

April 3, 1962

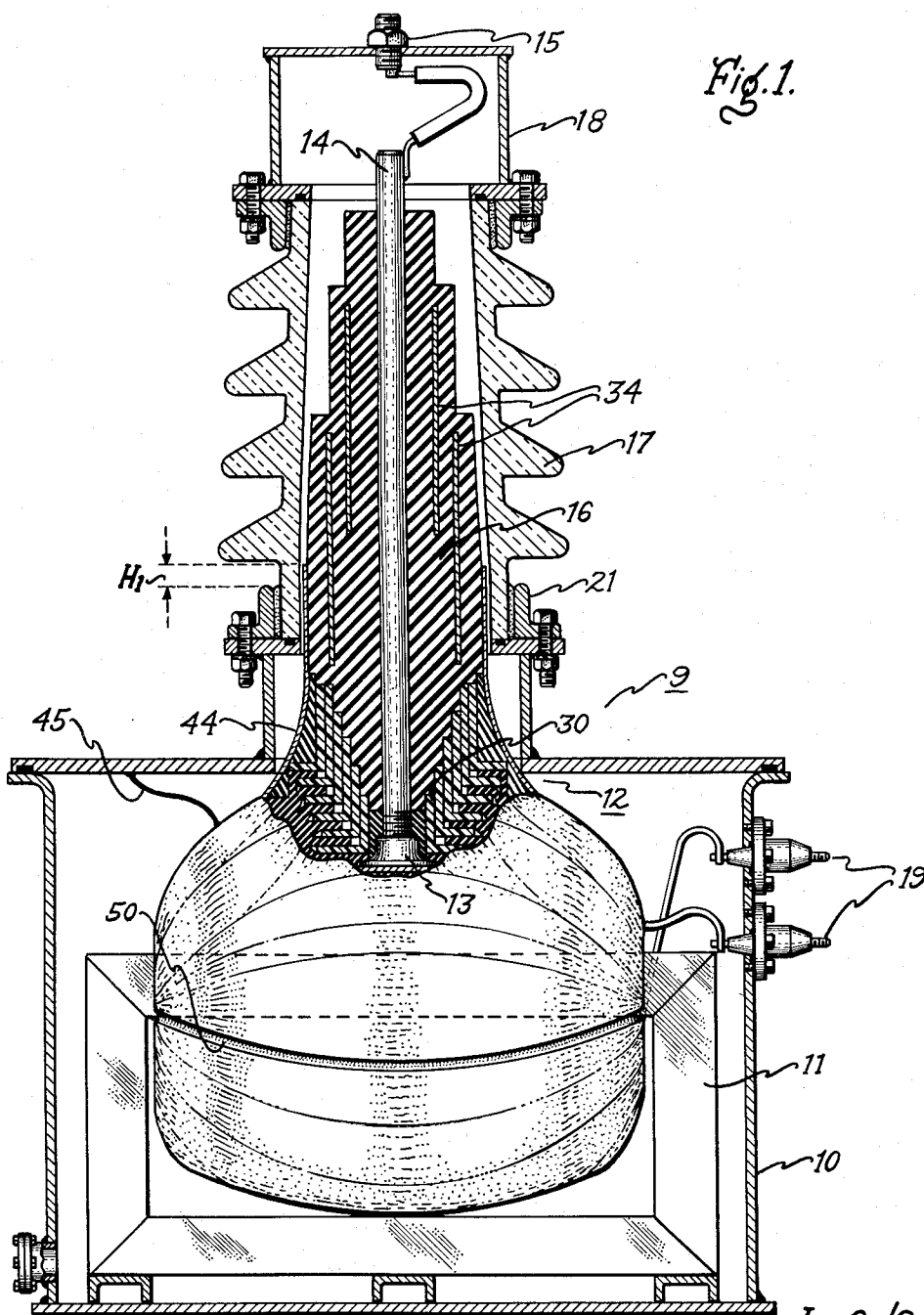
G. CAMILLI

3,028,568

POTENTIAL TRANSFORMER

Filed Sept. 28, 1960

4 Sheets-Sheet 1



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April 3, 1962

