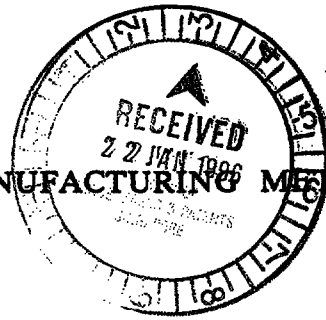


☒	Description	: paged 1 to paged 12
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DATE OF RECEIPT		

**TITLE OF THE INVENTION****RESIN MOLDED TRANSFORMER AND MANUFACTURING METHOD THEREOF****BACKGROUND OF THE INVENTION****1. Industrial Field of the Invention**

This invention relates to an induction apparatus such as transformer using resin molded coils and manufacturing method thereof.

2. Description of the Prior Art

Resin molded coils having a molded resin layer which is formed by casting a thermosetting resin around a coil have been used widely as coils of resin molded transformers.

Conventional resin molded coil techniques are disclosed in, for example, Japanese Patent Laid-Open No. Sho 54-50957 (1979) and Japanese Patent Laid-Open No. Sho 57-121207 (1982).

According to the technique disclosed in Japanese Patent Laid-Open No. Sho 54-50957, an insulating layer comprising a resin spacer and cast resin is formed on the inside periphery of a coil which is formed by winding conductor wire, and according to the technique disclosed in Japanese Patent Laid-Open No. Sho 57-121207, an insulating layer comprising insulating prepreg sheet and injected resin is formed on the inside and outside peripheries of a coil.

Otherwise, a method in which a coil is formed by winding conductor wire on a coil former-mold, and resin is cast to the coil using a mold formed as an outer mold. Conventionally, a transformer has been constituted by incorporating a coil produced as mentioned above to an iron core.

According to the above-mentioned technique disclosed in Japanese Patent Laid-Open No. Sho 54-50957, though the same resin as used for the spacer is used for casting to form solid insulating layer, the adhesion between the spacer and the insulating layer is insufficient because molten resin (casting resin) is cast on the resin which is previously hardened (spacer). After hardening of the cast resin, the spacer can happen to peel off from the cast resin, and the peeling off can cause dielectric breakdown.

In the case of the above mentioned technique disclosed in Japanese Patent Laid-Open No. Sho 57-121207, in the process in which insulating prepreg sheet is wound to form multi-ply layer, air is included between the layers, and the inclusion of air can cause dielectric breakdown.



On the other hand, according to the method in which molds are provided on the inside and outside peripheries, whereas the insulating layer is excellent in appearance of the coil surface, moisture-proof, and mechanical strength, this structure requires many parts which constitute a mold, the requirement causes poor productivity and less economy in the maintenance of the parts constituting a mold due to diversified specification.

Conventional transformers using these resin molded coils have been developed addressing on the improvement of safety and handling as the general purpose, however, the above-mentioned conventional techniques does not involve the improvement of safety by visually indicating live portion, when a resin molded coil is incorporated in a transformer.

SUMMARY OF THE INVENTION

An object of the present invention is to form an excellent insulating layer on a resin molded coil, and improve the safety and handling of a transformer.

To accomplish the above-mentioned object, the present invention provides a transformer comprising resin molded coils, iron cores inserted in the resin molded coils, and metal parts for fixing the coils and iron cores, wherein the resin molded coils are colored light and the metal parts are colored dark.

The transformer using resin molded coils of the invention is excellent in mechanical strength, moisture resistance, and appearance of the coil surface, and indicates a dangerous part on the resin molded coil having a possibility of careless touching not by chroma but lightness. Therefore, even if the transformer is installed in a dark place such as a basement where the illumination is insufficient, the dangerous portion is clearly indicated.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a vertical cross-sectional view of a resin molded coil of a first embodiment in accordance with the present invention.

Fig. 2 is a perspective view of insulating layer forming medium of the first embodiment of the invention.

Fig. 3 is a cross-sectional view taken on line III - III of Fig. 1.

Fig. 4 is an exploded perspective view for illustrating production of a resin molded coil of a third embodiment of the invention.

Fig. 5 is a perspective view for illustrating the assembled mold of the third embodiment of the invention.

Fig. 6 is an apparent view of the resin molded coil produced according to the third embodiment of the invention.

Fig. 7 is a cross-sectional view of the resin molded coil produced according to the third embodiment of the invention.

Fig. 8 is a front apparent view of a transformer of a fourth embodiment of the invention.

Fig. 9 is a back apparent view of the transformer of the fourth embodiment of the invention.

Fig. 10 shows three drawings for illustrating the structure of a cover for a tap switch of a transformer of the fourth embodiment of the invention.

Fig. 11 shows three drawings for illustrating the structure of a cover for a primary terminal of the transformer of the fourth embodiment of the invention.

Fig. 12 shows a display for showing the danger display on the transformer of the fourth embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments in accordance with the present invention will be described in detail referring to the drawings.

First, the first embodiment of the present invention is described referring to Fig. 1 to Fig. 3.

The mold coil of this embodiment is to be used for transformers. Generally, a transformer comprises a high-voltage coil 1 and a low-voltage coil 2 as shown in Fig. 1, herein, the resin molded high-voltage coil 1 (for example 3 kV) is addressed for description. In the figure, 3 represents an iron core.

The resin molded high-voltage coil 1 of this embodiment comprises a coil body 10 which is formed in a shape of ring cross-section using wound conductor wire 11 and insulating layer forming mediums 21 which are provided on the outside and inside peripheries of the coil body 10.

Inter-layer papers 12 are provided between each layer of conductor wire 11 of the coil body 10.

As shown in Fig. 2, the insulating layer forming medium 21 comprises prepreg sheet 22 (insulating sheet) composed of glass cloth sheet formed by knitting insulating glass fiber and epoxy resin impregnated in the glass sheet, and a plurality of rectangular glass mats 23, 23, ... (insulating fiber mat) which are formed by knitting glass fiber. The glass mat 23 has a size with the same length l as the prepreg sheet 22, a width w of 10 mm to 30



mm, and a thickness h of 2mm to 5 mm. A plurality of glass mats 23, 23, ... is adhered with epoxy adhesive on the prepreg sheet 22 with a certain interval of A along the inside and outside peripheries in Fig. 3. The spaces between the glass mats 23, 23, ... are to be served as passages 24 for flowing of resin 25 as described hereinafter. The total thickness of thickness h of the glass mat 23 and thickness t of the prepreg sheet 22 will be the thickness T (duct height) of insulating resin layer 20.

When the coil body 10 is molded with resin, as shown in Fig. 1 and Fig. 3, the insulating layer forming medium 21 is wound on the coil body 10 so as that glass mats 23 of the insulating layer forming medium 21 contact with the inside and outside peripheries of the coil body 10. The prepreg sheet 22 of the insulating layer forming medium 21 is semicured prepreg sheet.

Afterwards, epoxy resin 25 is cast between the prepreg sheet 22 of the insulating layer forming medium 21 and the inside and outside peripheries of the coil body 10. The cast epoxy resin 25 flows in the resin passage 24 between glass mats 23 and 23 and penetrates into glass mats 23, and also into the entire space between the prepreg sheet 22 of the insulating layer forming medium 21 and the inside and outside peripheries of the coil body 10. When casting epoxy resin 25, the resin is cast slowly so as not to include air and the coil body 10 is vibrated so as to exclude air even if the resin include air. The coil body 10 may be vibrated, for example, by applying ultrasonic vibration with a certain frequency. When cast epoxy resin 25 is hardened, the resin molded coil 1 is completed.

As described above, on the outside and inside peripheries of the coil body 10 the insulating resin layer 20 comprising cast epoxy resin 25 and insulating layer forming medium 21 is formed.

In the case that an insulating tape is wound to form multi-ply layer for forming an insulating layer as in conventional technique, air spaces are formed inevitably between tapes due to slackening or irreversible elongation of the tape. On the other hand, in this embodiment, air space will not be formed because fluid casting resin 25 is cast between the coil body 10 and the prepreg sheet 22 to form the insulating layer 20. When casting the resin 25, the above mentioned treatment allows the resin 25 to be free from air. The casting resin 25 penetrates into glass mats 23 to combine the insulating layer forming medium 21 with the cast resin 25, air space will not be formed differently from the conventional technique in which a spacer is used, in this case, the spacer



can happen to peel off to form air space in the insulating layer. Therefore, the dielectric breakdown and deterioration of thermal conductivity due to air space in the insulating layer 20 is prevented.

In this embodiment, the insulating layer forming medium 21 is prepared previously to eliminate the work for providing a plurality of spacers with a certain interval or working for winding an insulating tape around the coil body 10 to form multi-ply layer as in the conventional technique, thus time for production is shortened.

In this embodiment, the impact strength is improved because glass fiber is mixed in the insulating layer 21.

A method for producing a resin molded coil of the invention is described referring to Fig. 4 and Fig. 5.

In this embodiment, an inner mold 101 which is served as a coil mandrel and mold is used, a glass mat 104 is wound on the outside periphery of the inner mold 101 (it will be the inside periphery of the resin molded coil finally) to form an inside peripheral insulating layer, and then, conductor wire 11 and inter-layer paper 12 are wound on the insulating layer to form a wound coil 103. Then, on the outer periphery of the wound coil 103 (it will be the outer periphery of the resin molded coil finally), a glass mat 104 is wound to form the outer insulating layer. Two flexible metal plates 102 are used as the outer mold. The side edges of both metal plates 102 are faced to both bends of a casting jig 105 and the side edges and bends are clamped with clamping jigs such as a vise 106 (refer to Fig. 5), the metal plates are wound around the external shape of the coil body, and the coil body is fastened with bands. A pin 121 is projected from the side of the inner mold 101, and this pin 121 is engaged to a corresponding hole 122 of the casting mold 105 for positioning each other. Similarly, pins 123 and 124 are projected from the casting mold 105 at the bottom, these pins 123 and 124 are engaged to corresponding holes 125 and 126 provided on the bottom 120 for positioning each other. Resin is cast into the mold formed as described herein above.

The metal plate 102 for the outer mold may have a size with the same height as the coil or higher, with the same width as a half of the periphery of the coil or wider, and metal plates with a certain same size can be used as outer molds of coils with different various external form sizes. Metal plates are flat in shape before shaping for use as an outer mold, the metal plates can be stored in the form of a stack, therefore, the space for storing the outer mold is



minimized. The glass mat 104 is served to form an insulating layer and also to be impregnated with resin.

Fig. 6 is a perspective view from the back side of the resin molded coil 107 produced by the process described above. The glass mats 104 are located on the inside and outside peripheral insulating layers, the outer mold is wound around the external form of the coil, and the outer mold is fastened with bands, therefore, fibers of the glass mats 104 appears on the surface of the coil after completion of the coil sporadically (131). The metal plates 102 for forming an outer mold are overlapped each other on the back side, the overlapping makes a step on the coil surface by the thickness of the metal plate, therefore, the coil is featured by the appearance of a hem 109 which extends in the direction of the height of the coil or a trace of cutting of the hem.

Fig. 7 is a cross-sectional view taken on line A-A of the resin molded coil 107 shown in Fig. 6. Strong resin insulating layers 108b containing glass mats are formed on the inside and outside peripheries of the wound coil 103. Three insulating layers 108a consisting of resin only are formed at the three positions, top, middle, and bottom in the height direction of the coil. Glass mat with a fiber density of 300 to 500 g/m² is commercially available, this type of glass mat with a fiber density in the range is suitably used as the glass mat 104 for the insulating layer of the coil. Especially, glass mat with a fiber density of 500 g/m² is preferably used as insulating material provided on the inside and outside peripheral insulating layers because this glass mat gives excellent resin impregnation when casting and high strength which allows high pressure exerted when winding of wire and fastening of the outer mold.

In this embodiment, heat resistant films 15 such as polyethylene-terephthalate (PET), polyethylene-naphthalate (PEN), polyether-imide (PEI), and polyimide (PI) are used as the above-mentioned inter-layer paper 12. These materials have high thermal conductivity, and the use of this type of films makes the resin molded coil easy to be cooled. Therefore, in this embodiment, in case of producing a molded coil of the same rated capacity as that of conventional one, the conductor portion of the coil can be smaller in size than that of conventional one, due to the effective cooling capacity against increase of heat caused by increase of current density. In addition, the inside and outside insulating layers can be thinner than those of



the conventional coil because the strength of the insulating layer of the invention is high, thus this factor also allows the size of the coil to be minimized.

The thermal conductivity of polyethylene-terephthalate (PET) is 0.151 w/m·k, the thermal conductivity of polyethylene-naphthalate (PEN) is 0.151 w/m·k, the thermal conductivity of polyether-imide (PEI) is 0.198 w/m·k, and the thermal conductivity of polyimide (PI) is 0.156 w/m·k, and the dielectric breakdown voltage of polyethylene-terephthalate (PET) is 220 kV/mm, the dielectric breakdown voltage of polyethylene-naphthalate (PEN) is 294 kV/mm, the dielectric breakdown voltage of polyether-imide (PEI) is 210 kV/mm, and the dielectric breakdown voltage of polyimide (PI) is 260 kV/mm.

According to the embodiments described herein above, an inner mold, which is served as a coil mandrel and mold, an outer mold, which is formed by winding flexible flat plates around the outer periphery of the coil, and insulating layers, which are used as spacer for the inner mold and outer mold and accept the resin impregnation sufficiently, are used, thereby, the following effects are exhibited.

- (1) The workability in producing resin molded coils is improved.
- (2) The mechanical strength of inside and outside peripheral insulating layers is improved.
- (3) The maintenance of the outer mold is unnecessary.
- (4) The cooling of the coil is facilitated by processing of outer mold flat plates.
- (5) The moisture resistance of the coil is improved.
- (6) The required minimum insulating layer thickness is reduced by adhering the metal plates to the coil, and thus required amount of resin is reduced.

Hereinafter, a transformer in accordance with the fourth embodiment of the invention which uses molded coils described hereinbefore is described.

The appearance of the transformer in accordance with the present invention is shown in Fig. 8 and Fig. 9. Fig. 8 is a perspective view of the transformer viewed from above front, and Fig. 9 is a perspective view of the transformer viewed from above back.

In Fig. 8 and Fig. 9, 201U, 201V, 201W are U-phase, V-phase, and W-phase primary coils respectively, and 203a and 203b are iron cores.



