April 4, 1967 | J. A. ROSS | 3,312,919

SHIELDED TRANSFORMERS

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FIG. 1.

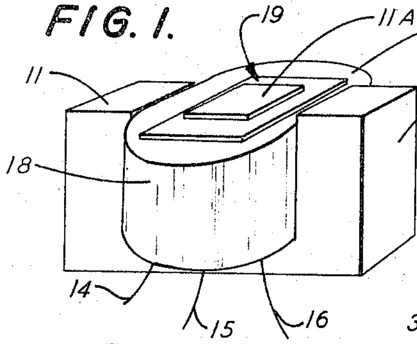
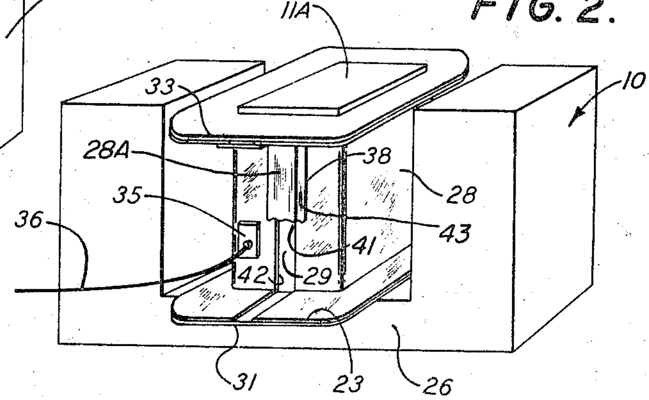


FIG. 2.



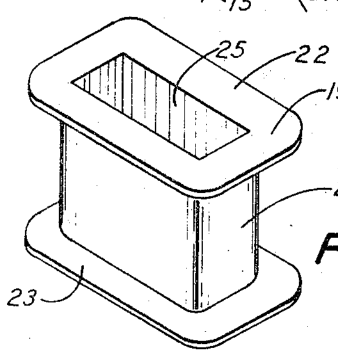


FIG. 3.

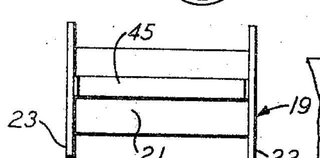


FIG. 4.

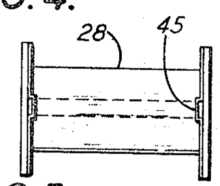


FIG. 5.

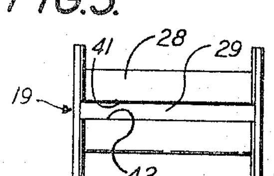


FIG. 6.

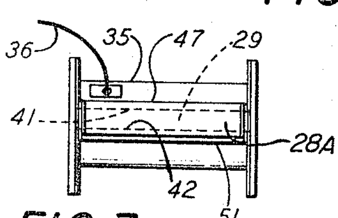


FIG. 7.

FIG. 8.

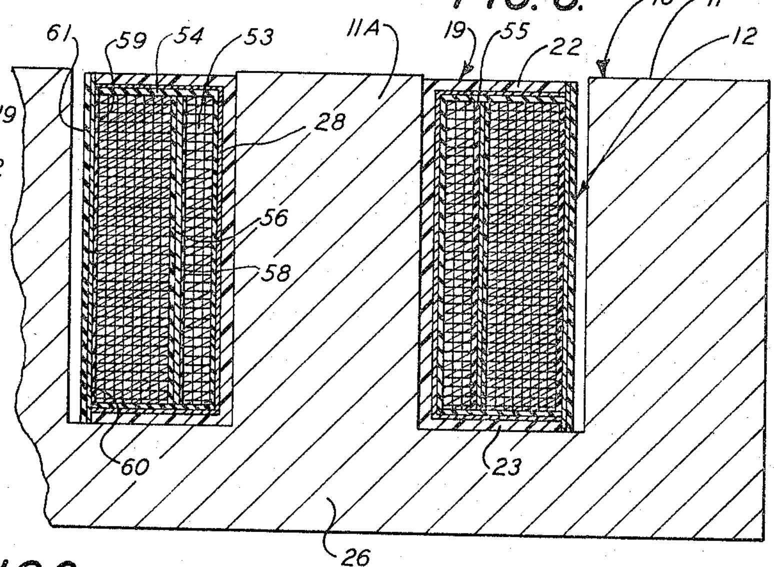


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FIG. 9.