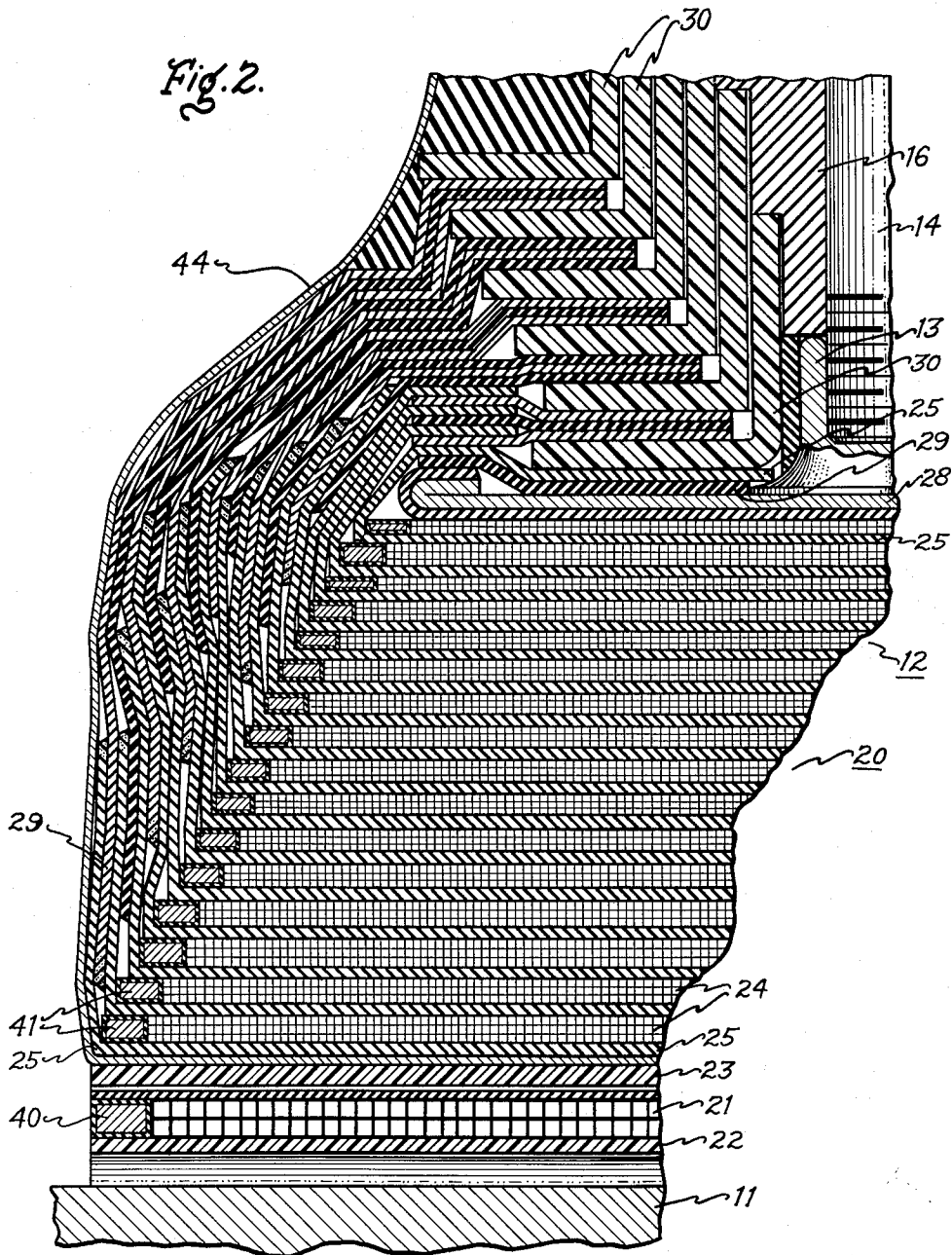
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POTENTIAL TRANSFORMER

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4 Sheets-Sheet 4

Fig. 4.

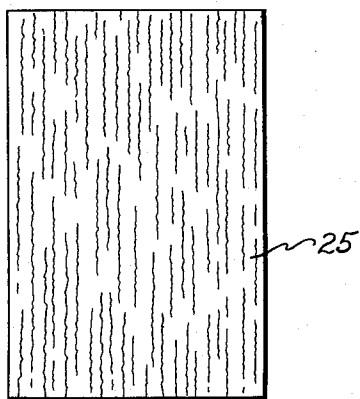


Fig. 5.