Secondary coils of 202U, 202V, and 202W, which are not shown in the figures, are inserted in primary coils of 201U, 201V, and 201W respectively. In the transformer shown in the figures, the legs of iron cores 203a and 203b are inserted in the secondary coils of 202U, 202V, and 202W, and the secondary coils of 202U, 202V, and 202W are inserted in the inside peripheries of the primary coils of 201U, 201V, and 201W. In these coils, insulating material with high thermal conductivity such as polyethylene-naphthalate is used as inter-layer paper as described in the third embodiment hereinbefore. Therefore, in this embodiment also, by using strong resin insulating layer comprising inter-layer papers with high thermal conductivity and glass mats, the current density can be increased, and the coil is minimized in size.

In this embodiment, a wound iron core which is produced by winding silicon steel plate is used for the iron cores 203a and 203b. The iron core may be a wound iron core which is produced by winding foil of amorphous metal. By using this type of wound magnetic core, the core loss is reduced to result in energy saving comparing with the case in which a laminated iron core is used. As described hereinbefore a molded coil is minimized in size by applying this invention, therefore, a small and light-weight iron core is sufficient for this type of molded coil. Accordingly, the core loss is reduced and energy saving is realized comparing with conventional techniques in this respect.

For example, in the case of a three-phase transformer with a capacity of 20 kVA to 500 kVA, the size of the transformer is minimized to a depth of 345 mm for 20 kVA and 505 mm for 500 kVA. In the case of a single-phase transformer with a capacity of 20 kVA to 500 kVA, the size of the transformer is minimized to a depth of 360 mm for 10 kVA and 505 mm for 300 kVA. Accordingly, the volume of a transformer is reduced by about 10 % comparing with a conventional transformer. By the minimization in size, an iron core is minimized by about 5 %, and the core loss is reduced by about 5 %, thus the no-load loss is reduced by about 5 %. The depth size is made smaller comparing with a conventional transformer, the transformer with a certain thickness of insulator can be contained in the thin cubicle with a depth of 700 mm, which is one of the sizes in GEM1424 recommendation.

Wound iron cores 203a, and 203b, primary coils 201U, 201V, and 201W, and secondary coils 202U, 202V, and 202W are fixed between a bottom frame 204 and a top frame 205. The bottom frame 204 is connected to



two bases 206a and 206b with interposition of four vibration-proof rubber 300, the two bases 206a and 206b are fixed by screwing screws into tapped hole on the floor when installing the transformer on the floor. The top frame 204 and the bottom frame 205 are connected together with connecting members which penetrate through the inside peripheries of the secondary coils 202U, 202V, and 202W, which structure is not shown in the figures. The wound iron cores 203a and 203b, primary coils 201U, 201V, and 201W, and secondary coils 202U, 202V, and 202W are fixed to the bottom frame 204 and the top frame 105 between both frames with interposition of rubber members 208 and spacers 209. In addition to such structure, a wound iron core is used as an iron core in the present invention, the use of a wound iron core reduces the joint, the reduced joint results in reduced noise generation.

In the figures, on the front right corner and on the back right (left side when viewing from the front) corner of the bottom frame 204, earth terminals 208a and 208b are provided respectively. In this embodiment, the earth terminals 208a and 208b are provided on a diagonal line of the transformer, this arrangement allows the transformer to be installed on a limited space. On the bottom frame 204, holes 219 are provided which are for engaging with hooks when the transformer is moved. By providing this hooking holes, the workability of moving is made easy.

In the figures, right and left cutouts 224 of the top frame 205 are hanging recesses for hanging, and secondary terminals 221 for the secondary coil 202U, 202V, and 202W and a bar 222 for connecting wirings are provided on the upper back of the top frame 205. An earth terminal 215 of the contact preventing plate (not shown in the figures) which is provided between a secondary coil and a primary coil 201 is provided on the back left side (right side when viewing from the front side) of the bottom frame 204.

Referring to Fig. 8 and Fig. 9, rotary type taps 210 for switching the connection between coils and coil layers and a connecting bar 220 are provided at the middle in the vertical direction of the secondary coils 202U, 202V, and 202W in the figures. Primary terminals 211 of the primary coils 201U, 201V, and 201W are provided on the upper front of the secondary coils 202U, 202V, and 202W. Semi-transparent insulating covers 212 and 213 (including smoked transparent material) are provided on the switching taps 210 and terminals 211.

The shape of the covers of the switching taps 210 is shown in

Fig. 10, and the shape of the covers of the terminals 211 are shown in Fig. 11. In both Fig. 10 and Fig. 11, "a" represents front views, "b" represents side views, and "c" represents top views. As shown in Fig. 11, the display 333 of "DANGER, HIGH-VOLTAGE" is displayed on the cover of the terminal 211.

As described above, by providing the insulating covers 212 and 213, the careless touching to exposed high-voltage portion is prevented. The use of semi-transparent material for these insulating covers 212 and 213 allows the switching taps 210 and terminals 211 to be seen from the outside and the tight fastening can be checked at a glance. Differently if a transparent cover is used, the existence of the cover is not perceived by a worker, and the worker will feel danger.

As shown in Fig. 8 and Fig. 9, in this embodiment, danger display marks 214 shown in Fig. 12 are marked on the four sides of a transformer. As shown in Fig. 12, in the danger display mark 214 of this embodiment, characters and a symbol 2141 for displaying the danger and a sentence 2142 for describing the type of danger and the dangerous action are located separately. By displaying not only the existence of the danger but also the reason and dangerous action, the safety will be improved.

In the structure of the transformer of the present invention described hereinbefore (refer to Fig. 8 and Fig. 9), the primary coils 201U, 201V and 201W, and secondary coils 202U, 202V and 202W are colored in a light yellow color with high brightness such as a color of Munsell No. 2.5Y8/14. The bottom frame 204, top frame 205, and base 206 are colored in a dark gray color with low brightness such as Munsell No. N4.0. The wound iron cores 203a and 203b are colored dark nearly black.

In this invention, the reason of the coloring is described hereinafter.

Though insulating layers are formed on the surface of the primary coils 201U, 201V and 201W and the secondary coils 202U, 202V and 202W, the high-voltage is induced on the surface of these insulating layers when the transformer is in service, and it is dangerous to touch with a bare hand. Therefore, it is desirable that the primary coils 201U, 201V and 201W, and the secondary coils 202U, 202V and 202W are colored in bright color (high chroma) so as that these coils are recognized as danger. However on the other hand, transformers are often installed in basement. In a basement, usually the intensity of illumination is 20lx to 50lx (Japan Illumination



Association, Illumination Data Book, published June 10, 1963 by Ohm Co.). In such a dark place, human eyes are not so sensitive to the difference in chroma but sensitive to the difference in brightness. Based on this fact, in this embodiment, the primary coils 201U, 201V and 201W, and the secondary coils 202U, 202V and 202W are colored yellow of which color has high brightness and high chroma and is recognized popularly as a color for danger, and other portions are colored dark so as that the yellow is remarkable in the dark.

In this embodiment, yellow of 2.5Y8/14 and gray of N4.0 (both are Munsell color system representation) are used, but the colors are not limited to these colors. The contrast between two colors colored on the two sections respectively is to be remarkable, it is said that the difference in the brightness of 3 to 10 or more and difference in the chroma of 8 or higher of Munsell color system is desirable (Motoro Kawakami, Dictionary of Color, published December 10, 1987 by Asakura Shoten).

The bright color used in accordance with the present invention includes hues of 5Y, 7.5Y, 10Y, 2.5GY, 5GY, 7.5GY, 10GY, 2.5YR, 5YR, 7.5YR, and 10YR in Munsell color system (or JIS standard color) which hue has the brightness of 7 or higher, and has the chroma of 8 or higher. The dark color used in accordance with the present invention includes colors with the brightness of 4 or lower for achromatic color and colors with the brightness of 4 or lower and the chroma of around 2 for chromatic color, and desirably the dark color is a complementary color of the bright color.

By coloring the iron cores and metal parts in achromatic color or color with low chroma, the resin molded cores become remarkable for easy perception, and thus the coloring prevents workers from happening to touch, and the safety and handling is improved.

The reflectance for each brightness is 78.66 % for the brightness of 9, 59.1 % for the brightness of 8, 43.06 % for the brightness of 7, 30.05 % for the brightness of 6, 19.77 % for the brightness of 5, 12.0 % for the brightness of 4, 6.555 % for the brightness of 3, and 3.126 % for the brightness of 2 (JISZ8721).

For example, for the combination of a bright color of the brightness of 8 and a dark color of the brightness of 4, the bright color reflects light about 4.9 times that of the dark color, for the combination of a bright color of the brightness of 7 and the dark color of the brightness of 3, the bright color reflects light about 6.6 times that of the dark color, and for the



combination of a bright color of the brightness of 9 and a dark color of the brightness of 6, the bright color reflects light about 2.6 times that of the dark color. By coloring with difference in the brightness of 3 or more, the bright color reflects light 2.6 times or more that of the dark color, both colors are easily distinguished in the dark.

By coloring the iron cores dark, the heat releasing from the iron core is facilitated based on the principle of the black body radiation.

The ceiling and walls of a room where a transformer is installed is colored generally white with the brightness of 8 to 9 or light gray chromatic color, and the chroma is regulated to be 4 or lower. (Japan Illumination Association, Illumination Data Book, published June 10, 1963 by Ohm Co.)

By coloring the resin molded coils with a chromatic color, the resin molded coils become remarkable because of the difference in chroma from the interior surface of the room. The iron cores and metal parts are colored in a low brightness color, the coloring makes the resin molded coils remarkable, and the existence of the transformer becomes remarkable.

The hue of the color for the resin molded coils are selected in a range of Munsell color system or JIS standard color hue circle from 2.5YR to 10Y, or yellowish red or yellow, thus a color with high brightness (brightness of 7 to 8) and high chroma (10 or higher) is selected. These colors are warm color, and these colors are perceived as expansive color, the resin molded coils become more remarkable, and the high-voltageed resin molded coils are perceived more easily, thus the coloring prevents workers from happening to touch.

If the iron cores and metal parts are colored pure black (brightness 1 or lower), the internal of the room where the transformer is installed becomes dark because of the significantly reduced reflection. Therefore, it is desirable that the iron cores and metal parts are colored dark gray (brightness of 4 to 2) for suitable reflection.

In this embodiment, wound iron cores are used as iron cores for description, but laminated iron cores may be used instead of wound iron cores when the problem of core loss is not important.

According to the present invention, there can be provided a transformer having resin molded coils with excellent insulating layers and capable of improving the safety and the handling.

WHAT IS CLAIMED IS:





1. A resin molded transformer comprising a resin molded coil, which comprises a coil of wound conductor and insulating resin layer covering an external surface of said coil, iron cores inserted to said resin molded coil, wherein said resin molded coil includes an insulating sheet wound around inner periphery and outer periphery of said coil, a plurality of insulating fiber mats of predetermined size which are formed by knitting glass fiber and disposed between said coil and said insulating sheet, and an insulating resin layer cast and hardened between said coil and said insulating sheet so as to penetrate into said insulating mats.

2. A resin molded transformer as claimed in claim 1, wherein said coil includes heat resistant inter-layer paper.

3. A resin molded transformer as claimed in claim 1, wherein said iron core is formed by winding amorphous metal foils.

4. A resin molded transformer comprising resin molded coils, which comprise wound conductor and molded resin, iron cores inserted to said resin molded coils, and metal parts for fixing said resin molded coils and said iron cores, wherein said resin molded coils are colored in light color and said iron cores and metal parts are colored in dark color.

5. A resin molded transformer as claimed in claim 4, wherein said resin molded coils are colored in chromatic color with a lightness of 7 or higher and with a chroma of 8 or higher, and said iron cores and metal parts are colored in achromatic color with a lightness of 4 or lower.

6. A resin molded transformer as claimed in claim 4, wherein said resin molded coils are colored in chromatic color with a reflectance of 40 % or higher, and said iron cores and metal parts are colored in achromatic color with a reflectance of 15 % to 3 %.

7. A resin molded transformer as claimed in claim 5 or claim 6, wherein said resin molded coils are colored yellowish red or yellow between hue 2.5YR and hue 10Y of Munsell color system.

8. A method of manufacturing a resin molded coil by disposing an insulating members at inner periphery and outer periphery of a coil having wound conductor, and molding said coil with thermo-setting resin, comprising the steps of;

disposing first resin pregnant insulating members around an inner mold which is served as a coil mandrel and casting mold,

forming a coil by winding conductor around said inner mold with said





first insulating members,

disposing second resin pregnant insulating members around said coil,
winding a flexible metal plate which is served as a outer mold around
said coil with said second insulating members,

casting resin into a space formed between said inner mold and outer
mold and hardening said resin.

