

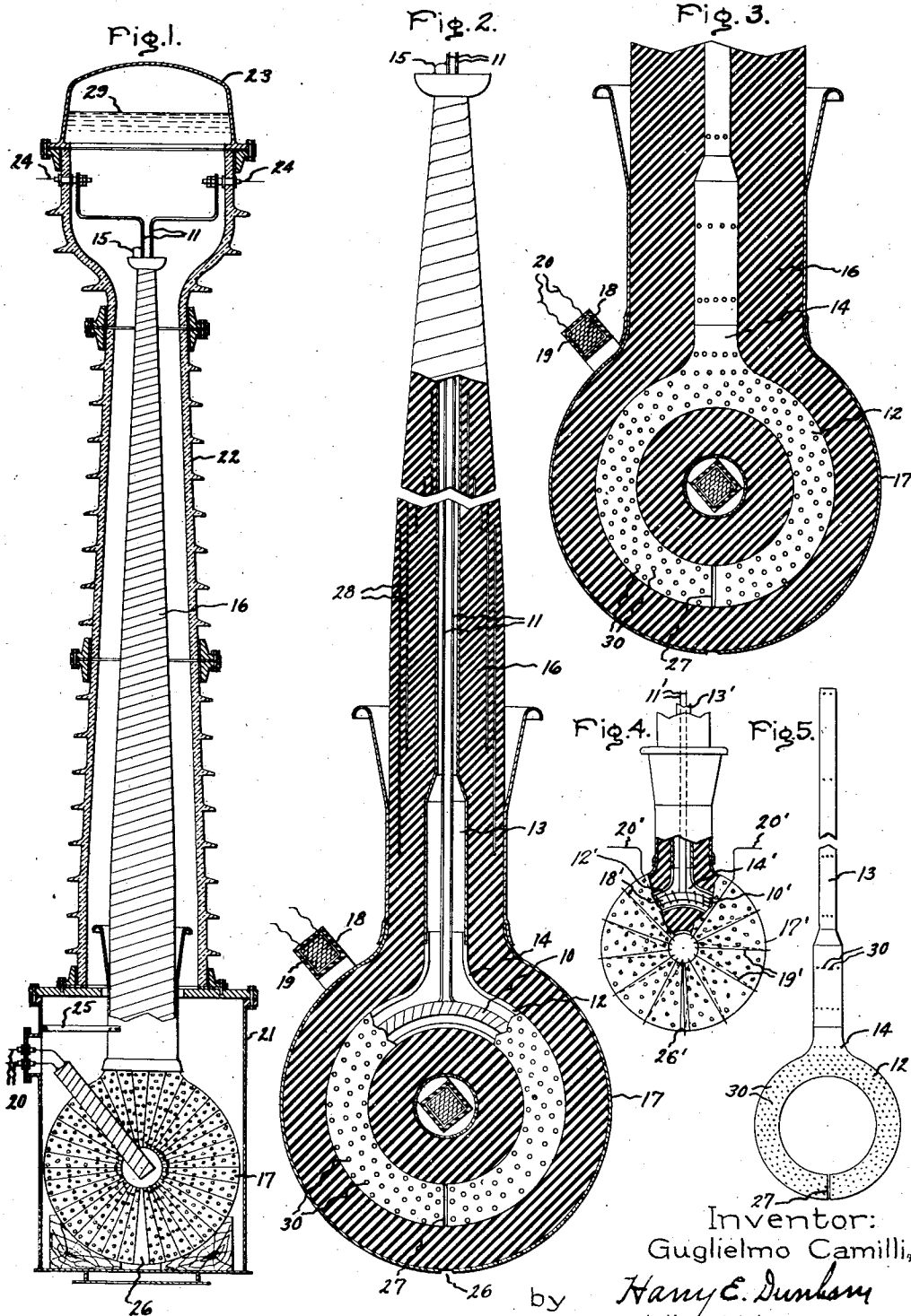
April 21, 1942.

G. CAMILLI

2,280,625

TRANSFORMER

Filed July 28, 1939



Inventor:
Guglielmo Camilli,
Harry E. Dunkson
His Attorney.