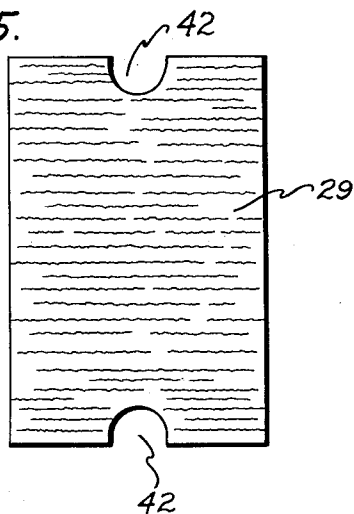


Fig. 6.

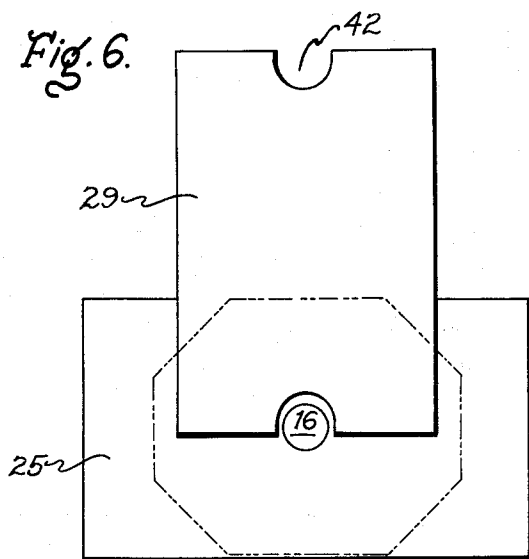


Fig. 7.

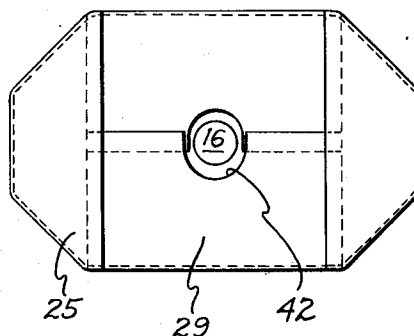
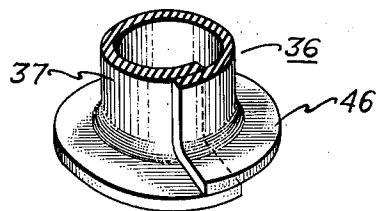


Fig. 8.



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3,028,568

POTENTIAL TRANSFORMER

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10 Claims. (Cl. 336—70)

This invention relates to transformers and more in particular to potential transformers for use in high voltage transmission line systems for the operation of relays and for the measurement of electrical power.

In high voltage electrical systems it is frequently desired to provide protectors and indicating systems responsive to the voltage in the system. Since the extremely high voltages encountered in such systems are not utilizable directly for such purposes, it has been common to employ potential transformers connected to the systems to provide a low voltage output that is proportional to the voltage of the system. In essence a potential transformer is very similar to a power transformer in that it must withstand operating as well as transient and lightning voltages. An important difference between the two types of apparatus however occurs in their power outputs and the related internal losses. The load on a potential transformer usually consists of only relays, voltmeters and other voltage sensitive devices with a total "burden" of only a few watts. In a power transformer, however, the power output is very large and the dissipation of the internal losses is of considerable concern to the designer.

In the past potential transformers have often been designed and built like miniature power transformers with similar insulating structures. In a power transformer solid insulation (which is also used for the mechanical support of the coils) is generally alternated with insulation oil ducts. In addition, the insulating oil ducts are also used for cooling purposes. Since there is no appreciable heat to be dissipated in a potential transformer, its insulation can be much more simplified and arranged in a much more compact and efficient manner. One arrangement for accomplishing this has been the use of interleaved laminations of crepe paper insulating material wrapped around the transformer windings as shown in my United States Patent 2,359,544, assigned to the same assignee as this invention. To prevent creepage and puncture, an unbroken insulating path or barrier must be provided between the conductor layers and the exterior of the winding. However, to accomplish this, previously employed arrangements for wrapping crepe paper have required that the laminations be either slit, or wetted and then dried in order that they can be folded so as to snugly fit around the ends of the winding.

Accordingly, it is an object of this invention to provide an improved transformer.

Another object of this invention is to provide an economical potential transformer for use in conjunction with high voltage transmission systems.

A further object of this invention is to provide a potential transformer which incorporates a novel insulating system with the net result that the size and the weight of the unit is greatly reduced from those built in the past.

Another object of the invention is to provide a potential transformer insulated by interleaved insulating laminations that need not be slit or wetted during fabrication of the apparatus.