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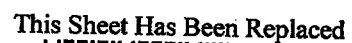


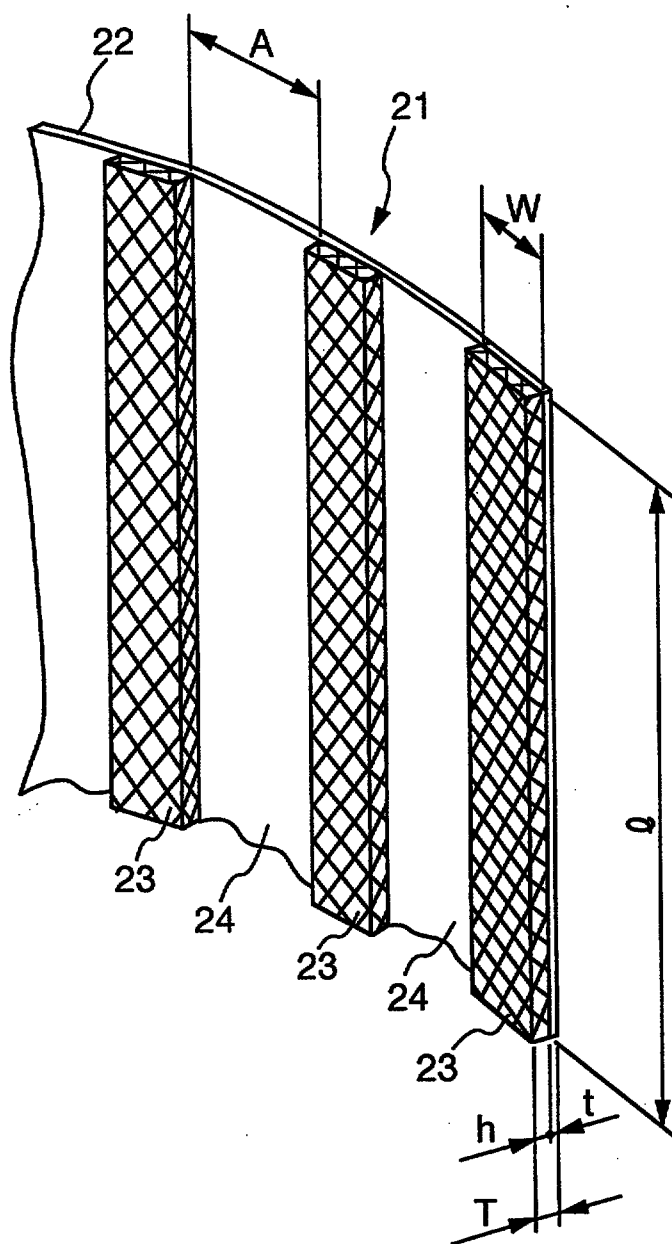
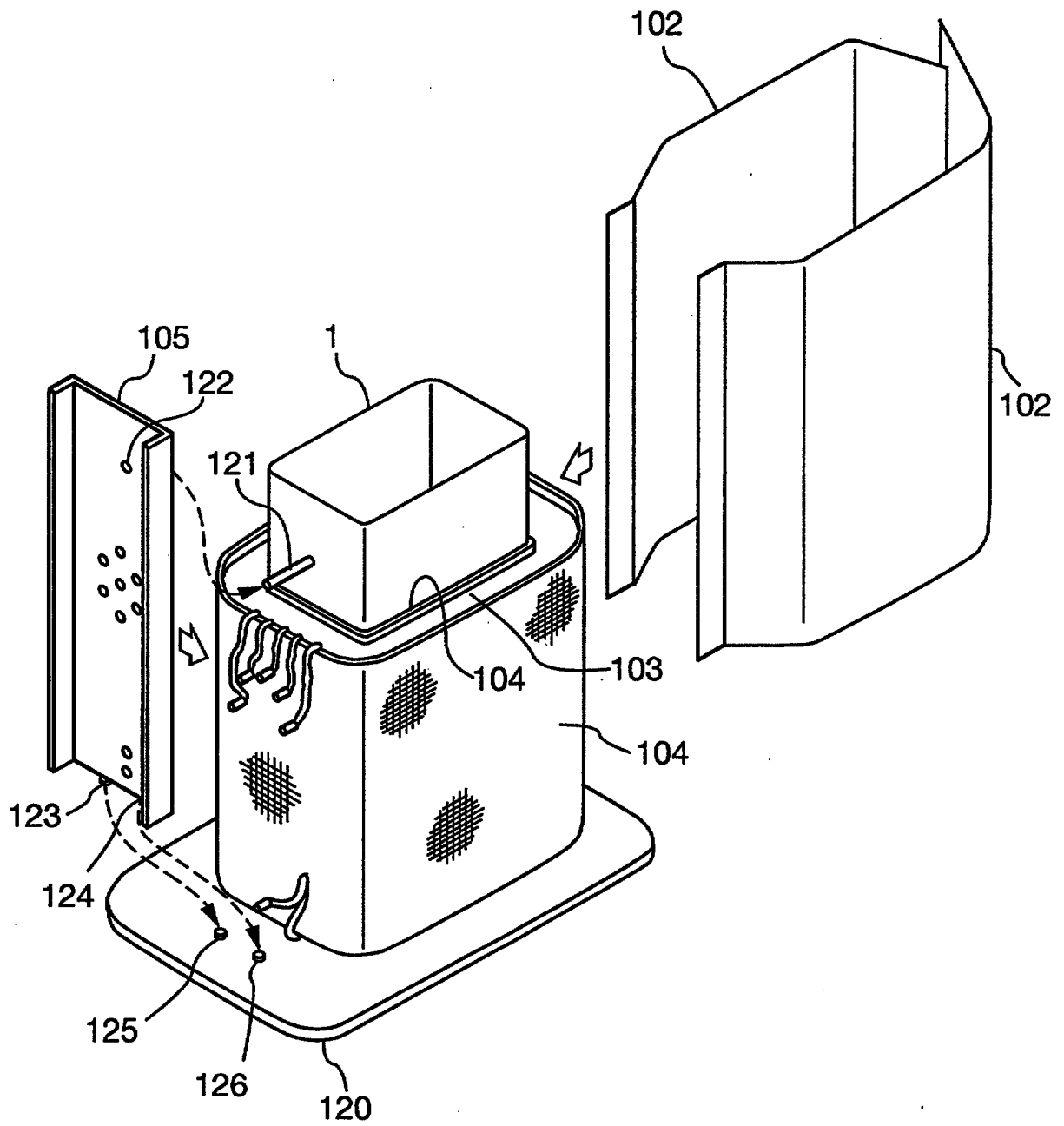
FIG. 2



FIG. 4



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FIG. 6

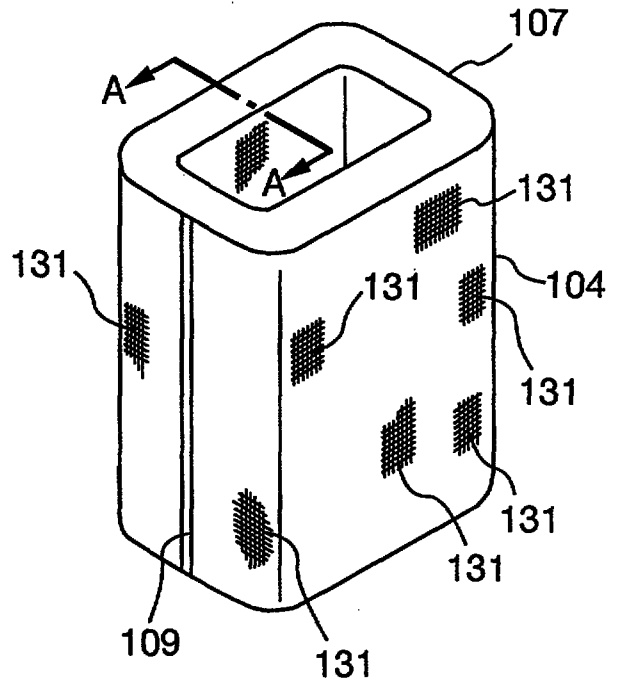


FIG. 5

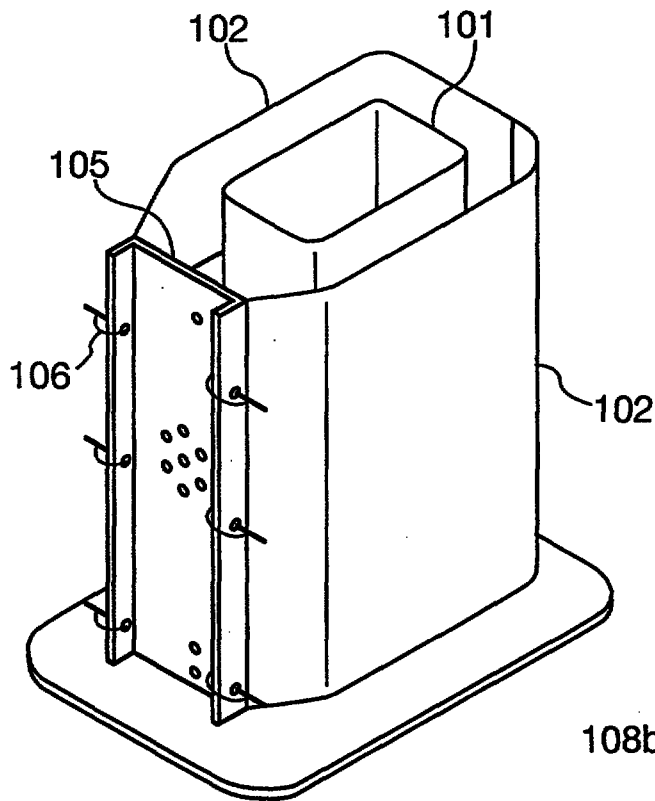
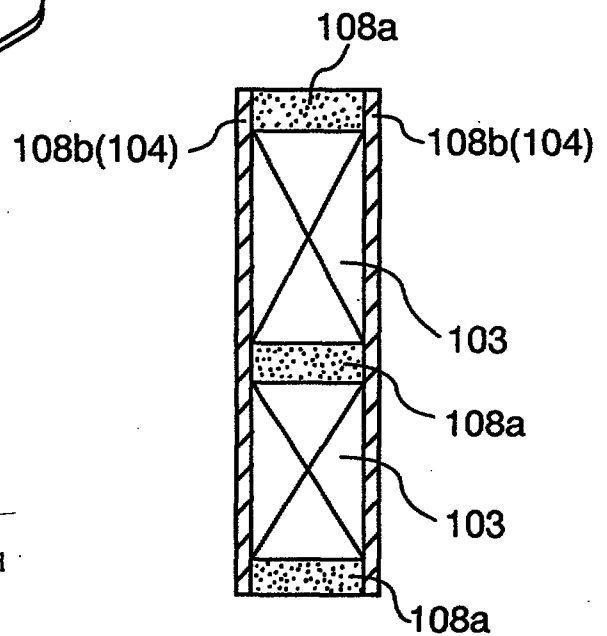


FIG. 7



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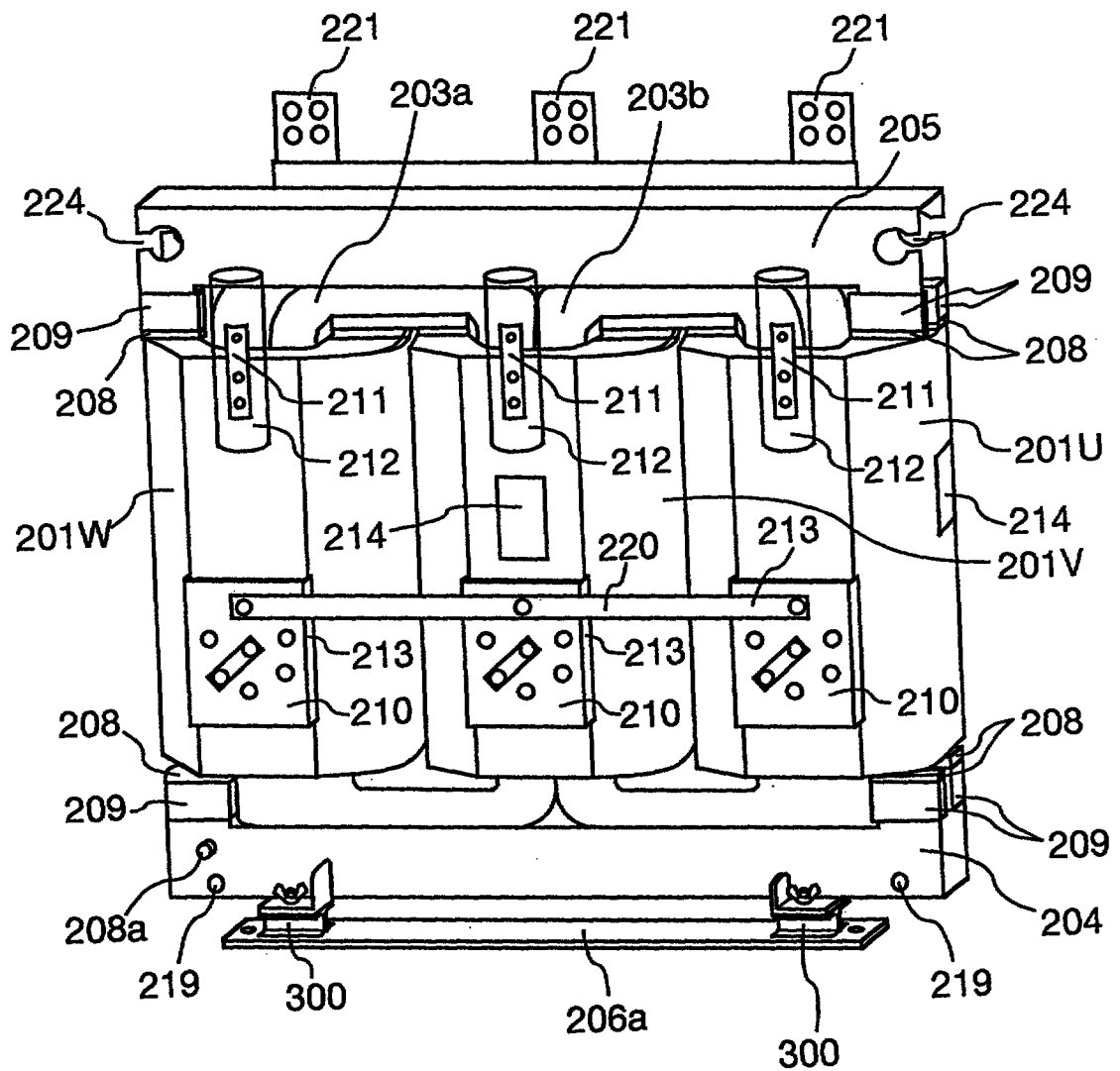
FIG. 8