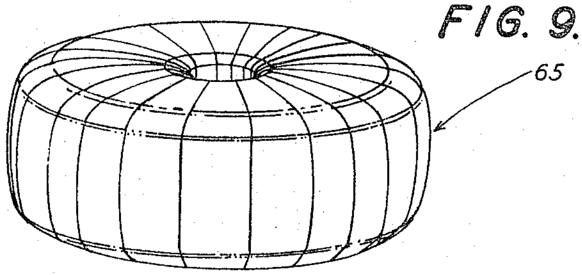
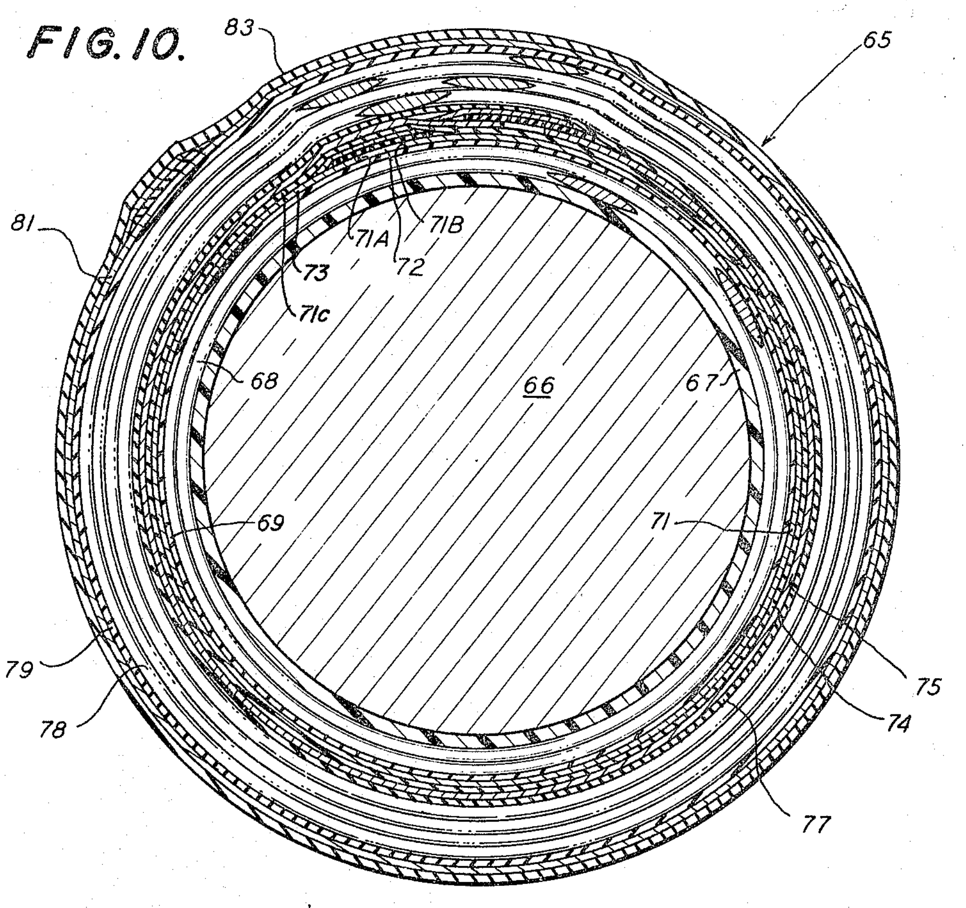


FIG. 10.



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United States Patent Office

3,312,919

Patented Apr. 4, 1967

3,312,919

SHIELDED TRANSFORMERS

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Filed Dec. 30, 1963, Ser. No. 334,219
2 Claims. (Cl. 336—84)

The invention relates to shielded transformers, more particularly to so-called miniature transformers, and to the method of fabricating such shielded transformers.

