Aug. 12, 1952 L. P. MACARDIER 2,606,950

TERMINAL BUSHING WITH THIN PAPER INSULATION

Filed Dec. 2, 1946 2 SHEETS—SHEET 1

Fig. 1.

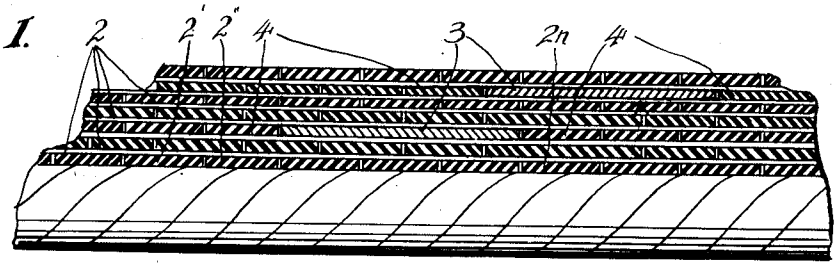


Fig. 2.

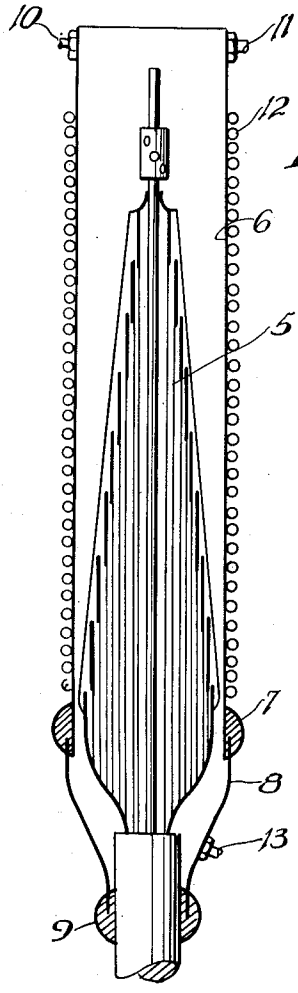
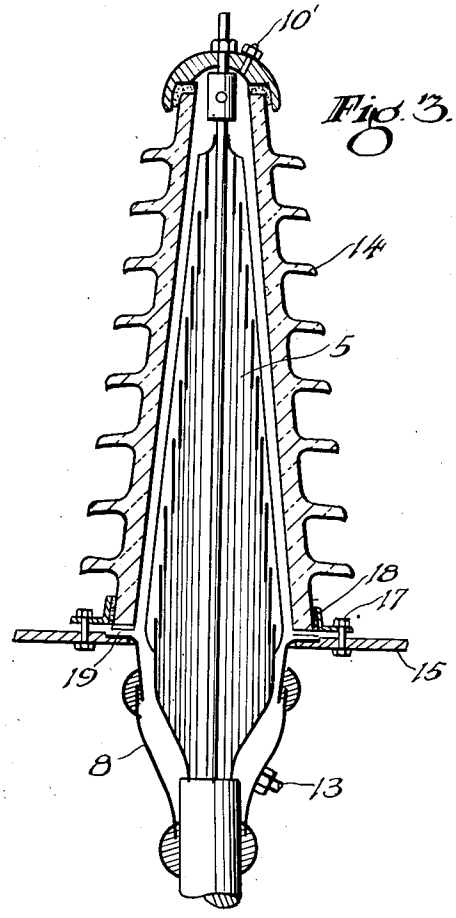


Fig. 3.



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Fig. 4.

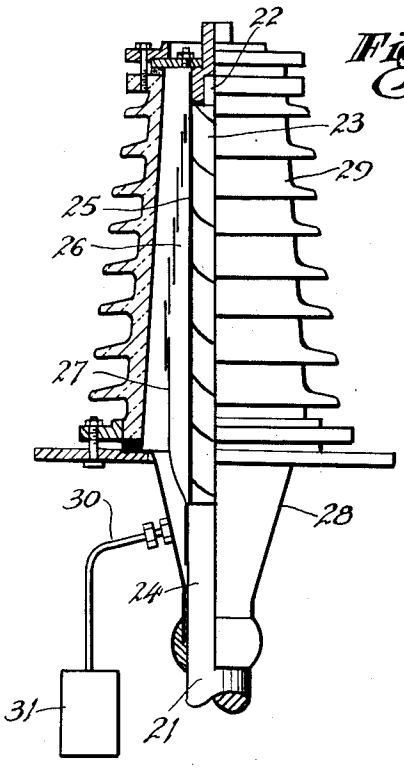


Fig. 5.