FIG. 9

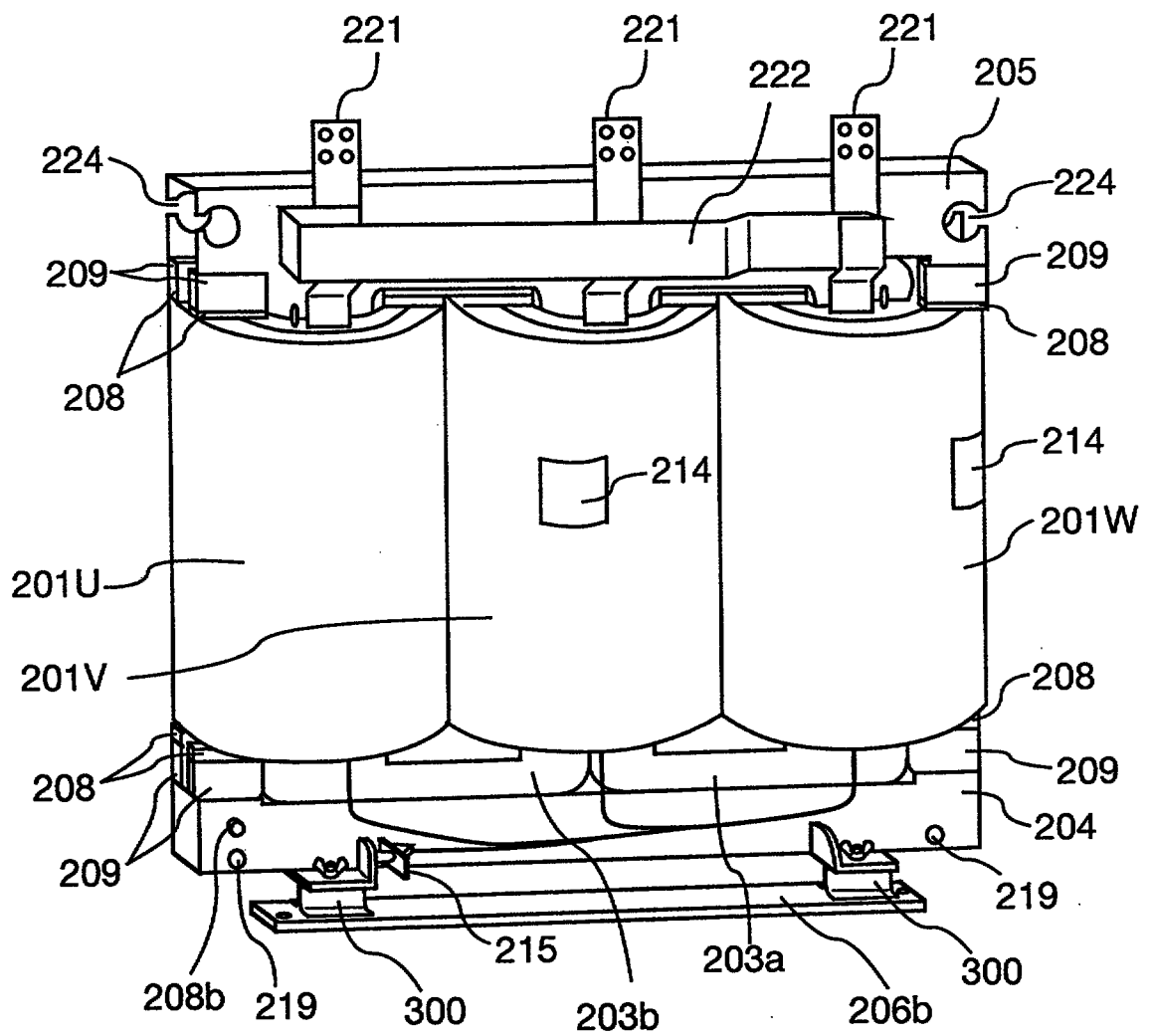


FIG. 10

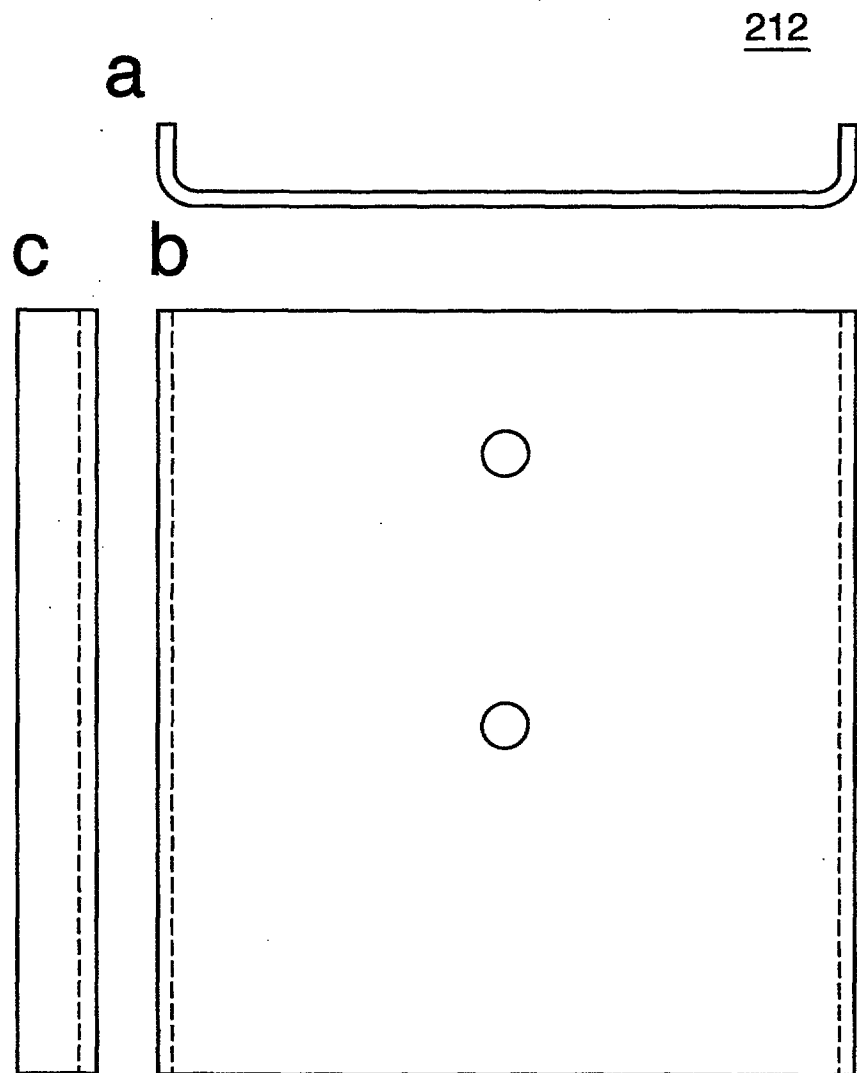
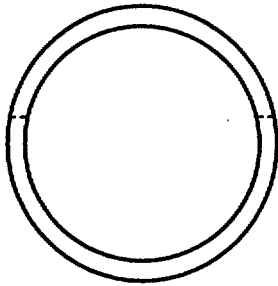


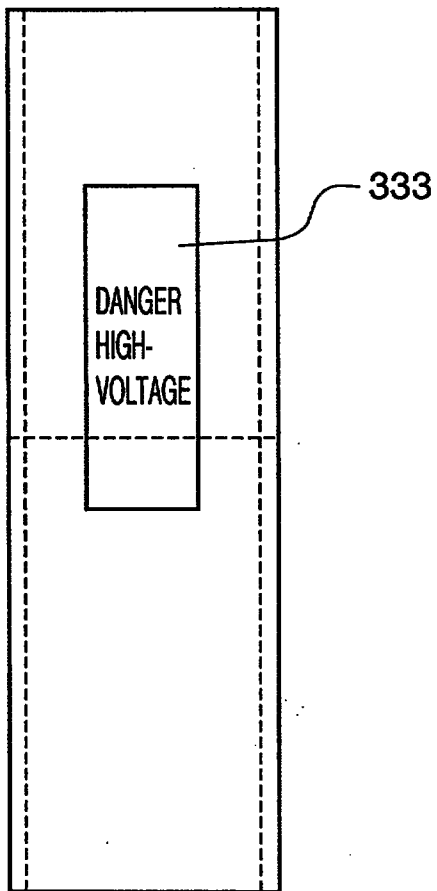
FIG. 11

a

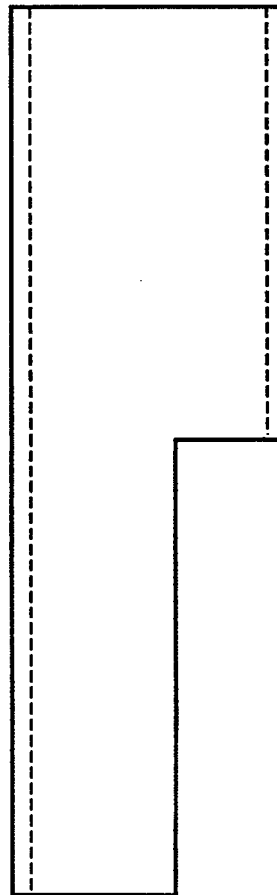


213

b



c

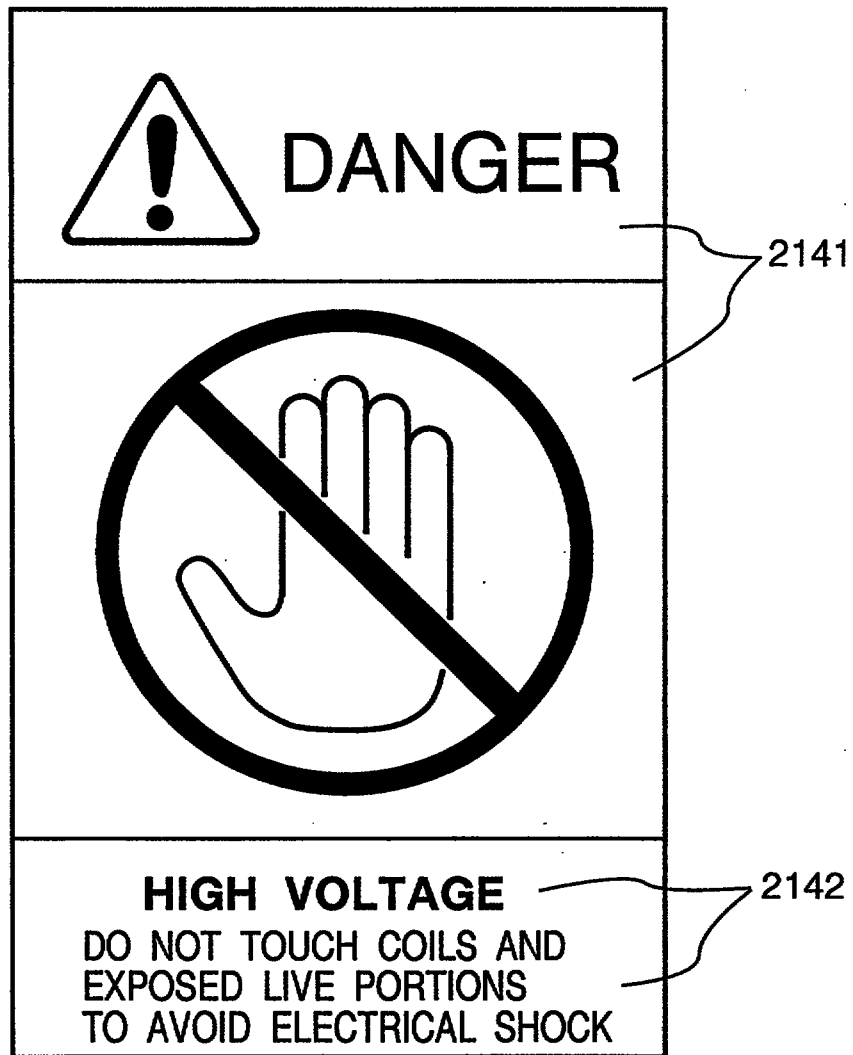


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FIG. 12

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RESIN MOLDED TRANSFORMER AND MANUFACTURING METHOD THEREOF

ABSTRACT

The present Invention relates to improvement on safety by indicating a dangerous portion of a resin molded transformer.

As U-phase, V-phase, and W-phase primary coils of the resin molded transformer are colored in different brightness or chroma from an iron core and metal parts, live portions where dangerous high voltage is applied are visually indicated clearly. For instance, primary coils are colored with a yellow color with a brightness of 7 or higher, and iron cores and other metal parts such as frames are colored with an achromatic color or a color of low chroma with a brightness of 4 or lower. Thus, even if the transformer is installed in a dark basement room, live portions are clearly indicated by difference of brightness. Further, the use of yellow color, which attracts attentions, can clearly indicate danger caused by careless touch to the dangerous live portions.

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REPLACEMENT SHEETS		SG
☒ Description	paged 1. to paged 2.	
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DATE OF RECEIPT		11/5/96

TITLE OF THE INVENTION

RESIN MOLDED TRANSFORMER AND MANUFACTURING METHOD THEREOF

BACKGROUND OF THE INVENTION

1. Industrial Field of the Invention

This invention relates to an induction apparatus such as transformer using resin molded coils and manufacturing method thereof.

2. Description of the Prior Art

Resin molded coils having a molded resin layer which is formed by casting a thermosetting resin around a coil have been used widely as coils of resin molded transformers.

Conventional resin molded coil techniques are disclosed in, for example, Japanese Patent Laid-Open No. Sho 54-50957 (1979) and Japanese Patent Laid-Open No. Sho 57-121207 (1982).

According to the technique disclosed in Japanese Patent Laid-Open No. Sho 54-50957, an insulating layer comprising a resin spacer and cast resin is formed on the inside periphery of a coil which is formed by winding conductor wire, and according to the technique disclosed in Japanese Patent Laid-Open No. Sho 57-121207, an insulating layer comprising insulating prepreg sheet and injected resin is formed on the inside and outside peripheries of a coil.

Otherwise, a method in which a coil is formed by winding conductor wire on a coil former-mold, and resin is cast to the coil using a mold formed as an outer mold. Conventionally, a transformer has been constituted by incorporating a coil produced as mentioned above to an iron core.

According to the above-mentioned technique disclosed in Japanese Patent Laid-Open No. Sho 54-50957, though the same resin as used for the spacer is used for casting to form solid insulating layer, the adhesion between the spacer and the insulating layer is insufficient because molten resin (casting resin) is cast on the resin which is previously hardened (spacer). After hardening of the cast resin, the spacer can happen to peel off from the cast resin, and the peeling off can cause dielectric breakdown.

In the case of the above mentioned technique disclosed in Japanese Patent Laid-Open No. Sho 57-121207, in the process in which insulating prepreg sheet is wound to form multi-ply layer, air is included between the layers, and the inclusion of air can cause dielectric breakdown.

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On the other hand, according to the method in which molds are provided on the inside and outside peripheries, whereas the insulating layer is excellent in appearance of the coil surface, moisture-proof, and mechanical strength, this structure requires many parts which constitute a mold, the requirement causes poor productivity and less economy in the maintenance of the parts constituting a mold due to diversified specification.

Conventional transformers using these resin molded coils have been developed addressing on the improvement of safety and handling as the general purpose, however, the above-mentioned conventional techniques does not involve the improvement of safety by visually indicating live portion, when a resin molded coil is incorporated in a transformer.

SUMMARY OF THE INVENTION

An object of the present invention is to form an excellent insulating layer on a resin molded coil, and improve the safety and handling of a transformer.

To accomplish the above-mentioned object, the present invention provides a transformer comprising resin molded coils, iron cores inserted in the resin molded coils, and metal parts for fixing the coils and iron cores, wherein the resin molded coils are colored light and the metal parts are colored dark.