The present day sophistication of electrical and electronic instruments and components has led to many attempts to reduce the size of included parts so that the multiplicity of parts does not result in impractical bulk. Heretofore the so-called miniaturization of shielded transformers has been limited by the irreducible thicknesses of the various insulating and shielding materials.

Recent chemical advances have made possible the development of insulating materials which may be applied by spraying or taping the involved electric components. New liquid conductive materials, such as the E. I. du Pont de Nemours & Company air dry silver preparations, have added great flexibility to the design of conductive patterns.

My invention utilizes these new advances in the field of materials and results in shielded transformers of appreciably less bulk than heretofore possible. The invention contemplates a shielded transformer that comprises a first winding of conductive wire about an insulated core and a first insulating layer about the first winding. A first shielding coating about the first insulated winding has separated coating edges defining a coating gap. The coating is preferably of a dried liquid conductive material, such as that mentioned above, that is otherwise continuous about the insulated winding. A first insulating strip covers the gap between the edges of the shielding coating. The strip overlaps the coating on either side of the edges so that a second coating of a dried liquid conductive material on the insulating strip joins one edge of the first coating and overlies but does not join the second edge of the first shielding coating. A foil patch having a conductive lead is fixed to the outer surface of the coating. A second insulating layer covers the shielding coatings and the foil patch, but permits the conductive lead to extend exteriorly. A second winding of conductive wire about the second insulating layer has a third insulating layer about it. A second thin shielding coating of dried conductive liquid and having separated edges defining a coating gap covers the outer surface of the third insulating layer. A second insulating strip overlies the interval between the separated edges of the second shielding coating and has a conductive coating applied thereon in the manner described for the first insulating strip. A second foil patch with a conductive lead is fixed to the shielding coating and a fourth insulating layer covers the conductive coatings with the electrical lead extending from the foil patch externally. Means may also be provided for external connection with the first and the second conductive windings.

The insulated transformer coil may be insulated by a molded phenolic covering, or may be insulated from the windings by a bobbin of a suitable insulating material.

The insulating layers may be of dielectric tape, sprayed coatings, or dipped solutions.

The shielding coating obviously can be applied in a very thin layer by conventional painting methods. Because material need not be folded or overlapped to conform to shape, the bulk of the shielding is considerably reduced. This is particularly true of toroidal transformers wherein the warped surfaces do not lend themselves to linear wrapping.

The invention includes a process for fabricating a

shielded transformer such as that defined above. The process comprises the steps of winding conductive wire about an insulated transformer core and applying a first layer of insulation material completely about the windings. Such layer may be applied by wrapping, dipping or spraying. An area of the insulation surface is masked and a thin coating of liquid conductive material applied over the exposed surfaces of the first layer of insulation material and the masked area. The liquid conductive material is then dried, forming a conductive shielding about the insulated first winding. The coated masking is removed to break the continuity of the shielding coating. A second layer of insulating material is applied to the unshielded area left by the removal of the masking. The second layer extends beyond each edge of the uncoated first layer of insulation. A conductive foil patch with a wire lead is applied to the coated surface after the conductive material is dried. A second thin coating of liquid conductive material is applied to a portion of the second insulating layer so that the second coating makes contact with the applied conductive coating at one edge of the second insulating layer without making contact at the other edge of the conductive coating. The two applied coatings of conductive material are such that the entire outer periphery of the first insulated layer is surrounded and thus shielded by an electrically discontinuous conductive shield. The second liquid conductive coating is then dried and an insulating layer is applied about the entire shielded surface.

The method and apparatus described can be utilized for, and result in, miniature transformers of many configurations. The invention has successfully been utilized with transformers of conventional toroidal, U, C, E, I, cup and L-shaped transformer cores. Each transformer, regardless of its configuration, may be made smaller than conventionally because of the invention. Much production time is also saved by the inventive fabricating process described.