UNITED STATES PATENT OFFICE

2,280,625

TRANSFORMER

Guglielmo Camilli, Pittsfield, Mass., assignor to
General Electric Company, a corporation of
New York

Application July 28, 1939, Serial No. 287,032

16 Claims. (Cl. 175—358)

My invention relates to transformers and to current transformers and is of particular advantage in connection with a current transformer with its primary winding arranged for connection to a high voltage electrical circuit. In a high voltage transformer, the insulation usually forms a considerable part of the total volume of the transformer and any rearrangement which will permit a reduction in the necessary amount of insulation without detriment to the reliability and efficiency of the transformer will contribute to a considerable reduction in its size and weight and in its final cost. An object of my invention is to provide a transformer with improved insulated winding structure.

Another object of the invention is to provide an improved high voltage current transformer so constructed that the insulation for the high voltage primary winding is extremely effective and the complete transformer is consequently very compact and may be produced very economically.

The invention will be better understood from the following description taken in connection with the accompanying drawing in which Fig. 1 is a vertical, sectional view of a transformer enclosed in its casing and constructed in accordance with the invention; Fig. 2 is a sectional view of the transformer showing details of construction; Fig. 3 is a sectional view of a portion of a modified form of the transformer; Fig. 4 is a view of a portion of a transformer partly in section showing another modified form; and Fig. 5 is a view of one of the details of the transformer.

Like reference characters indicate similar parts in all the figures of the drawing.

The transformer shown in Figs. 1 and 2 includes a primary or high voltage winding 10 provided with a pair of terminal leads 11. In a current transformer the primary winding is connected in series with an electrical circuit so that the voltage between the turns of the winding and between its terminal leads is very small although the voltage of the winding and its leads above ground may be very great. The voltage between the terminal leads 11 is therefore small and only a small amount of insulation between them is necessary, but these leads 11 and the high voltage winding 10 must be heavily insulated from ground. As shown in Fig. 2, the high voltage winding 10 is enclosed in a hollow metal ring 12 which communicates with or terminates in a long metal tube 13 extending from the upper

edge of the ring 12 and enclosing the terminal leads 11. The high voltage winding may be enclosed in the ring or annular shield member 12 in any suitable manner. Thus, the ring may comprise a pair of complementary portions. For example, the ring may be slit in a longitudinal plane which, in this case, is the plane of the paper, as indicated by the portion which is shown in full lines in Fig. 2 at the section of the ring 12 which has been partly broken away. In assembling the high voltage winding and the ring, the ring portions may be disposed on either side of the high voltage winding and the tube 13 fit over the upper edge or neck of the ring 12, and the winding 10 may be spaced from the inside surface of the ring as shown in Fig. 2, by any suitable means. This ring 12 and tube 13 form a casing or shield 14 for the winding 10 and the leads 11 and this shield is connected to one of the leads 11 by a conductor 15 so that the shield and the winding and its leads are all approximately at the same potential above ground. The shield 14 is covered or surrounded by solid insulation 16 having a dielectric strength and thickness sufficient to withstand the entire voltage between the shield 14 and ground. This solid insulation 16 preferably consists of porous crepe paper wrapped about the hollow ring 12 and the tube 13 to the required thickness. The shield 14 is formed with smoothly curved outer surfaces about which the crepe paper may be easily and smoothly wrapped. The radius of curvature of each part of the shield 14 is sufficient to prevent corona and the shield has the further function that it prevents corona on the enclosed high voltage coil 10 and its leads 11 because it surrounds these parts and is maintained at approximately the same potential. The surface of the insulation 16 surrounding the hollow ring 12 is provided with a closely fitting metal sheath or shield 17 which is extended a short distance up the sides of the insulation surrounding the tube 13, the upper portion of this shield 17 being flared outwardly and the extreme edge being smoothly rounded to prevent corona. The insulated high voltage winding 10 surrounds one side of a magnetic core 18 upon which are distributed the insulated turns of a secondary or low voltage winding 19, this low voltage winding being connected to low voltage terminals 20. The core member may be positioned with respect to the primary winding in any suitable manner. In the embodiment shown in Figs. 1 to 3, inclusive, the core member and secondary winding are assembled after the assembly of the high voltage winding,

ring 12, insulation 16 and sheath 17 by passing the material forming the core and the turns comprising the secondary winding through and around the insulated and sheathed annular ring so that the primary and secondary windings will be linked in a magnetic circuit. When the transformer is assembled according to this procedure, neither the core member nor the secondary winding is present to hinder the operation of insulating and sheathing the high voltage winding.