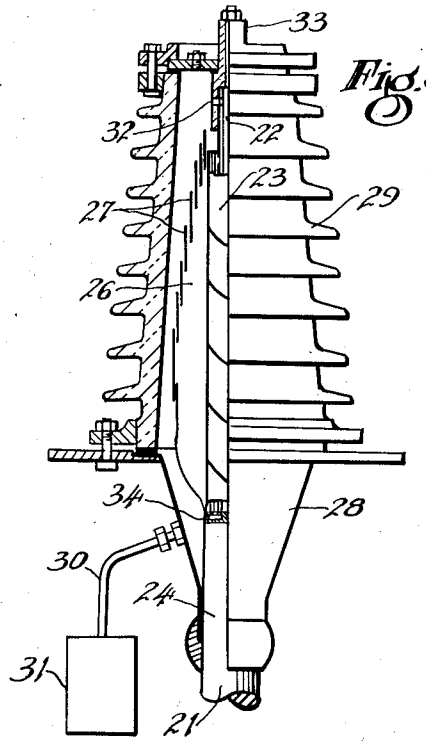
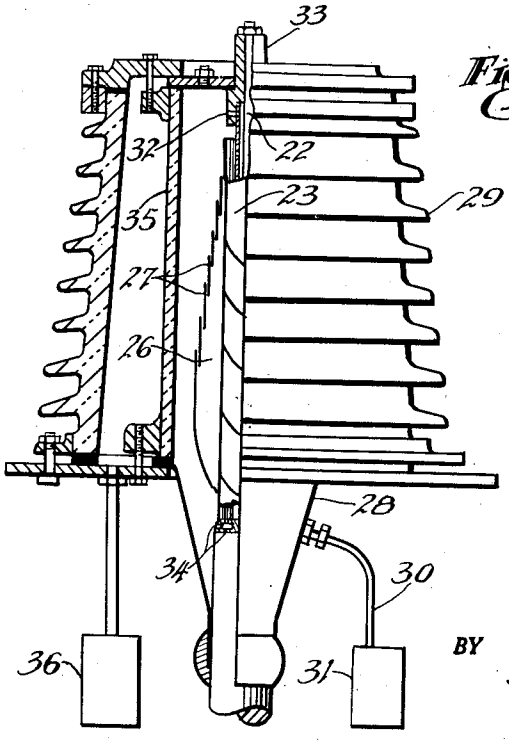


Fig. 6.



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TERMINAL BUSHING WITH THIN PAPER INSULATION

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Patent expires June 1, 1964

12 Claims. (Cl.. 174—20)

1

In apparatus such as the bushing terminals of electric apparatus, the bushing terminals of high voltage transformers, and the end boxes of cables, the voltage is distributed either radially or longitudinally by means of metal parts or intersheaths embedded between the different layers of the insulation. These devices are made by winding around the conductor insulating bands with interposed metal layers as of foil.

Hitherto there have been used for this purpose insulating bands of considerable width wound by machine on themselves, with the metal layers or intersheaths interposed. Since these condensers so formed have most often the general form of a double cone, the insulating bands to be wound have a decreasing width, but always equal to the total height of the insulation in each concentric cylinder around the central conductor. Thus in these prior art constructions, the insulating bands have a very considerable width in the neighbourhood of the central conductor, this width remaining always fairly large in the intermediate layers of the condenser.

This method of manufacture, as heretofore employed, in spite of its apparent simplicity, has serious disadvantages; it does not permit of avoiding the formation between the different layers of the wound insulation of air pockets producing either irregularities in the surface of the paper, or of the width of the bands, preventing at places their correct arrangement on the neighbouring layers.

Moreover, in these prior art constructions, due to the presence of these metal intersheaths or electrodes, the insulation forms a body which is not very permeable to the impregnating oils or materials. It happens in these arrangements heretofore used, that the temperature variations of the cable in use cause empty spaces to be formed in the insulating mass of the sleeve, which considerably reduce the dielectric strength of the whole.

The present invention avoids these disadvantages. A first object of the present invention consists in forming each layer of the insulation, or at least the central layers of such a condenser, which will often be of impregnated paper, by winding in a cylindrical spiral a narrow insulating band; this winding is preferably provided with abutting spirals or turns.