The transformer using resin molded coils of the invention is excellent in mechanical strength, moisture resistance, and appearance of the coil surface, and indicates a dangerous part on the resin molded coil having a possibility of careless touching not by chroma but lightness. Therefore, even if the transformer is installed in a dark place such as a basement where the illumination is insufficient, the dangerous portion is clearly indicated.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a vertical cross-sectional view of a resin molded coil of a first embodiment in accordance with the present invention.

Fig. 2 is a perspective view of insulating layer forming medium of the first embodiment of the invention.

Fig. 3 is a cross-sectional view taken on line III - III of Fig. 1.

Fig. 4 is an exploded perspective view for illustrating production of a resin molded coil of a third embodiment of the invention.

Fig. 5 is a perspective view for illustrating the assembled mold of the third embodiment of the invention.

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Fig. 6 is an apparent view of the resin molded coil produced according to the third embodiment of the invention.

Fig. 7 is a cross-sectional view of the resin molded coil produced according to the third embodiment of the invention.

Fig. 8 is a front apparent view of a transformer of a fourth embodiment of the invention.

Fig. 9 is a back apparent view of the transformer of the fourth embodiment of the invention.

Fig. 10 shows three drawings for illustrating the structure of a cover for a tap switch of a transformer of the fourth embodiment of the invention.

Fig. 11 shows three drawings for illustrating the structure of a cover for a primary terminal of the transformer of the fourth embodiment of the invention.

Fig. 12 shows a display for showing the danger display on the transformer of the fourth embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments in accordance with the present invention will be described in detail referring to the drawings.

First, the first embodiment of the present invention is described referring to Fig. 1 to Fig. 3.

The mold coil of this embodiment is to be used for transformers. Generally, a transformer comprises a high-voltage coil 1 and a low-voltage coil 2 as shown in Fig. 1, herein, the resin molded high-voltage coil 1 (for example 3 kV) is addressed for description. In the figure, 3 represents an iron core.

The resin molded high-voltage coil 1 of this embodiment comprises a coil body 10 which is formed in a shape of ring cross-section using wound conductor wire 11 and insulating layer forming mediums 21 which are provided on the outside and inside peripheries of the coil body 10.

Inter-layer papers 12 are provided between each layer of conductor wire 11 of the coil body 10.

As shown in Fig. 2, the insulating layer forming medium 21 comprises prepreg sheet 22 (insulating sheet) composed of glass cloth sheet formed by knitting insulating glass fiber and epoxy resin impregnated in the glass sheet, and a plurality of rectangular glass mats 23, 23, ... (insulating fiber mat) which are formed by knitting glass fiber. The glass mat 23 has a size with the same length l as the prepreg sheet 22, a width w of 10 mm to 30

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mm, and a thickness h of 2mm to 5 mm. A plurality of glass mats 23, 23, ... is adhered with epoxy adhesive on the prepreg sheet 22 with a certain interval of A along the inside and outside peripheries in Fig. 3. The spaces between the glass mats 23, 23, ... are to be served as passages 24 for flowing of resin 25 as described hereinafter. The total thickness of thickness h of the glass mat 23 and thickness t of the prepreg sheet 22 will be the thickness T (duct height) of insulating resin layer 20.

When the coil body 10 is molded with resin, as shown in Fig. 1 and Fig. 3, the insulating layer forming medium 21 is wound on the coil body 10 so as that glass mats 23 of the insulating layer forming medium 21 contact with the inside and outside peripheries of the coil body 10. The prepreg sheet 22 of the insulating layer forming medium 21 is semicured prepreg sheet.

Afterwards, epoxy resin 25 is cast between the prepreg sheet 22 of the insulating layer forming medium 21 and the inside and outside peripheries of the coil body 10. The cast epoxy resin 25 flows in the resin passage 24 between glass mats 23 and 23 and penetrates into glass mats 23, and also into the entire space between the prepreg sheet 22 of the insulating layer forming medium 21 and the inside and outside peripheries of the coil body 10. When casting epoxy resin 25, the resin is cast slowly so as not to include air and the coil body 10 is vibrated so as to exclude air even if the resin include air. The coil body 10 may be vibrated, for example, by applying ultrasonic vibration with a certain frequency. When cast epoxy resin 25 is hardened, the resin molded coil 1 is completed.

As described above, on the outside and inside peripheries of the coil body 10 the insulating resin layer 20 comprising cast epoxy resin 25 and insulating layer forming medium 21 is formed.

In the case that an insulating tape is wound to form multi-ply layer for forming an insulating layer as in conventional technique, air spaces are formed inevitably between tapes due to slackening or irreversible elongation of the tape. On the other hand, in this embodiment, air space will not be formed because fluid casting resin 25 is cast between the coil body 10 and the prepreg sheet 22 to form the insulating layer 20. When casting the resin 25, the above mentioned treatment allows the resin 25 to be free from air. The casting resin 25 penetrates into glass mats 23 to combine the insulating layer forming medium 21 with the cast resin 25, air space will not be formed differently from the conventional technique in which a spacer is used, in this case, the spacer

can happen to peel off to form air space in the insulating layer. Therefore, the dielectric breakdown and deterioration of thermal conductivity due to air space in the insulating layer 20 is prevented.

In this embodiment, the insulating layer forming medium 21 is prepared previously to eliminate the work for providing a plurality of spacers with a certain interval or working for winding an insulating tape around the coil body 10 to form multi-ply layer as in the conventional technique, thus time for production is shortened.

In this embodiment, the impact strength is improved because glass fiber is mixed in the insulating layer 21.

A method for producing a resin molded coil of the invention is described referring to Fig. 4 and Fig. 5.

In this embodiment, an inner mold 101 which is served as a coil mandrel and mold is used, a glass mat 104 is wound on the outside periphery of the inner mold 101 (it will be the inside periphery of the resin molded coil finally) to form an inside peripheral insulating layer, and then, conductor wire 11 and inter-layer paper 12 are wound on the insulating layer to form a wound coil 103. Then, on the outer periphery of the wound coil 103 (it will be the outer periphery of the resin molded coil finally), a glass mat 104 is wound to form the outer insulating layer. Two flexible metal plates 102 are used as the outer mold. The side edges of both metal plates 102 are faced to both bends of a casting jig 105 and the side edges and bends are clamped with clamping jigs such as a vise 106 (refer to Fig. 5), the metal plates are wound around the external shape of the coil body, and the coil body is fastened with bands. A pin 121 is projected from the side of the inner mold 101, and this pin 121 is engaged to a corresponding hole 122 of the casting mold 105 for positioning each other. Similarly, pins 123 and 124 are projected from the casting mold 105 at the bottom, these pins 123 and 124 are engaged to corresponding holes 125 and 126 provided on the bottom 120 for positioning each other. Resin is cast into the mold formed as described herein above.

The metal plate 102 for the outer mold may have a size with the same height as the coil or higher, with the same width as a half of the periphery of the coil or wider, and metal plates with a certain same size can be used as outer molds of coils with different various external form sizes. Metal plates are flat in shape before shaping for use as an outer mold, the metal plates can be stored in the form of a stack, therefore, the space for storing the outer mold is

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minimized. The glass mat 104 is served to form an insulating layer and also to be impregnated with resin.

Fig. 6 is a perspective view from the back side of the resin molded coil 107 produced by the process described above. The glass mats 104 are located on the inside and outside peripheral insulating layers, the outer mold is wound around the external form of the coil, and the outer mold is fastened with bands, therefore, fibers of the glass mats 104 appears on the surface of the coil after completion of the coil sporadically (131). The metal plates 102 for forming an outer mold are overlapped each other on the back side, the overlapping makes a step on the coil surface by the thickness of the metal plate, therefore, the coil is featured by the appearance of a hem 109 which extends in the direction of the height of the coil or a trace of cutting of the hem.

Fig. 7 is a cross-sectional view taken on line A-A of the resin molded coil 107 shown in Fig. 6. Strong resin insulating layers 108b containing glass mats are formed on the inside and outside peripheries of the wound coil 103. Three insulating layers 108a consisting of resin only are formed at the three positions, top, middle, and bottom in the height direction of the coil. Glass mat with a fiber density of 300 to 500 g/m² is commercially available, this type of glass mat with a fiber density in the range is suitably used as the glass mat 104 for the insulating layer of the coil. Especially, glass mat with a fiber density of 500 g/m² is preferably used as insulating material provided on the inside and outside peripheral insulating layers because this glass mat gives excellent resin impregnation when casting and high strength which allows high pressure exerted when winding of wire and fastening of the outer mold.

In this embodiment, heat resistant films 15 such as polyethylene-terephthalate (PET), polyethylene-naphthalate (PEN), polyether-imide (PEI), and polyimide (PI) are used as the above-mentioned inter-layer paper 12. These materials have high thermal conductivity, and the use of this type of films makes the resin molded coil easy to be cooled. Therefore, in this embodiment, in case of producing a molded coil of the same rated capacity as that of conventional one, the conductor portion of the coil can be smaller in size than that of conventional one, due to the effective cooling capacity against increase of heat caused by increase of current density. In addition, the inside and outside insulating layers can be thinner than those of

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the conventional coil because the strength of the insulating layer of the invention is high, thus this factor also allows the size of the coil to be minimized.

The thermal conductivity of polyethylene-terephthalate (PET) is 0.151 w/m[•]k, the thermal conductivity of polyethylene-naphthalate (PEN) is 0.151 w/m[•]k, the thermal conductivity of polyether-imide (PEI) is 0.198 w/m[•]k, and the thermal conductivity of polyimide (PI) is 0.156 w/m[•]k, and the dielectric breakdown voltage of polyethylene-terephthalate (PET) is 220 kV/mm, the dielectric breakdown voltage of polyethylene-naphthalate (PEN) is 294 kV/mm, the dielectric breakdown voltage of polyether-imide (PEI) is 210 kV/mm, and the dielectric breakdown voltage of polyimide (PI) is 260 kV/mm.

According to the embodiments described herein above, an inner mold, which is served as a coil mandrel and mold, an outer mold, which is formed by winding flexible flat plates around the outer periphery of the coil, and insulating layers, which are used as spacer for the inner mold and outer mold and accept the resin impregnation sufficiently, are used, thereby, the following effects are exhibited.

- (1) The workability in producing resin molded coils is improved.
- (2) The mechanical strength of inside and outside peripheral insulating layers is improved.
- (3) The maintenance of the outer mold is unnecessary.
- (4) The cooling of the coil is facilitated by processing of outer mold flat plates.
- (5) The moisture resistance of the coil is improved.
- (6) The required minimum insulating layer thickness is reduced by adhering the metal plates to the coil, and thus required amount of resin is reduced.

Hereinafter, a transformer in accordance with the fourth embodiment of the invention which uses molded coils described hereinbefore is described.

The appearance of the transformer in accordance with the present invention is shown in Fig. 8 and Fig. 9. Fig. 8 is a perspective view of the transformer viewed from above front, and Fig. 9 is a perspective view of the transformer viewed from above back.

In Fig. 8 and Fig. 9, 201U, 201V, 201W are U-phase, V-phase, and W-phase primary coils respectively, and 203a and 203b are iron cores.

Secondary coils of 202U, 202V, and 202W, which are not shown in the figures, are inserted in primary coils of 201U, 201V, and 201W respectively. In the transformer shown in the figures, the legs of iron cores 203a and 203b are inserted in the secondary coils of 202U, 202V, and 202W, and the secondary coils of 202U, 202V, and 202W are inserted in the inside peripheries of the primary coils of 201U, 201V, and 201W. In these coils, insulating material with high thermal conductivity such as polyethylene-naphthalate is used as inter-layer paper as described in the third embodiment hereinbefore. Therefore, in this embodiment also, by using strong resin insulating layer comprising inter-layer papers with high thermal conductivity and glass mats, the current density can be increased, and the coil is minimized in size.

In this embodiment, a wound iron core which is produced by winding silicon steel plate is used for the iron cores 203a and 203b. The iron core may be a wound iron core which is produced by winding foil of amorphous metal. By using this type of wound magnetic core, the core loss is reduced to result in energy saving comparing with the case in which a laminated iron core is used. As described hereinbefore a molded coil is minimized in size by applying this invention, therefore, a small and light-weight iron core is sufficient for this type of molded coil. Accordingly, the core loss is reduced and energy saving is realized comparing with conventional techniques in this respect.

For example, in the case of a three-phase transformer with a capacity of 20 kVA to 500 kVA, the size of the transformer is minimized to a depth of 345 mm for 20 kVA and 505 mm for 500 kVA. In the case of a single-phase transformer with a capacity of 20 kVA to 500 kVA, the size of the transformer is minimized to a depth of 360 mm for 10 kVA and 505 mm for 300 kVA. Accordingly, the volume of a transformer is reduced by about 10 % comparing with a conventional transformer. By the minimization in size, an iron core is minimized by about 5 %, and the core loss is reduced by about 5 %, thus the no-load loss is reduced by about 5 %. The depth size is made smaller comparing with a conventional transformer, the transformer with a certain thickness of insulator can be contained in the thin cubicle with a depth of 700 mm, which is one of the sizes in GEM1424 recommendation.

Wound iron cores 203a, and 203b, primary coils 201U, 201V, and 201W, and secondary coils 202U, 202V, and 202W are fixed between a bottom frame 204 and a top frame 205. The bottom frame 204 is connected to

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two bases 206a and 206b with interposition of four vibration-proof rubber 300, the two bases 206a and 206b are fixed by screwing screws into tapped hole on the floor when installing the transformer on the floor. The top frame 204 and the bottom frame 205 are connected together with connecting members which penetrate through the inside peripheries of the secondary coils 202U, 202V, and 202W, which structure is not shown in the figures. The wound iron cores 203a and 203b, primary coils 201U, 201V, and 201W, and secondary coils 202U, 202V, and 202W are fixed to the bottom frame 204 and the top frame 105 between both frames with interposition of rubber members 208 and spacers 209. In addition to such structure, a wound iron core is used as an iron core in the present invention, the use of a wound iron core reduces the joint, the reduced joint results in reduced noise generation.

In the figures, on the front right corner and on the back right (left side when viewing from the front) corner of the bottom frame 204, earth terminals 208a and 208b are provided respectively. In this embodiment, the earth terminals 208a and 208b are provided on a diagonal line of the transformer, this arrangement allows the transformer to be installed on a limited space. On the bottom frame 204, holes 219 are provided which are for engaging with hooks when the transformer is moved. By providing this hooking holes, the workability of moving is made easy.