A still further object of this invention is to provide an integral insulated high voltage winding and lead assembly for electrical apparatus.

Other objects and advantages of my invention will become apparent from the following specification, including the drawings and claims.

Briefly stated, according to one aspect of my invention,

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a transformer winding may be wrapped with laminations of flexible insulating material that are interleaved with each other and with insulating collars surrounding a lead from the winding so as to provide an integral insulated assembly.

It is believed that the invention will be better understood from the following description taken in connection with the accompanying drawings in which,

FIG. 1 is a cross-sectional partially broken away view of a potential transformer according to one embodiment of my invention.

FIG. 2 is a cross-sectional view of a portion of the transformer of FIG. 1.

FIG. 3 is a cross-sectional view, partially in phantom, of another embodiment of a transformer in accord with the teachings of my invention.

FIG. 4 is a plan view of a lamination of flexible insulation employed in the transformer of FIGS. 1-3.

FIG. 5 is a plan view of another lamination of flexible insulation employed in the transformer of FIGS. 1-3.

FIG. 6 is a plan view schematically illustrating the positions occupied by the laminations shown in FIGS. 4 and 5 before they are interleaved.

FIG. 7 is a plan view corresponding to FIG. 6 illustrating the positions of the laminations after they are interleaved.

FIG. 8 is a partially cross-sectional side elevation of an insulating collar employed in the embodiment of FIG. 3.

Referring now to the drawing, and more in particular to FIG. 1, therein is illustrated a single bushing potential transformer 9 in accord with the teachings of my invention. The transformer 9 may comprise a tank 10 which encloses a core 11 made from a stack of flat strips of grain-oriented silicon steel. The tank 10 may be filled with an insulating fluid, such as transformer oil. As shown in FIG. 2, the winding 12 comprising a high voltage coil 20, a low voltage coil 21, and a high voltage lead 14 is disposed in the tank 10 around a portion of the core 11. The high voltage coil 20 and lead 14 comprise an integral winding assembly and may be electrically connected by a metallic connector member 13, which is threaded on the high voltage lead 14. The lead 14 is connected to a line terminal 15.

In the embodiment of FIG. 1 the insulation for the high voltage lead 14 is a unitary insulating member 16 having a plurality of spaced, staggered stress equalizers 34 embedded therein. The insulating member 16 and lead 14 may be fabricated as a unit or assembly prior to the wrapping of the windings and then assembled on the connector 13, as will be explained in paragraphs that follow. The lead 14 extends into a porcelain bushing 17, which may be bolted to the tank 10 by means of a clamping ring 21. The tank 10 may also be provided with an expansion chamber 18, and low voltage terminals 19 according to conventional practice. The outer surface of the high voltage winding assembly may be enveloped by a layer 44 of electrical conducting material forming a ground shield which extends over a portion of the insulated member 16 to a level H_1 slightly above the clamping ring 21.

Referring now to FIG. 2, the construction of the winding 12 is shown in greater detail. The low voltage coil 21 may be layer wound in the conventional manner over an insulating cylinder 22, and provided with end shields 40. Another insulating cylinder 23 may then be placed over the low voltage coil 21 for supporting the high voltage winding assembly. The high voltage coil is made from a plurality of axially-wound radially-spaced layers 24 of insulated conductor material, and may also be provided with end shields 41.

The coil 20 is provided with my improved insulating

arrangement in the following manner. A first lamination 25 comprising several sheets of stretchable, flexible insulating material, such as crepe paper, is first wound around a conventional winding cylinder (not illustrated). When crepe paper is employed as the flexible insulation, the sheets forming the laminations 25 should be compressed without stretching before being used in order to increase the density and space factor of the layer insulation. The crepe paper laminations 25 should have a "stretch" of at least 50%, meaning for example, that a ten inch length should stretch to at least 15 inches. The crepe paper should also be sufficiently porous to absorb the dielectric fluid in the tank 10. The thickness of the various laminations 25 is determined by the dielectric stress between the conductor layers. A lamination 25 is shown as a developed surface in FIG. 4 with the direction of creping being indicated by the irregular lines. Next, one or more layers of insulated conductor material are wound axially along the lamination 25 to form a first layer 24 of the high voltage coil. The lamination 25 is longer than the layer 24 and extends beyond the edges thereof at opposite ends of the coil. Next, a second insulating lamination 25 is placed around and over the conductor layer 24, and the high voltage coil 20 is thus progressively wound to completion by alternating layers of conductor and laminations of insulation. It should be noted from FIG. 2 that the width of the successive laminations 25 and layers 24 gradually decreases in the axial direction as the coil is wound. This helps to improve the voltage distribution between conductor layers inasmuch as the series capacitances, which is proportional to the exposed surfaces between layers, is approximately the same if the width of the layers is decreased as diameter of the winding layers is increased.