Another object of the present invention consists in impregnating the paper bands of the insulation before winding with a relatively light fluid oil of the kind used for high-tension cables with oil circulation, and impregnating the whole

2

assembly body after the winding operation with a fluid oil of the same kind.

Another object of the present invention relates particularly to the case wherein the insulation has such a large thickness that in spite of the improved method of impregnation the variations of the temperature during use may produce empty spaces in certain parts of this thickness. In order to prevent such a possibility the present invention provides a continuous permanent impregnation of the insulation, after the winding, under a certain pressure, by making it communicate with the oil under pressure when the installation is put into service and during its operation.

It will be appreciated that between the various phases of the impregnating operations, especially after the winding of the insulation bands, it is advantageous to proceed in a known manner to a vacuum treatment of the insulation in order to expel air and humidity by heating.

In the end sleeves for cables which themselves are continuously subjected to a pressure of fluid oil, the permanent impregnation of the sleeves and the cable can be effected by one or more of the special containers provided for supplying oil to the cable.

Fig. 1 shows in cross section the winding insulating layer structure of a cable terminal according to the present invention.

Fig. 2 shows a wound terminal structure mounted in a treatment sleeve for the application of heat and vacuum and subsequent oil impregnation.

Fig. 3 shows a wound terminal structure mounted in the usual operating outer porcelain shell, for a final vacuum and oil impregnation treatment, without heat.

Fig. 4 shows the use of a varnished silk envelope to separate a cable terminal into two separate spaces to permit the use of oils of two different qualities for cables insulated by paper impregnated with viscous material.

Fig. 5 shows a cable terminal assembly construction having a communicating channel between the interior of the terminal and the oil circulation of the cable itself, to permit use of a common oil supply for both cable and terminal.

Fig. 6 shows a cable terminal construction divided into separate low pressure outer and high pressure inner concentric compartments separated by an insulating tube, for use with cables operating under high oil pressure.

Figure 1 shows diagrammatically the construction of a winding of the terminal insulation used by the present invention. In this drawing, the

central electric conductor is indicated by 1 and the different insulating layers by 2. Each of them is composed of a cylindrical spiral the different successive turns of which are indicated by 2', 2''. . . 2*n*. It is to be noted that, due to this staggered method of winding, there are obtained between the different layers, high reluctance leakage paths, an advantage additional to those indicated above.

The metal layers or intersheaths of the winding structure are indicated by 3. Each layer of which a metal layer or intersheath forms a part is continued to the ends of the condenser winding structure by an insulating band 4 of the same thickness, in such manner as to obtain a single cylindrical surface permitting a satisfactory positioning of the adjacent insulating band of slightly larger diameter.

Another important feature of the present invention is to provide a method of drying and impregnating the insulation of the terminal condensers. Hitherto, the condensers of terminals and end boxes of cables were given vacuum impregnating treatment while inside the insulating envelope which is generally of porcelain and which protects them and insulates them in operation. This treatment consists as is known in first producing a vacuum in this porcelain shell or envelope in order to extract therefrom air and moisture, and then to introduce into this porcelain envelope fluid oil in order to impregnate the insulation of the condenser, these two operations being effected at the ambient temperature.

According to the present invention, this treatment of the wound insulation is considerably improved by heating the insulation, at least while it is under vacuum, and preferably also during impregnation. In order to carry out this operation, the present invention provides the use of a special heating sleeve which is removed at the end of these operations, to be replaced by the normal insulating porcelain shell envelope of the completed terminal, within which the two operations of drying and impregation are repeated.

Figures 2 and 3 of the drawings showing in section respectively an embodiment of one end of the cable during the heat treatment, and in its finished assembly, will permit of a better understanding of this feature of the present invention.

As indicated in Figure 2, the condenser terminal structure 5 mounted on the end of the cable is surrounded by a metal treatment sleeve 6 connected by sealed coupling 7 to a metal cap 8 which has been soldered at 9 to the lead of the cable. This cap 8 serves for the final mounting of the end of the cable.

The treatment sleeve 6 is provided with a nozzle 10 connected to a vacuum pump and comprises a resistance heating device 12. At the respective ends of the sleeves 6 there are provided two nozzles 11 and 13 and, according to the position of the cable end, one of these nozzles permits of removing the oil in the course of the drying operation, the other of introducing the oil for refilling.

In order to dry the insulation, the inside of the treatment sleeve 6 is heated by the resistance 12 to about 120° C. and a vacuum is produced inside the sleeve by the nozzle 10, the oil being drawn through the nozzle 11 or 13.

