axiale dudit enroulement et du rayon des deux dites faces d'extrémité. 30
4. Procédé selon les revendications 1, 2 ou 3, caractérisé par le fait que pour ladite feuille de matériau, on utilise un matériau rétrécissable, et que la déformation pour obtenir, en coupe axiale, ledit profil est effectuée par rétrécissement. 35
5. Procédé selon les revendications 1 ou 3, caractérisé par le fait que la conformation dans ladite forme tubulaire est effectuée par expansion initiale flexible d'une pièce tubulaire dudit matériau en feuille, avec une section transversale correspondant à la face interne dudit enroulement, et par le fait que la déformation pour obtenir, en coupe axiale, ledit profil s'effectue par déformation flexible de retour vers ladite forme initiale. 40
45
6. Procédé selon l'une quelconque des revendications 1 à 5, caractérisé par le fait que la couche d'isolement est constituée par un nombre de minces couches de feuille de matériau, fournissant ensemble ladite épaisseur prédéterminée. 50

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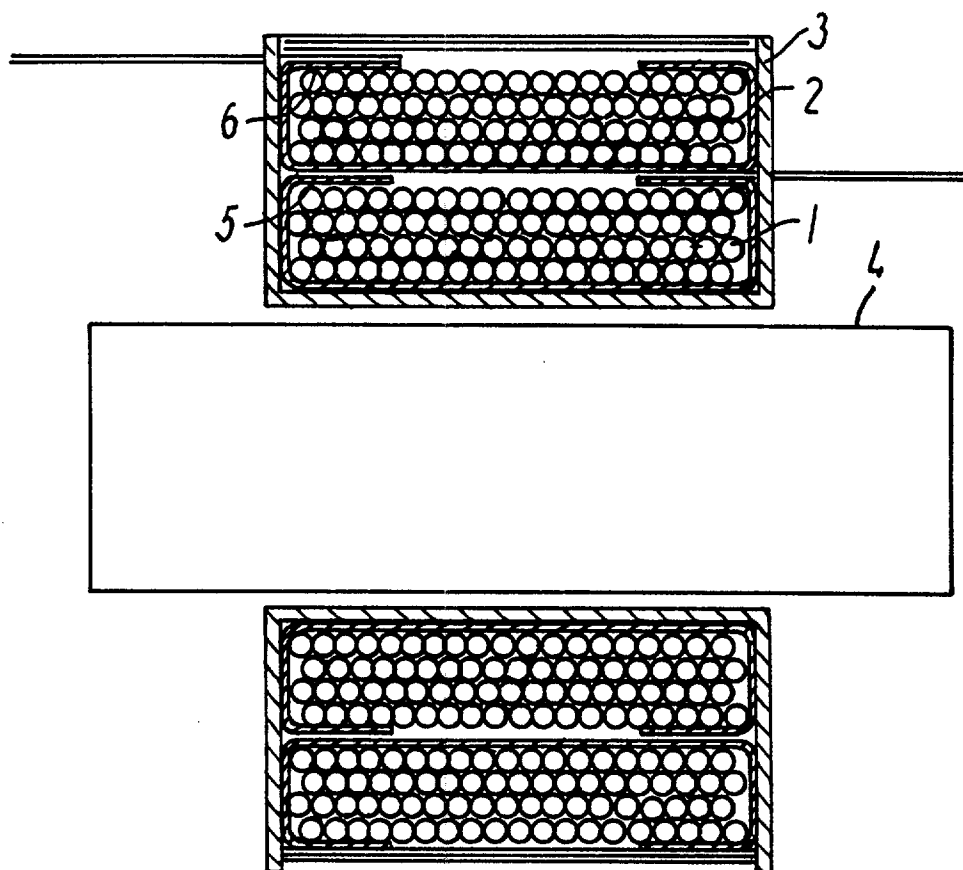
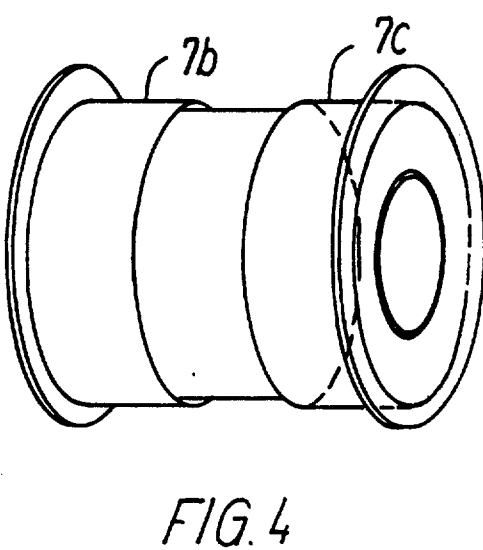
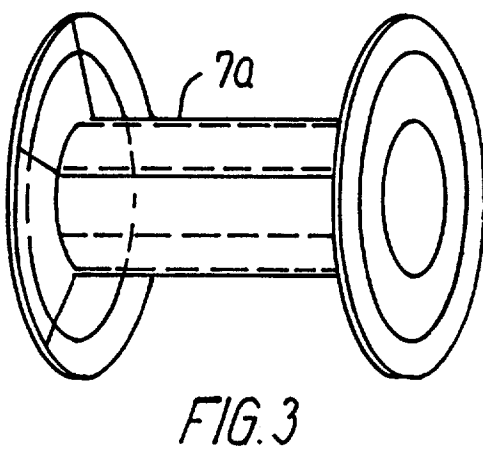
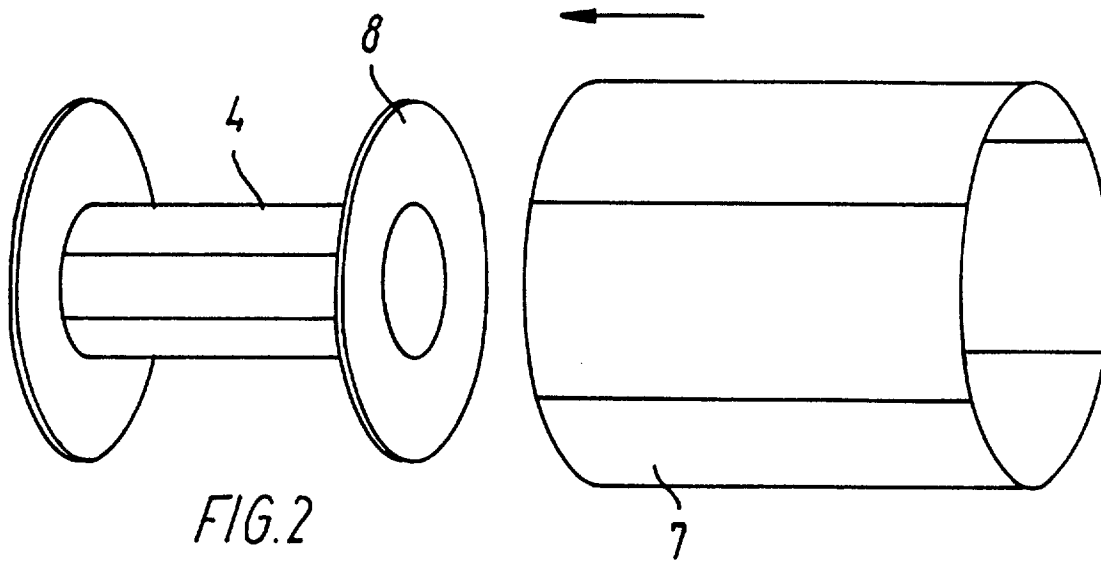