In the figures, right and left cutouts 224 of the top frame 205 are hanging recesses for hanging, and secondary terminals 221 for the secondary coil 202U, 202V, and 202W and a bar 222 for connecting wirings are provided on the upper back of the top frame 205. An earth terminal 215 of the contact preventing plate (not shown in the figures) which is provided between a secondary coil and a primary coil 201 is provided on the back left side (right side when viewing from the front side) of the bottom frame 204.

Referring to Fig. 8 and Fig. 9, rotary type taps 210 for switching the connection between coils and coil layers and a connecting bar 220 are provided at the middle in the vertical direction of the secondary coils 202U, 202V, and 202W in the figures. Primary terminals 211 of the primary coils 201U, 201V, and 201W are provided on the upper front of the secondary coils 202U, 202V, and 202W. Semi-transparent insulating covers 212 and 213 (including smoked transparent material) are provided on the switching taps 210 and terminals 211.

The shape of the covers of the switching taps 210 is shown in

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Fig. 10, and the shape of the covers of the terminals 211 are shown in Fig. 11. In both Fig. 10 and Fig. 11, "a" represents front views, "b" represents side views, and "c" represents top views. As shown in Fig. 11, the display 333 of "DANGER, HIGH-VOLTAGE" is displayed on the cover of the terminal 211.

As described above, by providing the insulating covers 212 and 213, the careless touching to exposed high-voltage portion is prevented. The use of semi-transparent material for these insulating covers 212 and 213 allows the switching taps 210 and terminals 211 to be seen from the outside and the tight fastening can be checked at a glance. Differently if a transparent cover is used, the existence of the cover is not perceived by a worker, and the worker will feel danger.

As shown in Fig. 8 and Fig. 9, in this embodiment, danger display marks 214 shown in Fig. 12 are marked on the four sides of a transformer. As shown in Fig. 12, in the danger display mark 214 of this embodiment, characters and a symbol 2141 for displaying the danger and a sentence 2142 for describing the type of danger and the dangerous action are located separately. By displaying not only the existence of the danger but also the reason and dangerous action, the safety will be improved.

In the structure of the transformer of the present invention described hereinbefore (refer to Fig. 8 and Fig. 9), the primary coils 201U, 201V and 201W, and secondary coils 202U, 202V and 202W are colored in a light yellow color with high brightness such as a color of Munsell No. 2.5Y8/14. The bottom frame 204, top frame 205, and base 206 are colored in a dark gray color with low brightness such as Munsell No. N4.0. The wound iron cores 203a and 203b are colored dark nearly black.

In this invention, the reason of the coloring is described hereinafter.

Though insulating layers are formed on the surface of the primary coils 201U, 201V and 201W and the secondary coils 202U, 202V and 202W, the high-voltage is induced on the surface of these insulating layers when the transformer is in service, and it is dangerous to touch with a bare hand. Therefore, it is desirable that the primary coils 201U, 201V and 201W, and the secondary coils 202U, 202V and 202W are colored in bright color (high chroma) so as that these coils are recognized as danger. However on the other hand, transformers are often installed in basement. In a basement, usually the intensity of illumination is 20lx to 50lx (Japan Illumination

Association, Illumination Data Book, published June 10, 1963 by Ohm Co.). In such a dark place, human eyes are not so sensitive to the difference in chroma but sensitive to the difference in brightness. Based on this fact, in this embodiment, the primary coils 201U, 201V and 201W, and the secondary coils 202U, 202V and 202W are colored yellow of which color has high brightness and high chroma and is recognized popularly as a color for danger, and other portions are colored dark so as that the yellow is remarkable in the dark.

In this embodiment, yellow of 2.5Y8/14 and gray of N4.0 (both are Munsell color system representation) are used, but the colors are not limited to these colors. The contrast between two colors colored on the two sections respectively is to be remarkable, it is said that the difference in the brightness of 3 to 10 or more and difference in the chroma of 8 or higher of Munsell color system is desirable (Motoo Kawakami, Dictionary of Color, published December 10, 1987 by Asakura Shoten).

The bright color used in accordance with the present invention includes hues of 5Y, 7.5Y, 10Y, 2.5GY, 5GY, 7.5GY, 10GY, 2.5YR, 5YR, 7.5YR, and 10YR in Munsell color system (or JIS standard color) which hue has the brightness of 7 or higher, and has the chroma of 8 or higher. The dark color used in accordance with the present invention includes colors with the brightness of 4 or lower for achromatic color and colors with the brightness of 4 or lower and the chroma of around 2 for chromatic color, and desirably the dark color is a complementary color of the bright color.

By coloring the iron cores and metal parts in achromatic color or color with low chroma, the resin molded cores become remarkable for easy perception, and thus the coloring prevents workers from happening to touch, and the safety and handling is improved.

The reflectance for each brightness is 78.66 % for the brightness of 9, 59.1 % for the brightness of 8, 43.06 % for the brightness of 7, 30.05 % for the brightness of 6, 19.77 % for the brightness of 5, 12.0 % for the brightness of 4, 6.555 % for the brightness of 3, and 3.126 % for the brightness of 2 (JISZ8721).

For example, for the combination of a bright color of the brightness of 8 and a dark color of the brightness of 4, the bright color reflects light about 4.9 times that of the dark color, for the combination of a bright color of the brightness of 7 and the dark color of the brightness of 3, the bright color reflects light about 6.6 times that of the dark color, and for the

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combination of a bright color of the brightness of 9 and a dark color of the brightness of 6, the bright color reflects light about 2.6 times that of the dark color. By coloring with difference in the brightness of 3 or more, the bright color reflects light 2.6 times or more that of the dark color, both colors are easily distinguished in the dark.

By coloring the iron cores dark, the heat releasing from the iron core is facilitated based on the principle of the black body radiation.

The ceiling and walls of a room where a transformer is installed is colored generally white with the brightness of 8 to 9 or light gray chromatic color, and the chroma is regulated to be 4 or lower. (Japan Illumination Association, Illumination Data Book, published June 10, 1963 by Ohm Co.)

By coloring the resin molded coils with a chromatic color, the resin molded coils become remarkable because of the difference in chroma from the interior surface of the room. The iron cores and metal parts are colored in a low brightness color, the coloring makes the resin molded coils remarkable, and the existence of the transformer becomes remarkable.

The hue of the color for the resin molded coils are selected in a range of Munsell color system or JIS standard color hue circle from 2.5YR to 10Y, or yellowish red or yellow, thus a color with high brightness (brightness of 7 to 8) and high chroma (10 or higher) is selected. These colors are warm color, and these colors are perceived as expansive color, the resin molded coils become more remarkable, and the high-voltageed resin molded coils are perceived more easily, thus the coloring prevents workers from happening to touch.

If the iron cores and metal parts are colored pure black (brightness 1 or lower), the internal of the room where the transformer is installed becomes dark because of the significantly reduced reflection. Therefore, it is desirable that the iron cores and metal parts are colored dark gray (brightness of 4 to 2) for suitable reflection.

In this embodiment, wound iron cores are used as iron cores for description, but laminated iron cores may be used instead of wound iron cores when the problem of core loss is not important.

According to the present invention, there can be provided a transformer having resin molded coils with excellent insulating layers and capable of improving the safety and the handling.

WHAT IS CLAIMED IS:

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1. A resin molded transformer comprising a resin molded coil, which comprises a coil of wound conductor and insulating resin layer covering an external surface of said coil, iron cores inserted to said resin molded coil, wherein said resin molded coil includes an insulating sheet wound around inner periphery and outer periphery of said coil, a plurality of insulating fiber mats of predetermined size which are formed by knitting glass fiber and disposed between said coil and said insulating sheet, and an insulating resin layer cast and hardened between said coil and said insulating sheet so as to penetrate into said insulating mats.

2. A resin molded transformer as claimed in claim 1, wherein said coil includes heat resistant inter-layer paper.

3. A resin molded transformer as claimed in claim 1, wherein said iron core is formed by winding amorphous metal foils.

4. A resin molded transformer comprising resin molded coils, which comprise wound conductor and molded resin, iron cores inserted to said resin molded coils, and metal parts for fixing said resin molded coils and said iron cores, wherein said resin molded coils are colored in light color and said iron cores and metal parts are colored in dark color.

5. A resin molded transformer as claimed in claim 4, wherein said resin molded coils are colored in chromatic color with a lightness of 7 or higher and with a chroma of 8 or higher, and said iron cores and metal parts are colored in achromatic color with a lightness of 4 or lower.

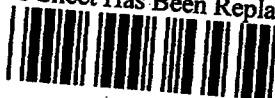
6. A resin molded transformer as claimed in claim 4, wherein said resin molded coils are colored in chromatic color with a reflectance of 40 % or higher, and said iron cores and metal parts are colored in achromatic color with a reflectance of 15 % to 3 %.

7. A resin molded transformer as claimed in claim 5 or claim 6, wherein said resin molded coils are colored yellowish red or yellow between hue 2.5YR and hue 10Y of Munsell color system.

8. A method of manufacturing a resin molded coil by disposing an insulating members at inner periphery and outer periphery of a coil having wound conductor, and molding said coil with thermo-setting resin, comprising the steps of;

disposing first resin pregnant insulating members around an inner mold which is served as a coil mandrel and casting mold,

forming a coil by winding conductor around said inner mold with said





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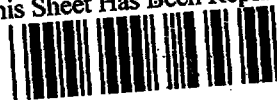
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first insulating members,

disposing second resin pregnant insulating members around said coil,
winding a flexible metal plate which is served as a outer mold around
said coil with said second insulating members,

casting resin into a space formed between said inner mold and outer
mold and hardening said resin.

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RESIN MOLDED TRANSFORMER AND MANUFACTURING METHOD THEREOF

ABSTRACT

The present Invention relates to improvement on safety by indicating a dangerous portion of a resin molded transformer.

As U-phase, V-phase, and W-phase primary coils of the resin molded transformer are colored in different brightness or chroma from an iron core and metal parts, live portions where dangerous high voltage is applied are visually indicated clearly. For instance, primary coils are colored with a yellow color with a brightness of 7 or higher, and iron cores and other metal parts such as frames are colored with an achromatic color or a color of low chroma with a brightness of 4 or lower. Thus, even if the transformer is installed in a dark basement room, live portions are clearly indicated by difference of brightness. Further, the use of yellow color, which attracts attentions, can clearly indicate danger caused by careless touch to the dangerous live portions.

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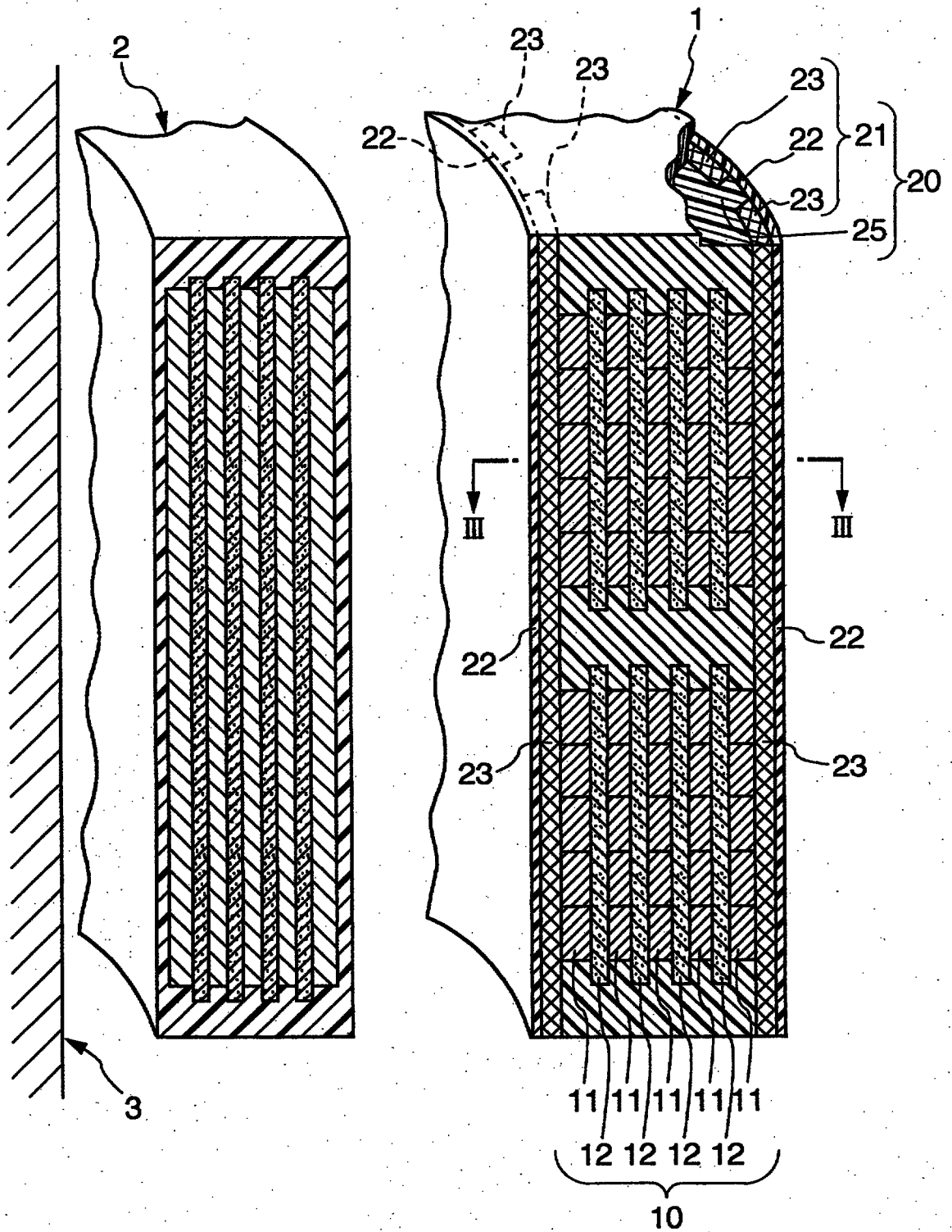
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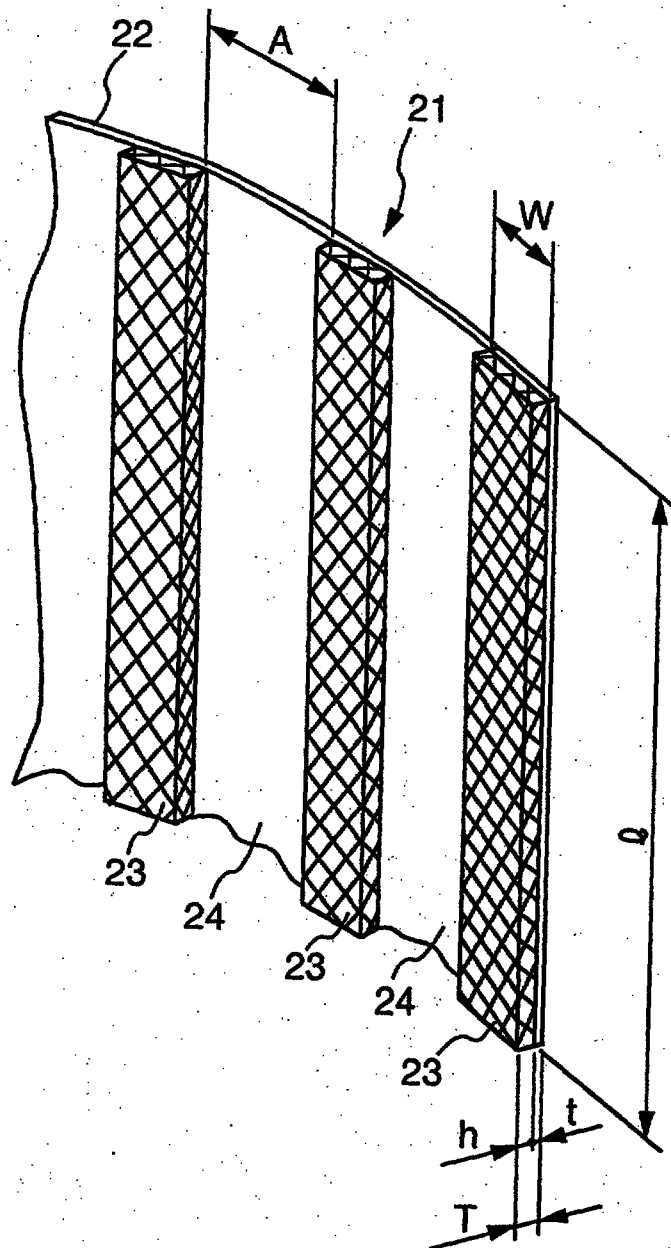
FIG. 1