The insulated high voltage winding 10 is enclosed in a metal casing or shield 21. The insulated high voltage leads 11 and tubular shield 13 extend up through an opening in the cover of the casing 21 and are surrounded by a porcelain wall 22 having its upper end closed and sealed by a metal cap 23. The metal casing 21, the porcelain wall 22 and the cap 23 constitute a complete casing for the transformer. The high voltage leads 11 are connected to high voltage terminals 24 extending through the upper end of the casing.

The metal shield or sheath 17 is connected to ground by a strap 25 so that it is at ground potential and needs no insulation from the casing 21 and so that this casing need be only just large enough to surround the insulated high voltage winding 10. The grounded shield 17 extends up through the opening in the cover of the casing 21 to shield the adjacent edge of the cover from voltage stresses.

The portion of the ground shield 17 surrounding the insulation about the high voltage winding 10 may be provided by wrapping strips of thin conducting material, such as metal about the surface of the insulation, as shown in Fig. 1. In order to avoid a short-circuited turn around the core 18, a gap 26 is left in the grounded shield 17 and a gap 27 is provided in the hollow metal ring 12.

A series of electrostatic shields 28 are embedded in the insulation 16 surrounding the high voltage leads 11 and their tubular shield 13. These electrostatic shields 28 are distributed longitudinally and radially in the insulation to improve the longitudinal and radial distribution of the high voltage throughout this insulation. The necessary thickness of the insulation 16 surrounding the tube 13 will be a minimum if the voltage distribution in the insulation is uniform.

The transformer casing is filled with insulating fluid or liquid, such as a mineral oil, to a level 29 as indicated in Fig. 1, space being left above the liquid to permit thermal expansion and contraction. This insulating liquid fills the high voltage shield 14 and all spaces surrounding the transformer and it also completely impregnates the crepe paper insulation 16. In order to obtain the best results it is of course necessary that the insulation 16 be completely free of all moisture and air or other deleterious gas. A very effective way to remove the moisture is to force a heated gas into the upper open end of the shield 14, an inert gas such as heated and thoroughly dried carbon dioxide being desirable. The hollow shield 14 and the external grounded shield 17 are formed with a number of small openings 30 and the heated compressed gas in the shield 14 is forced slowly through these openings and through all the pores of the insulation 16 until all the moisture has been removed from the insulation. The insulation 16 is gradually reduced in thickness toward the upper end of the shield 14 so that there would be a tendency for the

heated gas to escape more easily through this thinner portion of the insulation than through the thicker portion within the ground shield 17. The openings 30 are therefore closer together or larger or both in the ground shield 17 and in the hollow ring 12 of the shield 14 than in the upper portion of the tubular shield 13 surrounded by the thinner insulation. This distribution of the openings 30 tends to equalize the flow of the heated gas through all parts of the insulation at the same time that it is being forced through the insulation 16 to remove moisture. The equalization of the flow of heated gas through the insulation 16 may also be improved by using a more porous crepe paper in the thicker insulation around the high voltage winding 10 and the lower part of the tubular shield 13 than in the insulation about the upper portion of the tubular shield 13 where the insulation is not so thick. It is also considered desirable to heat the walls of the casing surrounding the transformer so that there will be no tendency for the moisture to condense within the casing after it leaves the insulation. After the insulation has been thoroughly dried, the insulating liquid should be introduced into the transformer casing and should thoroughly impregnate the solid insulation 16 and replace all gas remaining after the drying of the insulation is complete. This result may be secured by producing a partial vacuum in the inner high voltage shield 14 and maintaining this vacuum while the insulating liquid is very slowly introduced into the casing. It has been found desirable in some cases to maintain the vacuum in the high voltage shield 14 and to introduce the insulating liquid so slowly as to require several days to reach its final level 29.