The winding of the high voltage coil 20 is completed by placing a metallic shield 28 over the last layer. This shield may be insulated from the last high voltage layer by a folded lamination of the flexible insulation, and the shield is electrically connected to the last turn of the high voltage coil. A connector member 13 may then be attached to the shield 28. At this point the high voltage coil 20 resembles a tapered cylindrical body with the ends of the insulating laminations 25 protruding beyond its ends.

The remainder of the insulation is applied to the coil in the following manner. A second lamination 29 of flexible insulating material, such as crepe paper of the type used for the first laminations 25, is stretched around and over the shield 28. A lamination 29 is shown as a developed surface in FIG. 5, with the direction of creping being indicated by the irregular lines. Next, the protruding ends of uppermost lamination 25 are folded so as to overlap the lamination 29. To provide insulation between the connector member 13 and ground, a series of rigid flanged insulating collars 30 are nested therearound in the manner described below. The remaining first laminations 25 are progressively interleaved with additional second laminations 29 in the manner illustrated in FIGS. 6 and 7. As shown in FIG. 6, a notch 42 at one end of the laminations 29 is first mated with a collar 30. The lamination 29 is then stretched around and over the coil until its ends overlap and the notch 42 at its other end mates with and circumscribes the collar 30 also. The ends of the lamination 29 extend axially beyond the ends of the coil and are folded radially inwardly therearound. Then the extended ends of the lamination 25 are folded radially outwardly over the lamination 29. At suitable intervals additional collars 30 are nested over the assembly 16, and interleaved with the laminations 29. The direction of creping of both the first and second laminations is substantially parallel to the axis of the winding. This technique is continued until all of the first laminations 25 have been alternately interleaved with second laminations 29. The insulated lead assembly 16 is then threaded into the connector

member 13. It should be noted that the assembly 16 is progressively reduced in diameter toward its ends so as to define a series of steps. The steps at the lower end are dimensioned to mate with steps defined by the upstanding ends of the nested collars 30. Finally the high voltage coil 20 is provided with the ground shield 44, which may comprise a length of electrical conducting material, such as aluminum foil, wrapped around the winding assembly and grounded to the tank 10 by a lead 45. The shield 44 should be provided with a gap 50 in the direction of the axis of the coil to avoid having a short-circuited turn. The high voltage winding assembly is then removed from the winding cylinder and the low voltage coil 21 and insulating cylinder 23 are inserted into hole previously occupied by the winding cylinder.

FIG. 3 shows another embodiment of my invention employing an alternative arrangement for insulating the high voltage lead 14 and connector member 13 into which the lead is threaded. An insulating cylinder 31 is placed over the lead 14, and this is followed by a series of nested flanged collars 36 made from flexible insulating material. In the embodiment of FIG. 3 the portion 37 of the collars 36 extends axially for substantially the entire length of the lead 14 and is thus much longer than that of the collars used in the FIG. 1 embodiment. These extended portions 37 provide the insulation for the lead 14 and connector member 13. The flanged collars 36 are interleaved with the stretched and folded insulating laminations 25 and 29 in the same manner illustrated and described with regard to the embodiment of FIGS. 1 and 2, except that the lead 14 and member 13 may be threaded together before the collars 36 and second laminations 29 are applied to the winding. A ground shield 44 of the type previously described extends axially as far as possible along the outside of the outermost collar 36 and terminates in an annular metallic shield 34 located at a level H_2 above the bushing clamping ring 21. The terminal ends 38 of the collars 36 are folded over the annular shield 34 and secured in place in order to hold the shield 34. A tapered cylindrical piece 45 of insulating material may be placed over the cylinder 31 to help clamp the collars 36 to the desired shape. It should be noted that no equalizers are employed in this embodiment, and consequently the distance H_2 must be several times the distance H_1 in order to prevent corona.