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FIG. 2



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Date: 17 MAY 1996

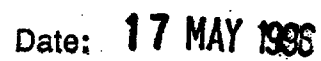
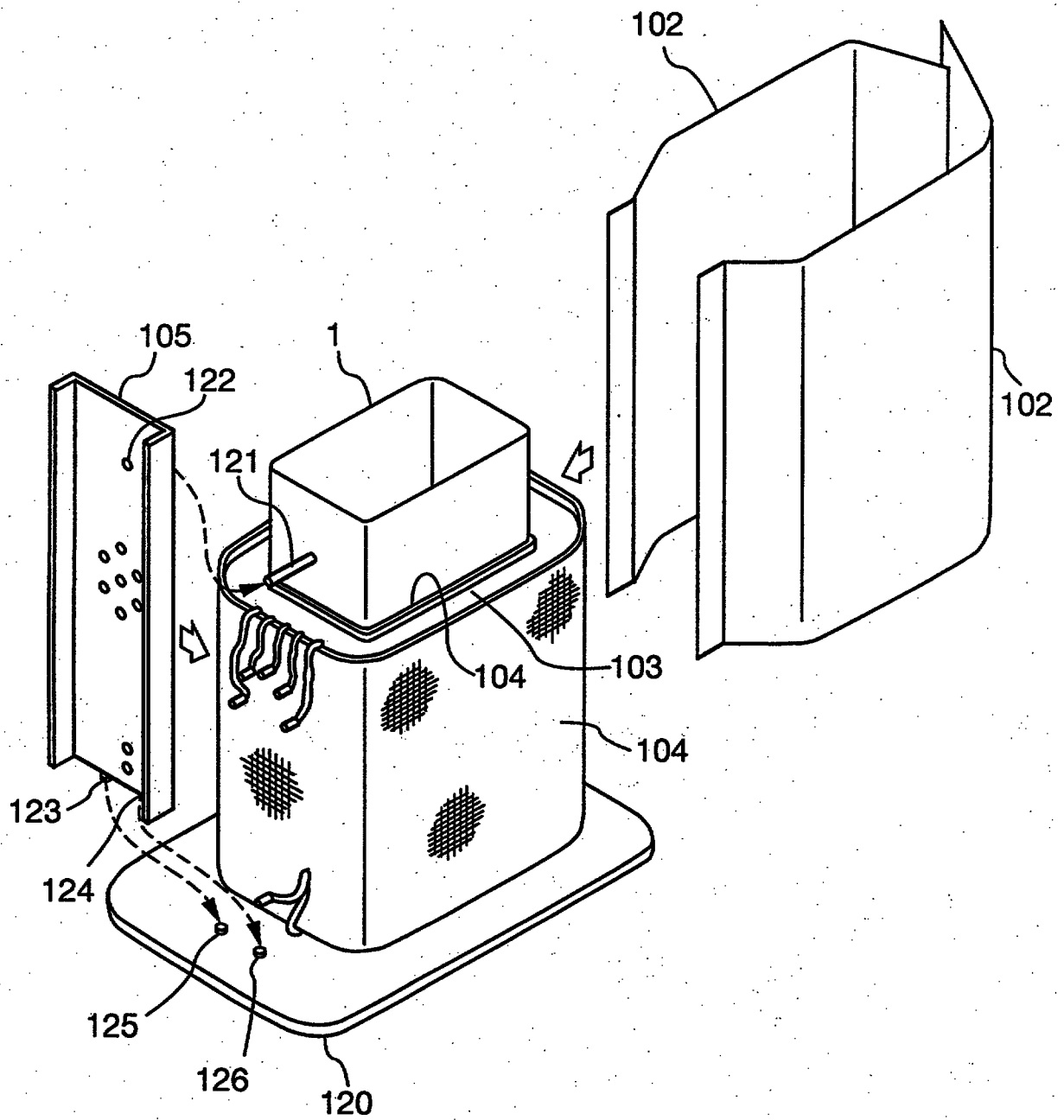


FIG. 4



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FIG. 6

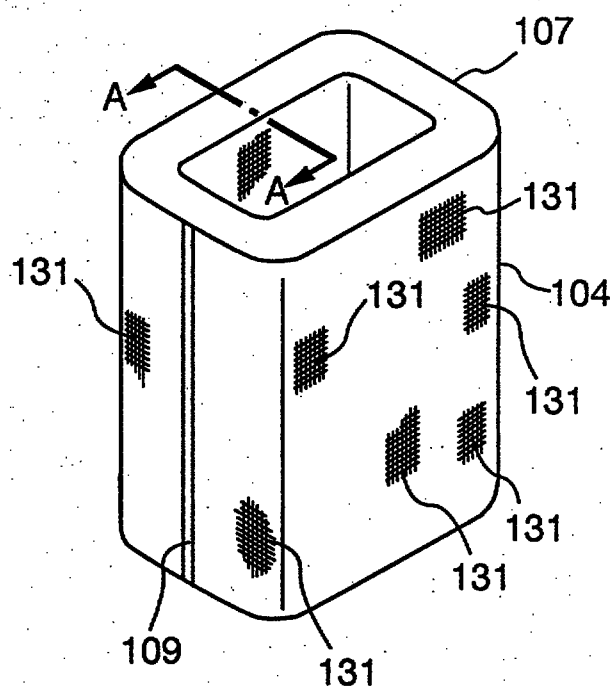


FIG. 5

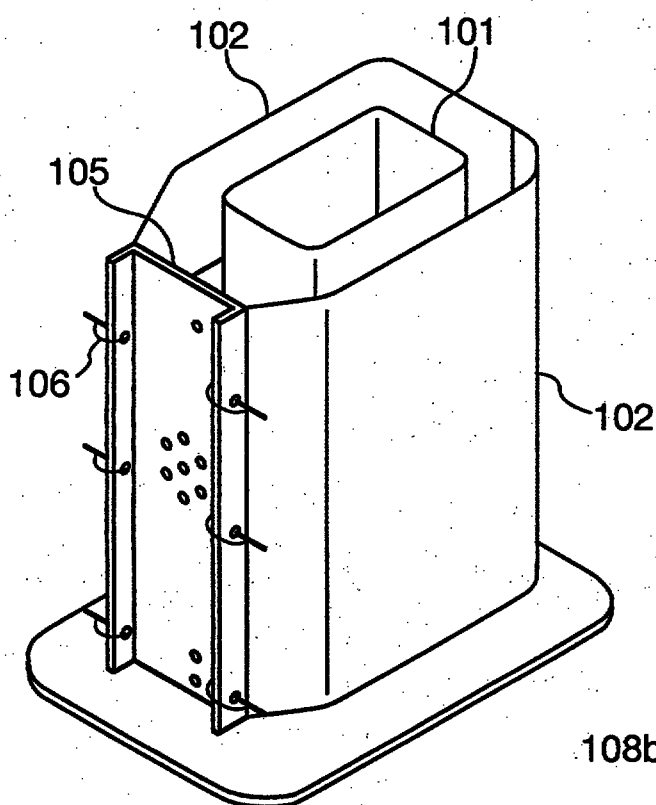
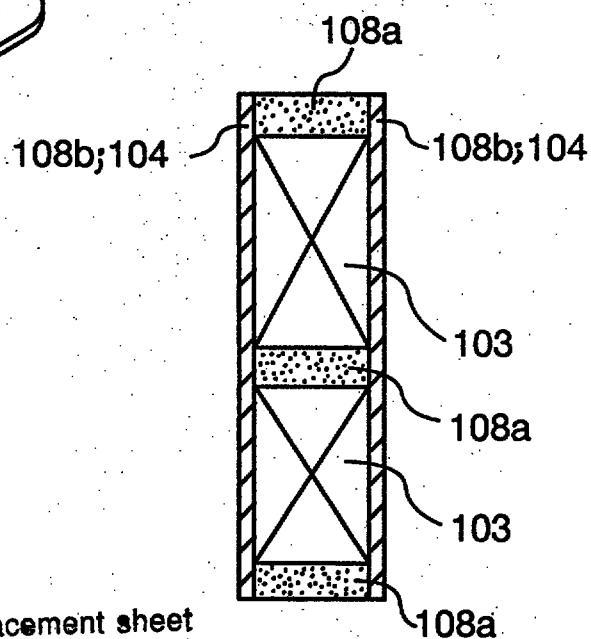