For the purpose of raising the temperature of the condenser structure for drying purposes, the sleeve 6 may be filled with oil before the vacuum is applied, and heated, and when a temperature of 110 to 120° C. is obtained in the mass of the

wound insulation the oil is withdrawn and the vacuum applied.

The condenser 5 having been thus dried, is impregnated by closing one of the nozzles 11 or 13 and filling the sleeve 6 with oil through the other, the vacuum being maintained during the filling operation.

When the end of the cable is thoroughly impregnated, its final mounting in the flanged porcelain insulating shell 14, represented by Figure 3, is effected, and it is then subjected to a new vacuum operation, without heat, and to impregnation with oil. For this purpose, the metal tip of the usual flanged porcelain insulating shell has a nozzle 10' connected to the pump and the impregnating oil flows, as in the first operation, through the nozzle 13.

As shown in Figure 3, the two halves of the envelope of the condenser terminal structure are locked together in tight manner and fixed with their ends registering with an orifice in an adaptor plate 15. To effect this assembly, there is employed a metal sleeve 16, one end of which is soldered to the cap 8 after removal of the heating sleeve 6. The other end of the sleeve 16 is secured by means of bolts 17 and flange 18 against the porcelain outer shell 14, with an interposed joint 19, and fixed on the plate 15.

Figure 4 shows an end sleeve assembly for a cable insulated by paper which is impregnated with a viscous material. The cable 21 whose conductor 22 is covered with the normal wrapped insulation 23 of the cable, impregnated as above explained, is covered with a lead sheath or envelope 24, which extends slightly into the end sleeve. In the interior of this sleeve the wrapped insulating part 23, stripped of its lead cover, is surrounded by an insulating envelope 25 impermeable to the impregnating materials and also covering in a tight manner the junction between the uncovered part of the insulation 23 and its lead sheath cover 24. This envelope 25 consists of one or several layers of insulating impermeable windings, such as varnished silk.

The insulation structure 26 arranged around the impermeable partition envelope 25 is that to which the invention relates, and it consists of wound paper bands impregnated with the relatively light fluid oil of the kind used in high-tension cables with oil circulation and interposition of metal intersheaths or electrodes 27. The cable terminal formed in this manner is placed in the interior of a tight sleeve formed by a cap 28 and an outer porcelain shell insulator 29 and provided with a supplying pipe 30 leading to an appropriate oil supply source.

After assembly of the parts, there follows the described treatment with vacuum and heating, then the sleeve 28, 29 is filled with fluid oil of the kind used for the preceding impregnation of the paper bands, forming the wound insulation structure 26, before winding. This filling may be effected by a container 31 similar to those used for filling cables having oil circulation. When the impregnation is finished, the container can be removed, or can remain connected to the sleeve in the regular service of the installation, in order to subject the insulation of the sleeve to a permanent impregnation. In both cases, the presence of the impermeable insulating envelope 25 prevents the mixing of the two oils of different quality which impregnate respectively the insulation 26 of the sleeve 28, 29 and that of the cable itself, which latter is viscous.

In systems using cables with light fluid oil circulation, the oil container for supplying the

end sleeve may be the same as that for the cable itself. It is then sufficient to establish a communication between the interior of the terminal sleeve and the oil circulation conduits of the cable. This communication, shown in Figure 5, may be effected by a channel **32** traversing the binding screw **33** in case of a cable with a central channel, or by the lead tube **34** in case of a cable with peripheral channels, or in both ways in case of a cable having both types of channels.

In the case of cables with fluid oil circulation operating under high pressure and comprising end sleeves covered with an insulator shell, for instance of porcelain, not strong enough for these pressures, each terminal sleeve is subdivided into two concentric tight compartments, the peripheral compartment being filled with an insulating oil subjected to a pressure lower than that impregnating the wound insulation **26** of the cable end which is located in the central compartment. This embodiment is shown in Figure 6 in which the separating wall between the two compartments consists of an insulating tube **35**.

The oil impregnating in a permanent manner the wound insulation **26** of the cable end sleeve in the interior of this separating tube **35**, is the same oil under high pressure as that impregnating the cable from the container **31** owing to the existence of the communication channels **32** or **34** already described in the preceding embodiments. The permanent filling of the outer peripheral compartment with an oil of a lower pressure is secured by a separate container **36**.