FIG. 8 is a more detailed illustration of how the collars 36 can be fabricated. These collars may be formed from the same type of compressed crepe paper as is used for the laminations 25 and 29. The paper is rolled to a substantially cylindrical shape with its edges overlapping in a direction parallel to its axis, and with one end being stretched and spread out to form the flanged portion 46. It is thus apparent that the insulation for the high voltage lead 14 employed in the embodiment of FIG. 3 is less costly and easier to manufacture than the insulated assembly 16 and rigid collars 30 employed in the embodiment of FIGS. 1 and 2. However, because of the lack of embedded equalizers and somewhat lower insulating strength of the compressed crepe paper, the FIG. 3 embodiment requires the use of a longer ground shield 44 and also the use of the ground ring 34.

My improved insulating arrangement provides a high voltage winding assembly having an unbroken insulation path between the conductors in the winding and ground, the insulation being made from interleaved laminations of flexible stretchable material and flanged insulating collars. It has thus been demonstrated that a winding assembly in accord with the teachings of my invention can be fabricated with a minimum of wrinkling or bunching of the insulating material at the "neck" where the lead and coils come together; consequently the size of the winding assembly and the number of air pockets therein will be kept to a minimum. Furthermore, this can be accomplished without the waste of lamination material caused by slitting or cutting, and without the added

expense of wetting and drying brought about by previous insulating arrangements. Also, both embodiments described being integral winding assemblies of a high voltage coil and a high voltage lead, possess the advantage of that they are suitable for assembly line type mass production operations and can be easily handled and stored after fabrication.

It will be understood, of course, that while the forms of the invention herein shown and described constitute preferred embodiments of the invention, it is not intended herein to illustrate all of the equivalent forms or ramifications thereof. For example, an integral winding assembly insulated in accord with the teachings of my invention may also be employed under suitable conditions in electrical induction apparatus other than potential transformers. It will also be understood that the words used are words of description rather than of limitation, and that various changes may be made without departing from the spirit and scope of the invention herein disclosed, and it is aimed in the appended claims to cover all such changes as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An integral electrical winding assembly comprising a high voltage coil comprising axially-wound radially-spaced layers of insulated conductor material and high voltage lead extending therefrom, a plurality of insulating collars nested around said lead, and said coil being insulated by laminations of flexible insulating material interleaved with said layers and said collars.

2. In combination as an integral insulated assembly, an electrical winding comprising a plurality of axially-wound radially-spaced layers of insulated conductor material, a high voltage lead extending from said winding, a plurality of insulating collars nested around said lead, the conductor layers being radially separated by first laminations of flexible insulating material, each of said first laminations having an end extending beyond said conductor layers and folded radially outwardly thereof, second laminations of flexible insulating material wrapped around said winding and having an axially extending end folded radially inwardly thereof, ends of said first and second insulating laminations being alternately interleaved with each other, said second laminations having a notch in opposite edges thereof, said second laminations also being interleaved with said insulating collars, and said collars being circumscribed by said notches.

3. In combination as an integral insulated assembly, an electrical winding comprising a plurality of axially-wound radially-spaced layers of insulated conductor material, a high voltage lead extending from said winding, a plurality of flanged insulating collars nested around said lead, the conductor layers being radially separated by first laminations of flexible insulating material, each of said first laminations having its ends extending beyond said conductor layers and folded radially outwardly thereof, second laminations of flexible insulating material being wrapped around said winding and having axially extending ends folded radially inwardly thereof, ends of said first and second insulating laminations being alternately interleaved with each other, said second laminations each having a notch in opposite edges thereof, said second laminations also being interleaved with said insulating collars, said collars being circumscribed by said notches, said notches being dimensioned so that said opposite edges to overlap, and the outer surface of said assembly comprising an electrical conducting material connected to ground.

4. In combination as an integral insulated assembly, an electrical winding comprising a plurality of axially-wound radially-spaced layers of insulated conductor material and a high voltage lead extending from said winding, a plurality of flanged insulating collars nested around said lead, the conductor layers being radially separated

by first laminations of crepe paper, each of said first laminations having its ends extending beyond said conductor layers and folded radially outwardly thereof, second crepe paper laminations being wrapped around said winding and having axially extending ends folded radially inwardly thereof, ends of said first and second insulating laminations being alternately interleaved with each other, said second laminations each having a notch in opposite edges thereof, said second insulating laminations also being interleaved with said insulating collars, and said collars being circumscribed by the pair of notches on said second laminations.