These and other advantages of the invention are apparent in the following detailed description and drawing in which:

FIG. 1 is a schematic perspective view of a conventional E-shaped transformer having a center winding in accordance with the invention;

FIG. 2 is a side elevation of the embodiment of FIG. 1, partly broken away;

FIG. 3 is a perspective view of an insulated wire bobbin for use on a transformer core;

FIGS. 4–7 are side elevational views of the bobbin of FIG. 3 illustrating the steps of electrostatically shielding the bobbin;

FIG. 8 is a fragmentary sectional elevation of the transformer of FIG. 1, taken along line **8—8** of FIG. 1;

FIG. 9 is a perspective view of a shielded toroidal transformer in accordance with the invention; and

FIG. 10 is an enlarged sectional elevation taken along line **10—10** of FIG. 9.

In FIG. 1 a transformer **10** in accordance with the invention has the conventional E configuration core **11**. The core may be a laminar core. About the central post **11A** of the core are the insulated and electrostatically shielded windings **12** from which electrical leads, such as the wires **14, 15, 16** extend. An outer insulating layer **18** surrounds the windings **12**, and in FIG. 1, conceals the components of the windings. The windings are about a bobbin **19**, preferably of dielectric plastic material. Bobbin **19** is shown in more detail in FIG. 3.

The bobbin has a hollow shank **21** terminating at opposite ends in flanges **22, 23**. A central aperture **25** extends through the shank of the bobbin. Aperture **25** conforms to the general exterior configuration of central post **11A** of the transformer core.

In FIG. 2 the bobbin without its electrical windings is shown in place about post **11A** of transformer core **10**. Lower flange **23** of the bobbin rests upon a back **26** of the E-shaped core. The bobbin has an electrostatic shielding coating **28** that covers shank **21** of the bobbin and the inner surfaces of flanges **22** and **23**. This covering of shielding conductive material is interrupted by a continuous shielding gap **29**. As shown in FIG. 2, the gap is continuous from outer edge **31** of flange **23** and across the flange, the shank, and flange **22** to the outer edge **33** thereof.

The conductive electrostatic shielding coating is preferably applied as a liquid by dipping, spraying, or by brush and then dried to a smooth, uniformly thin layer. A small conductive foil patch **35**, having a conductive wire lead **36** secured thereto, is fixed to the bobbin by adhering it to some convenient portion of the shielding coating. An insulating strip **38**, which is partly broken away in FIG. 2, overlies gap **29** and overlaps the edges **41**, **42** of the shielding coating. A secondary shielding coating **28A** covers all but a small border area **43** of strip **38**.

The method whereby the bobbin is shielded is illustrated in FIGS. 4 through 7. In FIG. 4 the bobbin **19** has applied thereto a narrow elongate masking strip **45** which extends across bobbin shank **21** and outwardly from the shank across both flanges **22** and **23** to break the electrical continuity of conductive shielding coating **28**. In FIG. 5 the entire unmasked outer surface of the shank and inner surfaces of the flanges are covered with electrostatic shielding coating **28**, as described above. The masking strip **45** is also covered to make less exacting the task of applying the liquid conductive coating to the bobbin.

After the liquid coating has been dried, the masking strip **45** is carefully removed. The bobbin then has a discontinuous electrostatic shielding coating **28** having a gap **29** defined by the aforesaid coating edges **41**, **42**, as shown in FIG. 6. In FIG. 7 the shielded bobbin has applied thereto a first insulating strip **47** that adheres to the shielding coating on both the shank and the flanges of the bobbin and extends slightly beyond edges **41** and **42** on both the shank and the flanges. The conductive foil patch **35** and its lead **36** may be applied to the bobbin at the same stage as the application of the first insulating strip. A thin added layer **28A** of liquid conductive material is then applied to the insulating strip **47**, making electrical contact with the dried shielding coating **28** adjacent edge **41**. Note that the added liquid coating does not extend beyond border **51** of the first insulating strip **46** and is therefore out of contact with the first applied shielding coating adjacent the border, but overlies the shielding coating immediately adjacent edge **42** of gap **29**. The adding layer may also be extended to include the foil patch to insure perfect contact.