In installations comprising cables under very high tension, operating under very high oil pressures, which also permit the permanent filling of the cable terminal sleeves with impregnating oil it is possible to appreciably reduce the thickness of the wound insulation condenser structure by using as the paper bands constituting that structure paper bands made of flax paste, which are first impregnated with oil of the kind impregnating the cable itself, and have an individual thickness between 0.01 and 0.04 mm.; to prevent breaking down of the winding it is sufficient to use bands of small width. The use of thin paper of low permeability is made possible by the high pressure of the oil, which allows the maintaining of an impregnation sufficient to avoid any empty space in the insulating condenser structure in spite of the temperature variations of the cable end during operation.

The preceding dispositions which have just been described for end boxes of cables can be used also for bushing terminals of transformers and other electric apparatus.

It will be apparent to those skilled in the art that my invention is susceptible of modifications to meet particular applications, and all such modifications which are within the scope of the appended claims, I consider to be comprehended within the spirit of my invention.

I claim:

1. In high tension electrical equipment, a high tension electric cable including a conductor having insulation thereon, a fluid-tight insulating casing spacedly surrounding a portion of said insulated conductor and in sealed relation to said insulation thereon, wound paper band condenser-structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said condenser-structure insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil and permanently connected with said casing for continuously supplying said fluid oil to said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

2. In high tension electrical equipment, a high tension electric cable including a conductor having insulation thereon, a fluid-tight insulating casing spacedly surrounding a portion of said insulated conductor and in sealed relation to said insulation thereon, wound paper band condenser-structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said condenser-structure insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil and permanently connected with said casing for continuously supplying said fluid oil under super-atmospheric pressure to said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

3. In high tension electrical equipment, a high tension electric cable including a conductor having insulation thereon, a fluid-tight insulating casing spacedly surrounding a portion of said insulated conductor and in sealed relation to said insulation thereon, wound paper band condenser-structure insulation closely surrounding all of the insulated portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said condenser-structure insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil and permanently connected with said casing for continuously supplying said fluid oil under super-atmospheric pressure to said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

4. In high tension electrical equipment, a sheathed cable including a conductor having high tension insulation thereon, a conductor extending from said cable beyond the sheath thereof as a continuation of the conductor of said cable and having insulation thereon constituting a continuation of at least that part of the insulation within said cable which is immediately adjacent the conductor in said cable, a fluid-tight insulating casing spacedly surrounding said insulated conductor extension and sealed to the sheath of said cable, wound paper band condenser-structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said condenser-structure insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light

fluid cable oil and connected with said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

5. In high tension electrical equipment, a high tension electric cable including a conductor having insulation thereon, a fluid-tight insulating casing in sealed relation to said insulation on said conductor and spacedly surrounding a portion of said conductor having insulation thereon which is a continuation of at least that portion of said first-mentioned insulation which is adjacent to said conductor, wound paper band condenser-structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said condenser-structure insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil and permanently connected with said casing for continuously supplying said fluid oil under super-atmospheric pressure to said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

6. In high tension electrical equipment, a cable including a conductor having insulation thereon, a conductor extending from said cable as a continuation of the conductor thereof and having insulation thereon as a continuation of at least that part of the insulation of said cable which is immediately adjacent the conductor of said cable, a fluid-tight insulating casing spacedly surrounding said insulated conductor extension and in sealed relation to said cable, wound paper band condenser-structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with at least some of the layers of insulating paper, said wound paper band insulation being impregnated with relatively light fluid cable oil, and the periphery of said wound paper band insulation expanding to impart a convex profile thereto from the end thereof adjacent said cable and then decreasing toward the opposite end thereof, and a reservoir for said relatively light fluid cable oil permanently connected with said casing for continuously supplying said fluid oil to said casing and to said paper band insulation within said casing for permanent impregnation of said last-mentioned insulation.

7. In high tension electrical equipment, a sheathed cable including a conductor having thereon insulation impregnated with relatively heavy viscous oil, a conductor extending from said cable as a continuation of the conductor of said cable and having insulation thereon as a continuation of at least that part of the insulation within said cable which is immediately adjacent the conductor in said cable, a fluid-tight insulating casing spacedly surrounding said insulated conductor extension and sealed to the sheath of said cable, an oil-impermeable insulating wall encircling said insulation on said conductor extension and dividing said casing into coaxial chambers, wound paper band condenser-structure insulation in the outermost of said chambers and closely surrounding said wall and said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with layers of insulating paper, said wound paper band insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil permanently connected to said outer chamber for permanent impregnation of said condenser-structure insulation.