Since the shield 12 is at substantially the same potential as the primary winding, the oil which is disposed between the inner shield 12 and the primary winding will be substantially free of electrostatic stress. Thus, if bubbles form in the oil inside the shield 12 as the result of a short circuit, for example, no harm will be done because the bubbles will merely rise to the top of the structure. Furthermore, since the outer shield or sheath 17 is at substantially the same potential as the secondary winding or ground, no insulation is needed outside the sheath 17.

In the modified form of the invention shown in Fig. 3 the construction is similar to that shown in Figs. 1 and 2 except that the electrostatic shields 28 are omitted from the insulation 16. The distribution of the high voltage through the insulation 16 is not so uniform and a greater thickness of the insulation 16 is therefore necessary for the same voltage but this may not be objectionable if the voltage of the high voltage winding 10 and its leads 11 is not too high.

In the modified form of the invention indicated in Fig. 4 the magnetic core 18' is enclosed within the hollow ring 12' of the inner high voltage shield 14', the turns of the high voltage winding 10' being distributed along the core within the ring 12' and the turns of the low voltage winding 19' being distributed around the outer surface of the grounded sheath 17'. In order to avoid short-circuited turns in the ring 12' extending around the core 18' the ring should be provided with a gap, as has already been described above with respect to Fig. 2. Since the ring is split in order to permit easy assembly the parts of the ring may be separated to provide this gap. The shield 17' should also be arranged, as has

been explained with respect to Fig. 2, in order that the shield will not constitute a short-circuited turn around the core.

Besides providing a smoothly curved surface upon which the crepe paper insulation 16 may be conveniently wrapped, the internal high voltage shield 14 provides communication between the liquid surrounding the high voltage winding 10 in the metal ring 12 and the liquid in the upper portion of the casing near its upper level 29 where heat may be more readily dissipated. The metal tube 13 and the hollow ring 12 of the shield 14 are large enough in cross-section to permit the liquid heated by the high voltage winding 10 in the ring 12 to rise by convection through the tube 13 to the upper part of the casing where it may be cooled. The insulation 16 surrounding the internal shield 14 prevents any effective dissipation of heat by conduction from the high voltage winding 12, but this winding 12 may be satisfactorily cooled by the convection flow of liquid between the winding 12 and the liquid in the upper end of the transformer casing.

The invention has been explained by describing and illustrating a particular high voltage current transformer and certain modified forms thereof, but it will be apparent that changes may be made without departing from the spirit of the invention and the scope of the appended claims.

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

1. A current transformer including a high voltage winding, insulation around said winding, a grounded metal sheath enclosing and closely fitting said insulation, a casing enclosing said winding and its insulation and sheath, said casing having an opening, and terminal leads extending through said opening from the winding, said insulation and sheath extending around said leads and through said opening.

2. A current transformer including a high voltage winding, insulation around said winding, a grounded metal sheath enclosing said insulation, a casing enclosing said winding and its insulation and sheath, said casing having an opening, terminal leads extending through said opening from the winding, said insulation and sheath extending around said leads and through said opening, and electrostatic shields distributed radially and longitudinally in said insulation to improve the voltage distribution therein and decrease the necessary thickness of the insulation around the leads.

3. A current transformer including a magnetic core, a high voltage winding on said core, terminal leads connected to the winding, a hollow metal shield surrounding said winding and its core and leads, insulation surrounding said shield, and a grounded metal sheath enclosing and closely fitting said insulation.

4. A current transformer including a high voltage winding, terminal leads connected to the winding, a hollow metal shield surrounding said winding and leads, insulation surrounding said shield, a casing enclosing the transformer, and insulating liquid in said casing and shield, the shield providing communication between the winding space in the shield and the upper portion of the casing to permit cooling of the winding by convection currents in the liquid.