FIG. 1



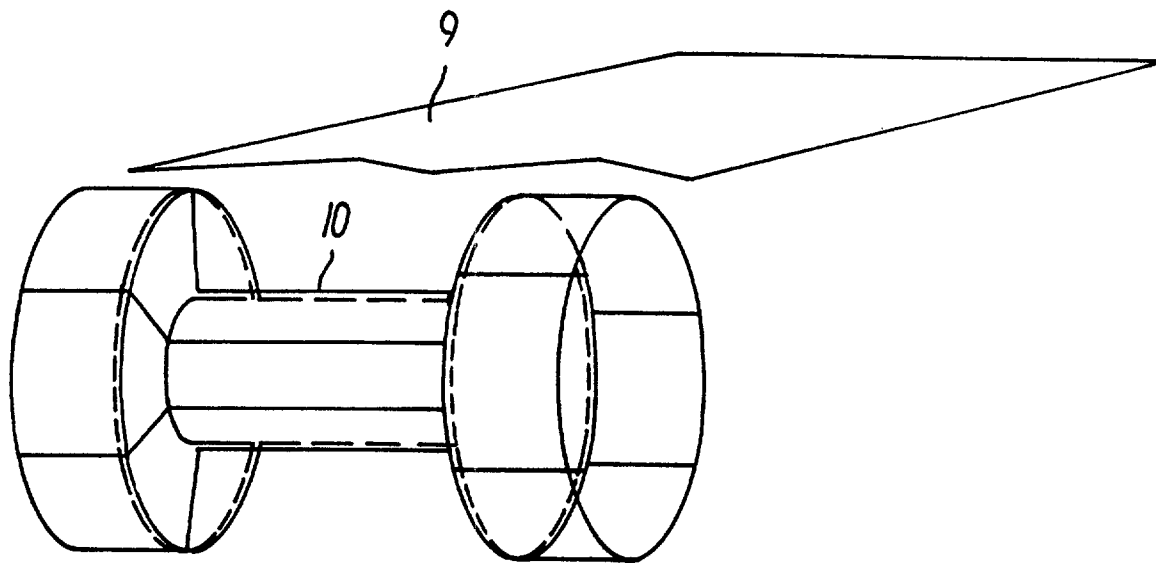


FIG. 5

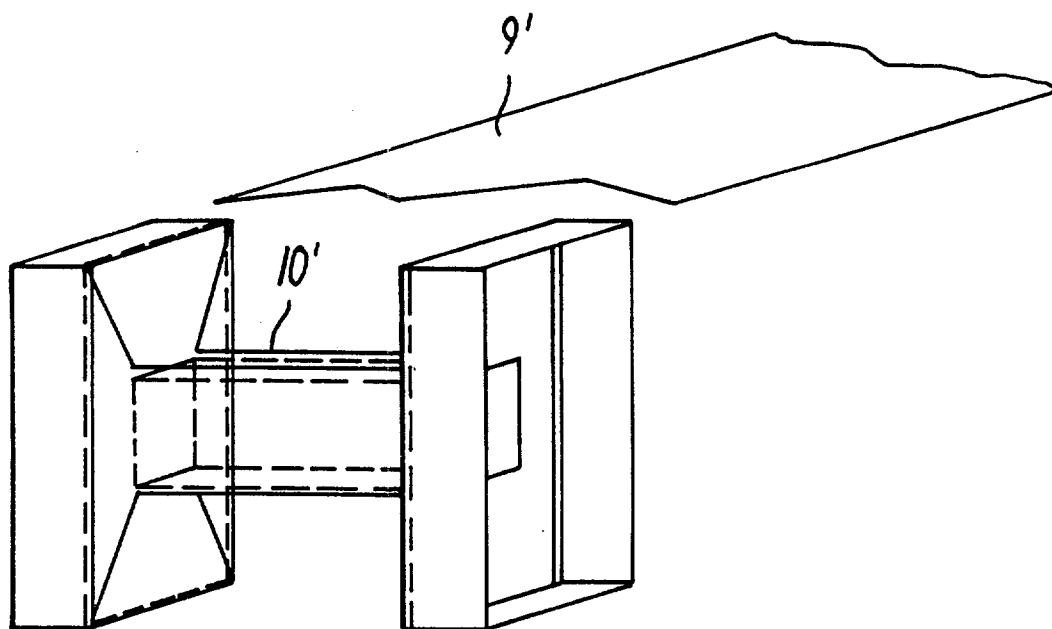


FIG. 6

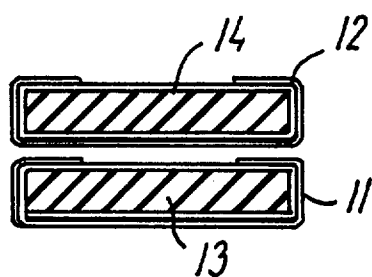


FIG. 7

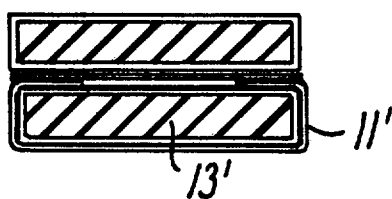


FIG. 8

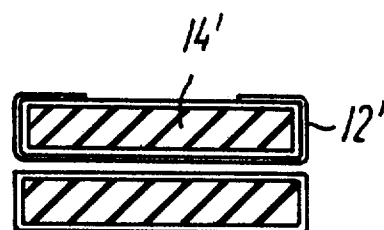


FIG. 9

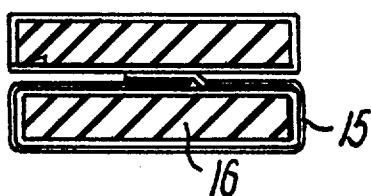


FIG. 10

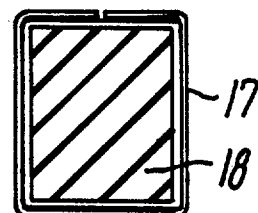


FIG. 11

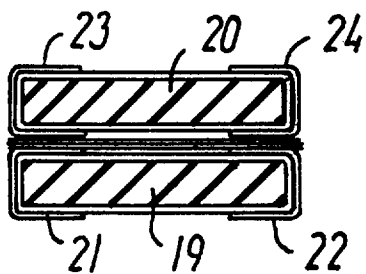


FIG. 12

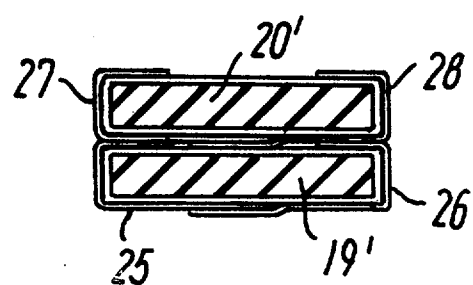


FIG. 13