After the bobbin has been prepared as illustrated in FIGS. 4–7, conventional transformer windings **53** are wound about the shank of the bobbin over an insulating layer **54** that is applied about the shielding coating **28** on the bobbin. After the requisite number of turns are wrapped about the bobbin, a second insulating layer **55** is applied over the winding. A second masking strip is then applied to the insulating layer **55** and the exposed insulating layer is coated with a thin liquid shielding material, encompassing the masking strip. After the conductive coating **56** is dried, the masking strip is removed to make discontinuous the conductive path of the electrostatic shielding coating about the insulating layer. A second insulating strip and a second lead-bearing conductive foil patch **57** are then applied to the dried shielding coating in the manner described previously with respect to bobbin **19**. The second insulating strip is then coated with a shielding coating, as previously described, to complete the electrically discontinuous shielding coating about the entire insulating layer.

The shielding coating is covered by a third insulating layer **58** about which second transformer windings are wound. These second windings are then covered by an insulating layer **59** shielded in the manner previously described by a shielding coating **60** which is covered by an insulating layer **61**.

Since the objective of the method and apparatus of the invention is to achieve the most compact transformer unit possible, it is preferable that the insulating layers employed in the combination also be as thin as electrically possible. The insulating layers may be thin dielectric ape wrapped about the components of the transformer or may be sprayed or dipped coatings that harden into a dielectric layer.

In accordance with conventional practice, each electrostatic shielding coating has an electrical lead **36** extending externally of the last insulating layer, as do the leads from the windings themselves extend. Conventional electrical circuitry is employed to connect the transformer of the invention in the desired circuit. The method described above results in a transformer with much less bulk and weight than conventional transformers capable of performing the same functions. In addition to a saving in size and weight, the use of fast drying liquid elements lessens the material and labor costs usually necessary to produce transformers of the same quality. While the transformer illustrated has been one of conventional E-core configuration, the invention is equally applicable to transformer of C, U, EI or toroidal core configurations.

A toroidal transformer **65** is illustrated in FIGS. 9 and 10. Transformer **65** has in insulated core **66** of toroidal configuration. Conventionally the core is of silicone steel and may have a phenolic insulating molding **67**. A first winding **68** of conductive wire surrounds the core. A first insulating layer **69** covers the first windings.

While wrapped windings of insulated tape are used in the illustrative embodiment, other suitable insulating layers may be used, such as fast drying liquid coatings applied by dipping or spraying.

A first thin electrostatic shielding coating **71** forms a discontinuous coating about the insulating layer **69**. A conductive gap **72** defined by terminal edges **71A**, **71B** of the shielding coating (see FIG. 10) precludes electrical shorting of the shielding coating. A masking strip **73** having a shielding coating **71C** over the major portion of its exterior completes the shielding about the first winding. The masking strip coating is electrically connected only to edge **71A** while overlapping edge **71B**.

A second insulating layer **74** completely covers the shielding coating **72**. A second discontinuous electrostatic shielding coating **75** surrounds the second insulating layer **74**. The second coating **75**, while electrically discontinuous, completely surrounds the insulating layer by combining with a coated mask similar to the masking strip **73** described with respect to first shielding coating **71**.

A third insulating layer **77** completely covers the second shielding coating **75**. A second winding **78** of conductive wire is wound upon the insulating layer in spiral fashion about the toroidal shape. The second winding is covered by a fourth insulating layer **79**, in turn surrounded by a third discontinuous electrostatic shielding coating **81**. The entire toroidal shielded transformer thus far described is covered by a final insulating layer **83**. All of the shielding coatings are of a dried liquid conductive material.

Leads from each of the first and second windings, and from the conductive electrostatic shielding coatings extend externally of the transformer. Such leads may be fixed to the shielding coatings in the manner described for the embodiment illustrated by FIGS. 1–7. The shielded toroidal transformer shown in FIGS. 9 and 10 is extremely compact, yet very efficient electrically because of the doubly shielded windings.