8. In high tension electrical equipment, a cable including a conductor having oil-impregnated wrapped insulation thereon, a fluid-tight insulating casing spacedly surrounding a portion of said insulation and in sealed relation to said cable, wound paper band condenser-structure insulation closely surrounding all of said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with layers of insulating paper, said wound paper band insulation being impregnated with fluid cable oil, and a reservoir for said fluid cable oil permanently connected with said casing for continuously maintaining a supply of said fluid oil under super-atmospheric pressure to said casing and to said paper band insulation and wrapped insulation within said casing.

9. In high tension electrical equipment, a cable including an electric conductor having insulation thereon, a fluid-tight insulating casing spacedly surrounding a portion of said insulated conductor and in sealed relation to said cable, an oil-impermeable insulating wall extending longitudinally of said casing and surrounding said insulated conductor with said casing and dividing said casing into two coaxial chambers, wound paper band condenser-structure insulation disposed within a first one of said chambers and coaxial with that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with layers of insulating paper, said wound paper band insulation being impregnated with relatively light fluid circulating cable oil, a reservoir of said fluid cable oil permanently connected with the last-mentioned chamber for continuously maintaining a supply of said relatively light fluid oil to said first chamber and to said paper band insulation within said casing for continuously applying said light fluid oil for permanent impregnation of said condenser-structure insulation therewith, and insulating oil disposed within the other of said chambers.

10. In high tension electrical equipment, a cable including a conductor having insulation thereon and having a fluid oil circulation passage containing light fluid circulating oil, a conductor extending from said cable as a continuation of the conductor of said cable and having insulation thereon as a continuation of at least that part of the insulation withn said cable which is immediately adjacent the conductor in said cable, a fluid-tight insulating casing spacedly surrounding said insulated conductor extension and sealed to the sheath of said cable, the interior of said casing being in communication with said oil passage of the cable, wound paper band condenser-

structure insulation closely surrounding said insulation on that portion of said conductor within said casing and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with layers of insulating paper, said wound paper band insulation being impregnated with relatively light fluid cable oil, and a reservoir for said relatively light fluid cable oil permanently connected with said casing for continuously applying said fluid oil for permanent impregnation of said condenser-structure insulation therewith.

11. In high tension electrical equipment, a sheathed cable including a conductor having insulation thereon, said cable containing oil under high pressure and having an oil circulation passage therein, a conductor extending from said cable as a continuation of the conductor of said cable and having insulation thereon as a continuation of at least that part of the insulation within said cable which is immediately adjacent the conductor in said cable, a fluid-tight insulating casing spacedly surrounding said insulated conductor extension and sealed to the sheath of said cable, an oil-impermeable insulating wall extending longitudinally of said casing and spacedly surrounding said insulated conductor within said casing and dividing said casing into two coaxial chambers one within the other, the interior of the innermost of said chambers being in communication with the high-pressure oil passages of the cable, wound paper band condenser-structure insulation in said inner chamber and closely surrounding said insulation on that portion of said conductor within said chamber and including a plurality of layers of narrow paper bands having a thickness up to 0.04 mm. wound in closely adjacent spirals about the axis of said conductor and thin metal sheaths alternating with layers of insulating paper, said wound paper band insulation being impregnated with said high-pressure oil, a high-pressure reservoir for said high-pressure oil permanently connected with said inner chamber for continuously applying said oil under high pressure for permanent impregnation of said condenser-structure insulation therewith, and a source of supply of oil under relatively lower pressure connected to the outermost of said chambers.

12. In high tension electrical equipment, an insulated conductor, a fluid-tight insulating casing spacedly surrounding a portion of said insulated conductor, an oil impermeable insulating tube extending longitudinally of said casing and surrounding said insulated conductor and dividing said casing into two coaxial chambers, wound paper band condenser-structure insulation positioned in a first one of said chambers and closely surrounding said insulated conductor, said wound paper condenser-structure insulation including a plurality of layers of narrow paper bands wound in closely adjacent spirals and having a thickness up to 0.04 mm. and thin metal shields alternating with at least some of said layers of paper, said wound paper band insulation being impregnated with relatively light fluid circulating cable oil, a reservoir of the said relatively light fluid circulating cable oil connected to said first chamber of said casing containing said oil for permanent impregnation of said paper band insulation therewith, and an insulating oil positioned in the second one of said chambers.

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