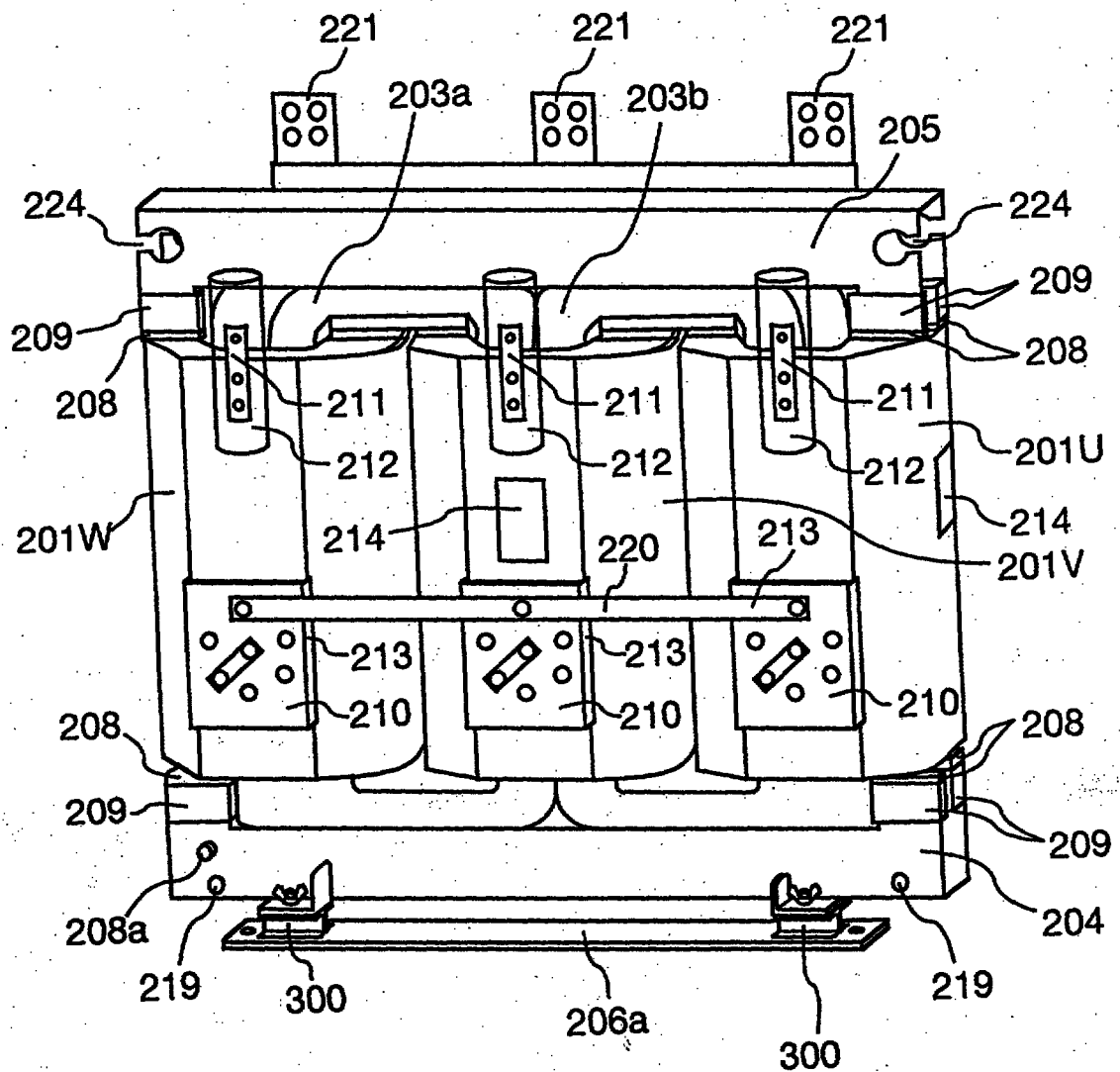
FIG. 7



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FIG. 8



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FIG. 9

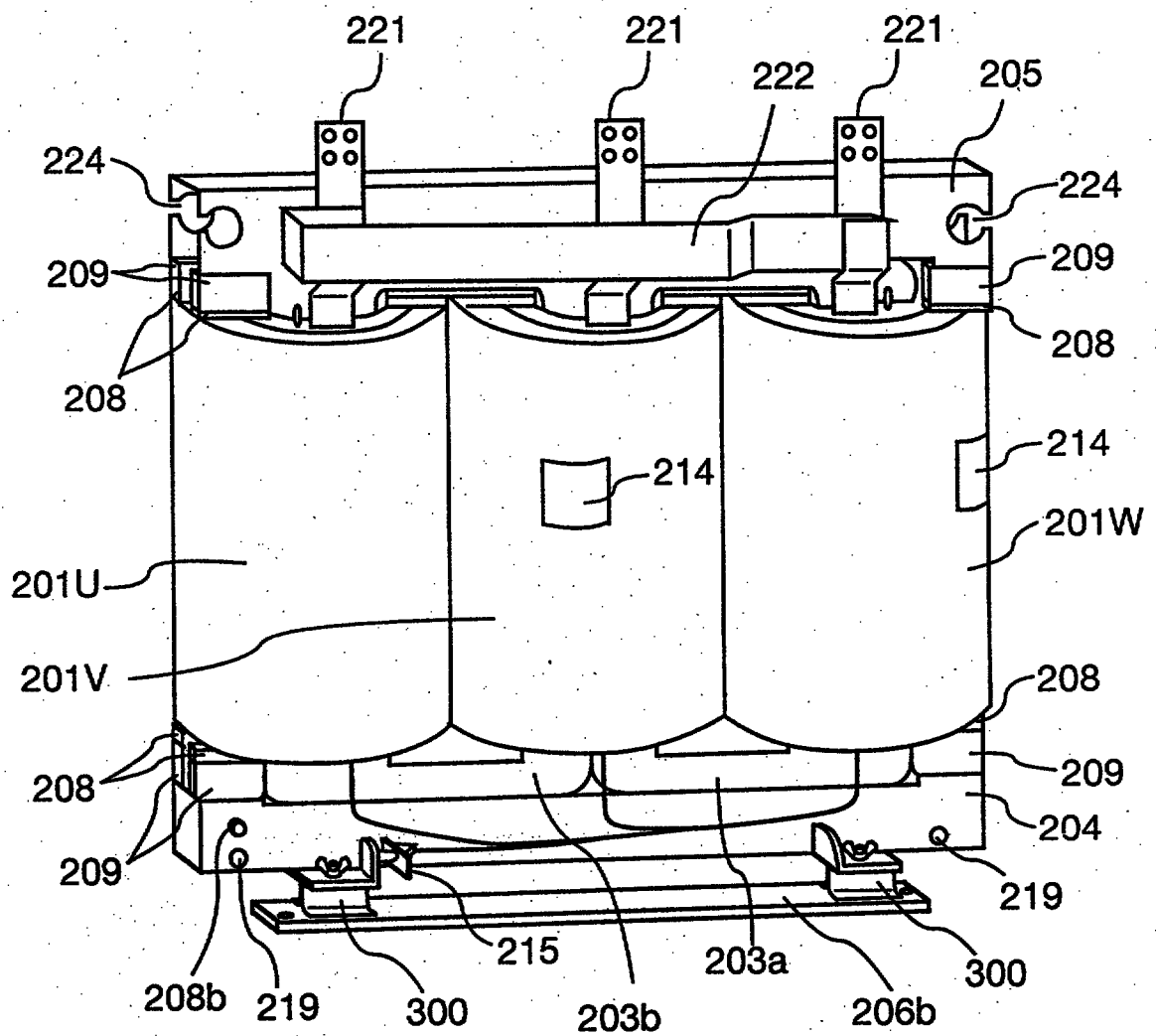
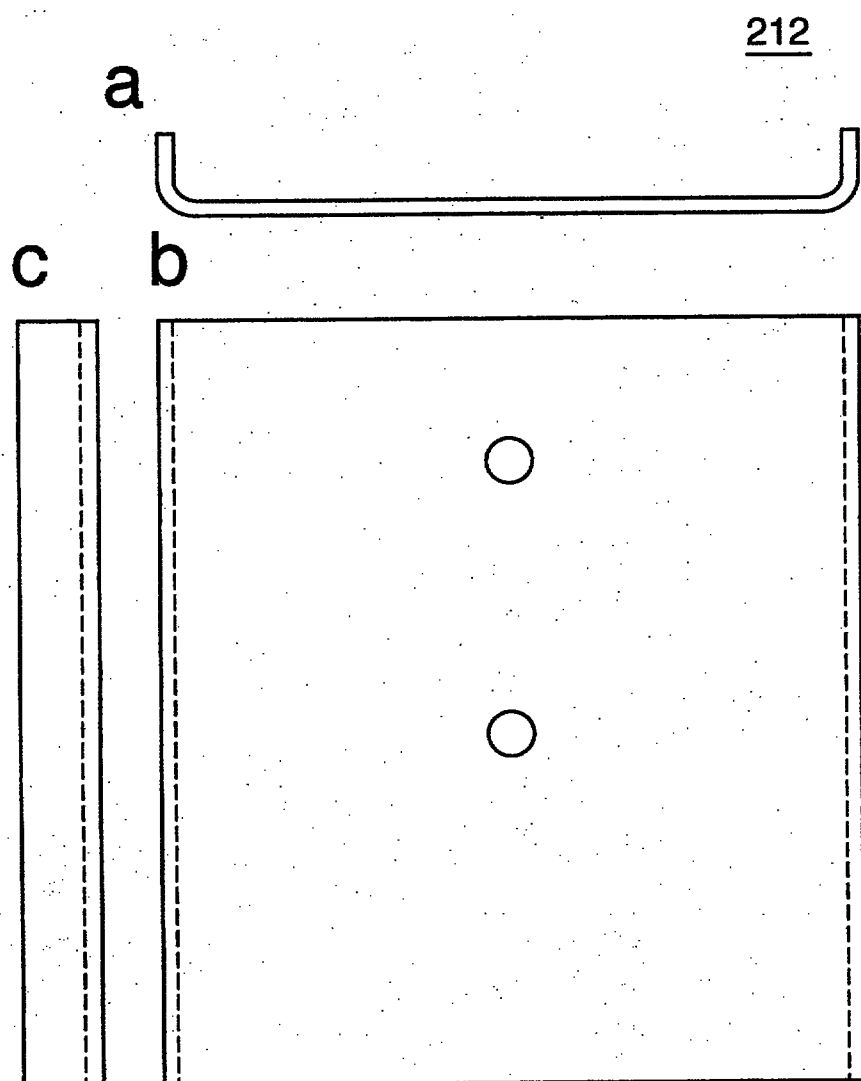


FIG. 10

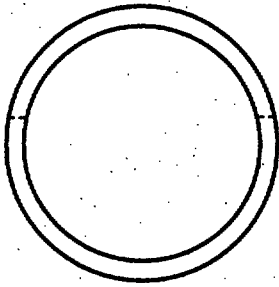


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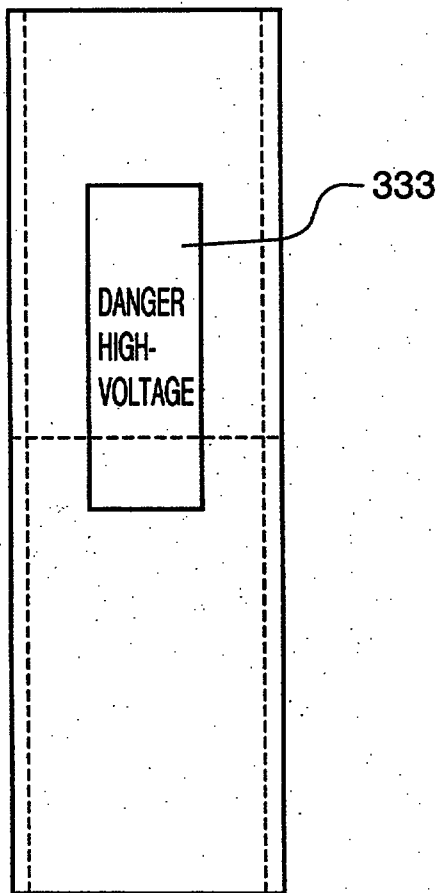
Date: 17 MAY 1996

FIG. 11

a

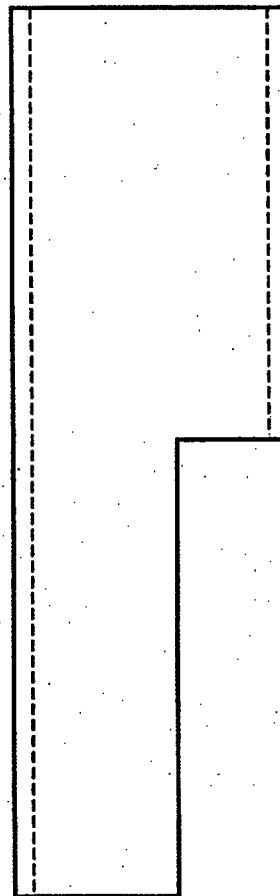


b



213

c

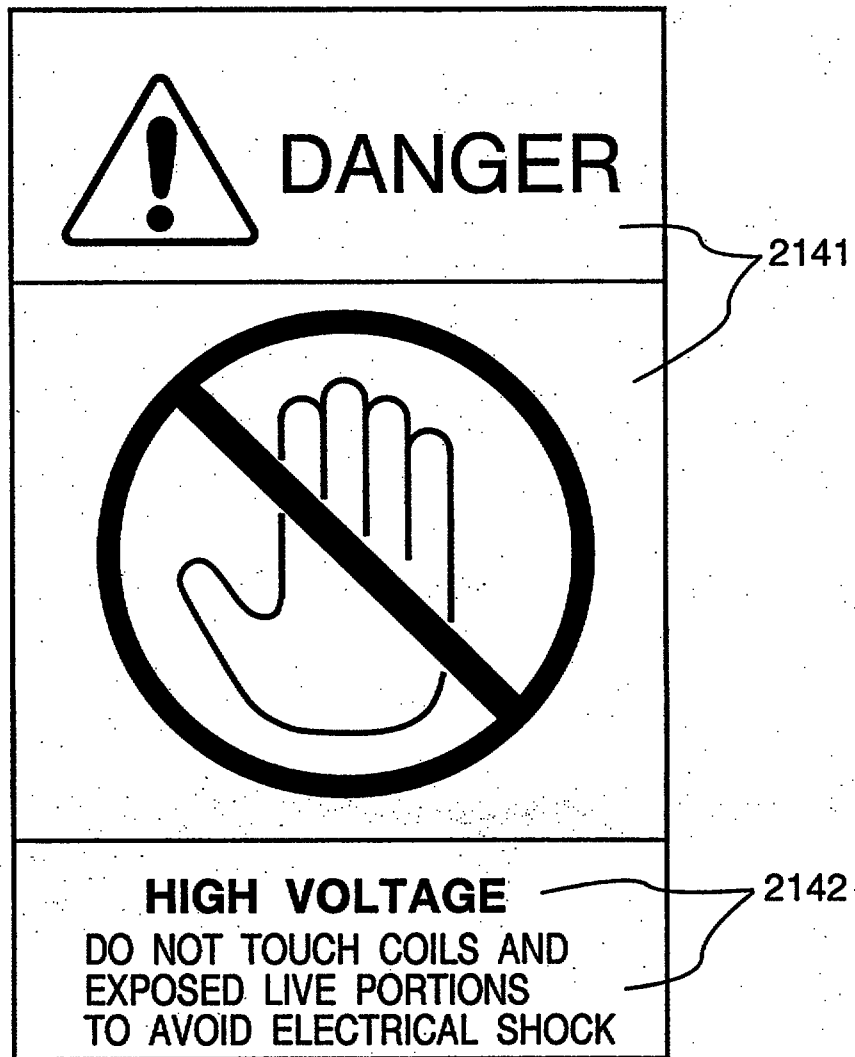


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Date: 17 MAY 1996

FIG. 12

214



1-7520000

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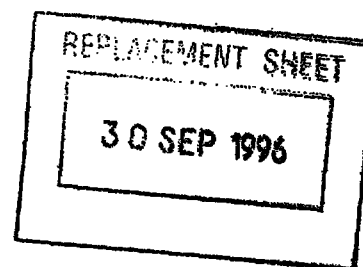
Date: 17 MAY 1998



TEXT OF THE ABSTRACT

To obtain a transformer comprising resin molded coils (1,2) having superior insulation humidity resistance and mechanical strength performed glass mats (23) are embedded between the coils (12) and an inner and outer insulating sheets (22). The glass mats (23) are formed by knitting glass fiber and are cut to predetermined size. The insulating sheets (22) comprise a prepreg sheet composed of glass cloth sheet and epoxy resin impregnated in the glass sheet. Epoxy resin (25) is cast between the semicured prepreg sheet (22) and the inside and outside peripheries of the coil body (12) penetrating the glass mats (23).

Figure 1



WHAT IS CLAIMED IS:

1. A resin molded transformer comprising a resin molded coil, which comprises a coil of wound conductor and insulating resin layer covering an external surface of said coil, iron cores inserted to said resin molded coil, wherein said resin molded coil includes an insulating sheet wound around inner periphery and outer periphery of said coil, a plurality of insulating fiber mats of predetermined size which are formed by knitting glass fiber and disposed between said coil and said insulating sheet, and an insulating resin layer cast and hardened between said coil and said insulating sheet so as to penetrate into said insulating mats.

2. A resin molded transformer as claimed in claim 1, wherein said coil includes heat resistant inter-layer paper.

3. A resin molded transformer as claimed in claim 1, wherein said iron core is formed by winding amorphous metal foils.

4. A method of manufacturing a resin molded coil by disposing an insulating members at inner periphery and outer periphery of a coil having wound conductor, and molding said coil with thermo-setting resin, comprising the steps of;

disposing first resin pregnant insulating members around an inner mold which is served as a coil mandrel and casting mold,

forming a coil by winding conductor around said inner mold with said first insulating members,

disposing second resin pregnant insulating members around said coil,

winding a flexible metal plate which is served as a outer mold around said coil with said second insulating members,

casting resin into a space formed between said inner mold and outer mold and hardening said resin.