The method whereby the described shielded toroidal transformer is fabricated is as follows: the first transformer windings are wrapped about the insulated core. The windings are then covered with an insulating layer such as insulating tape. A first narrow masking band is placed on the insulating tape in a complete circle about the outside of the toroid. A thin conductive liquid coating is then applied over the insulating tape and by the mask by spraying, dipping or brushing. The coating is dried and the masking band peeled from the insulating tape, leaving a nonconductive gap defined by the terminal edges of the conductive coating. An insulating strip is placed over the uncoated area left by the removal of the masking strip. The insulating strip overlaps the coating at each edge completely around the toroid. A liquid conductive coating is then applied by brushing or spraying to the major part of the insulating strip, contacting the previous conductive coating near one of its edges and overlying the second edge of the previous conductive coating without making electrical contact therewith. The second coating is dried. The entire toroid is surrounded by the conductive electrostatic shielding coating but the coating is an incomplete conductive path. A foil patch having a lead-out wire is then adhered to the shielding coating. It is preferable that the patch is covered with additional liquid conductive coating at the same time that the insulating strip is coated, to insure good electrical contact.

A second insulating layer is applied to the now shielded toroid. A second transformer winding of conductive wire is wrapped about the insulating layer. The second winding is then insulated, and then shielded by a further discontinuous conductive electrostatic shielding coating applied in liquid form to the insulating layer in the manner previously described. A final insulating layer is placed about the insulated and shielded toroidal transformer windings after a foil patch with a lead-out wire is fixed to the shielding coating. The external wires for the transformer windings are of course made externally accessible through the insulating and shielding layers.

Variations of method and apparatus within the scope of the invention will occur to those skilled in the art. While standard transformer configurations have been referred to illustratively, the invention is applicable to a variety of transformer and transformer core shapes. Split windings and multiple transformer stage windings are equally within the scope of the invention. Therefore, I wish that the invention be measured by the appended claims rather than by the purely illustrative embodiments disclosed herein.

I claim:

1. An electrostatically shielded transformer comprising an insulated transformer core, a first winding of conductive wire about the insulated core, a first insulating layer about the first winding, a first electrostatic shielding coating about the insulated first winding, a coating gap defined by separated coating edges, said coating being of a dried liquid conductive material continuous between its separated edges, a first insulating strip more than spanning the gap between the edges of the shielding coating, an added coating of a dried liquid conductive material on the insulating strip such that the added coating electrically joins one edge of the first coating and overlies but does not electrically join the second edge of the first shielding coating, a conductive lead extending externally from the shielding coating, a second insulating layer covering the electrostatic shielding coatings, a second winding of conductive wire about the second insulating layer, a third insulating layer about the second conductive windings, a second electrostatic shielding coating of dried conductive liquid having separated edges defining a coating gap and applied to the outer surface of the third insulating layer so that the coating is continuous between its separated edges, a second insulating strip overlying the interval between separated edges of the second shielding coating and extending over the coating on each side of the separated edges, an added conductive coating on the second insulating strip electrically joining one edge but electrically separate from and overlying the other edge, an electrical lead fixed to the second shielding coating, a fourth insulating layer covering the conductive coatings such that the electrical lead extends externally, and means for external connections to the first and the second conductive windings.

2. An electrostatically shielded transformer comprising an insulated transformer core, a first winding of conductive wire about the insulated core, a first insulating layer about the first winding, a first thin electrostatic shielding coating about the insulated first winding, separated coating edges defining a narrow coating gap making the coating electrically discontinuous, said coating being of a dried liquid conductive material continuous between its separated edges, a first insulating strip spanning the gap between the edges of the shielding coating and fixed to the coating, an added coating of a dried liquid conductive material on the insulating strip such that the added coating electrically joins one edge of the first coating and overlies but does not electrically join the second edge of the first shielding coating, a foil patch having a conductive lead extending therefrom fixed to the shielding coating, a second insulating layer covering the electrostatic shielding coating and the foil patch so that the conductive lead extends exteriorily therefrom, a second winding of conductive wire about the second insulating layer, a third insulating layer about the second conductive windings, a second thin electrostatic shielding coating of dried conductive liquid having separated edges defining a coating gap and applied to the outer surface of the third insulating layer so that the coating is continuous between its separated edges, a second insulating strip overlying the interval between separated edges of the second shielding coating and extending over the coating on each side of the separated edges, an added conductive coating on the second insulating strip electrically joining one edge but electrically separate from and overlying the other edge, a second foil patch having an electrical lead and fixed to the shielding coating, a fourth insulating layer covering the conductive coatings such that the electrical lead extends externally from the foil patch, and means for external connections to the first and the second conductive windings.

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