5. An integral electrical winding assembly comprising a layer wound coil of insulated conductor material and a high voltage lead extending therefrom, said lead comprising a conductor rod threaded at one end, a threaded connector member electrically connected to said coil, said conductor rod threadedly engaging said connector member, a plurality of nested flanged insulating collars surrounding said rod and extending substantially the entire length thereof, said coil being insulated by laminations of flexible insulating material interleaved with the flanges on said collars and the conductor layers, the outer surface of said winding assembly comprising an electrical conducting material connected to ground, said conducting material extending around said collars for substantially the entire length of said rod, the terminal end of said conducting material being connected to a metallic shield ring surrounding said rod, an end of said collars being folded over said ring, and a tapered piece of insulating material surrounding said rod and clampingly holding said collars against said ring.

6. An integral electrical winding assembly comprising a layer-wound coil of insulated conductor material and a high voltage lead assembly extending from said coil, said lead assembly comprising a conductor rod threaded at one end and substantially enclosed by a body of insulating material having staggered stress equalizers embedded therein, an end of the insulating body being progressively reduced in diameter so as to define steps, a plurality of flanged insulating collars nested around said lead assembly so as to mate with the steps on said lead assembly, a threaded connector member electrically connected to said coil, said conductor rod threadedly engaging said connector member, and said winding being insulated by laminations of flexible insulating material interleaved with the flanges on said collars and the conductor layers of said coil.

7. A potential transformer comprising a core, a high voltage winding comprising a plurality of radially-spaced axially-wound layers of insulated conductor material around said core, a high voltage lead extending from said winding, a plurality of flanged insulating collars nested around said lead adjacent said winding, and laminations of flexible insulating material interleaved with the flanges on said collars and the conductor layers.

8. A potential transformer comprising a tank containing a dielectric fluid, bushing attached to and extending from said tank, a magnetic core in said tank, a low voltage layer-wound coil extending axially along said core, an insulated high voltage winding assembly having an integral lead extending into said bushing, said winding assembly comprising a high voltage coil surrounding said low voltage coil, said high voltage coil comprising a plurality of axially-wound radially-spaced layers of insulated conductor material, said layers being separated by first laminations of crepe paper, ends of said first laminations extending axially beyond said winding and folded radially outwardly thereof, a plurality of flanged insulating collars nested around said lead, second laminations of crepe paper being wrapped around said winding and interleaved with said flanged collars, ends of said second laminations being folded radially inwardly so as to be interleaved with said first laminations, said second laminations having a notch in opposite edges thereof, said

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collars being circumscribed by said notches, the outer surface of said high voltage winding assembly comprising an electrical conducting material electrically grounded to said tank, and a threaded connector member electrically connecting said lead and said high voltage coil.

9. A potential transformer as recited in claim 8 in which said lead is an integral assembly comprising a body of insulating material substantially enclosing said threaded rod, staggered stress equalizers embedded in said body, and end of said insulating body being progressively reduced in diameter so as to define steps, and said flanged insulating collars being nested so as to mate with said steps on said lead assembly.

10. A potential transformer comprising a tank containing a dielectric fluid, a single high voltage bushing attached to and extending from said tank, a magnetic core in said tank, a low voltage layer-wound coil extending axially along said core, shields at opposite ends of said low voltage coil, an insulated high voltage winding assembly in said tank having an integral high voltage lead extending into said high voltage bushing, said winding assembly comprising a high voltage coil surrounding said low voltage coil, said high voltage coil comprising a plurality of axially-wound radially-spaced layers of insulated conductor material, shields at opposite ends of said layers, said layers being separated by first lamina-

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tions of compressed crepe paper whose direction of creping is substantially parallel to the axis of said coil, ends of said first laminations extending axially beyond said coil and folded radially outwardly thereof, a plurality of flanged insulating collars nested around said lead, second laminations of compressed crepe paper being wrapped around said winding and interleaved with the flanges on said collars, the direction of creping of said second laminations being substantially parallel to the axis of said coil, ends of said second laminations being folded radially inwardly so as to be interleaved with said first laminations, said second laminations each having a notch in opposite edges thereof, said collars being circumscribed by said notches, said notches being dimensioned so that said opposite edges overlap, said first and second laminations being permeated by said dielectric fluid occupying said tank, the outer surface of said winding assembly comprising a length of electrical conductor material wrapped therearound and electrically grounded to said tank, a threaded connector member electrically connected to said high voltage coil and said integral high voltage lead comprising a threaded conductor rod threadedly engaging said connector member.

No references cited.