5. A current transformer including a high voltage winding, terminal leads connected to the winding, a hollow metal shield surrounding said winding and leads, and porous insulation surrounding said shield, said metal shield having

perforations to permit gas in the shield to be forced through the insulation to remove moisture.

6. A current transformer including a high voltage winding, terminal leads connected to the winding, a hollow metal shield surrounding said winding and leads, and porous insulation surrounding said shield, said metal shield having perforations to permit gas in the shield to be forced through the insulation to remove moisture, the perforations being arranged to permit the gas to reach the insulation around the winding more easily than that around the terminal leads.

7. A transformer including a high voltage winding enclosed in a conductive shield terminating in a conducting tube, terminal leads connected to the winding and extending through said tube, means connecting said winding and said shield whereby said shield is at substantially the potential of said winding, insulation around said shield including said tube, and a grounded metal sheath enclosing said insulation and extending part way along said tube.

8. A transformer including a high voltage winding, a conducting member substantially surrounding said winding, said conducting member being spaced from said winding, an insulating liquid disposed in the space between said winding and said conducting member and surrounding said high voltage winding, and means electrically connecting said conducting member to said winding so that said liquid will be substantially free of electrostatic stress.

9. A transformer including a high voltage winding, solid porous insulation surrounding said winding, conducting shielding members contiguous with the inside and outside surfaces of said insulation, said inside shield being adjacent said high voltage winding and being electrically connected therewith, said outside shield being connected to ground, and an insulating liquid surrounding said transformer, said shields being perforated so that said liquid may permeate said insulation and surround said winding.

10. A transformer including a high voltage winding, spaced-apart conducting shields surrounding said winding, solid porous insulation within the space between said shields, said inner shield being adjacent to and electrically connected to said high voltage winding, said outer shield being connected to ground, and an insulating liquid surrounding said transformer, said shields being perforated so that said liquid may permeate said insulation and surround said winding.

11. A transformer including a high voltage winding, solid porous insulation surrounding said winding, a conducting sheath surrounding said insulation, an insulating liquid, said transformer being immersed in said liquid, said sheath being perforated so that said liquid may permeate said insulation and conductive means spacing said insulation from said winding so as to provide a space around said high voltage winding in which said insulating liquid may circulate.

12. A transformer including an annular high voltage winding, solid porous insulation surrounding said winding, a conducting sheath surrounding said insulation, an insulating liquid, said transformer being immersed in said liquid, said sheath being perforated so that said liquid may permeate said insulation, an annular core member, and a low voltage winding having turns distributed around said core member, said core

member and low voltage winding passing through and around said sheath, said sheath being grounded so that failure of said insulation will not cause damage to said low voltage winding.

13. A transformer including an annular core member, a primary winding distributed along said core member, insulating means surrounding said annular core member and winding, a grounded conducting sheath enclosing said insulation, and a secondary winding distributed around said sheath.

14. A transformer including a hollow annular insulating means, a core member, a primary winding distributed along said core member, said core member and primary winding being within said hollow part of said insulating means, conductive means around said primary winding and within said insulating means, and a secondary winding distributed around and adjacent the outside surface of said insulating means.

15. A transformer including a high voltage winding, solid porous insulation surrounding said winding, conducting shielding members contiguous with the inside and outside surfaces

of said insulation, said inside shield being adjacent said high voltage winding and also being electrically connected therewith, said outside shield being connected to ground, and an insulating liquid surrounding said transformer, said inside shield being perforated so that said liquid may permeate said insulation and surround said winding.

16. A transformer including a primary winding having an annular shape, a conducting shield substantially surrounding said winding and terminating in a conducting tube, said conducting shield being spaced from said winding, terminal leads connected to said winding and extending through said tube, solid porous insulation surrounding said shield and tube, a grounded sheath enclosing said insulation and extending part way along said tube, a low voltage winding linking said primary winding adjacent said grounded sheath, and an insulating fluid surrounding said transformer, said shield and sheath being perforated so that said fluid may permeate said insulation and surround said winding.

GUGLIELMO CAMILLI.