

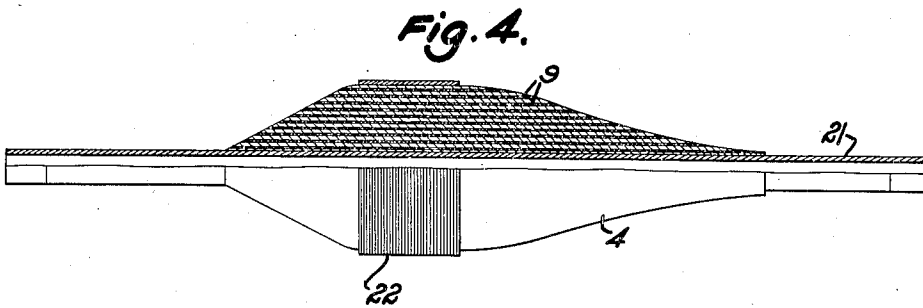
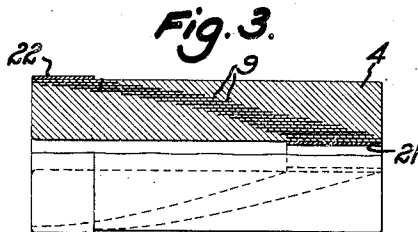
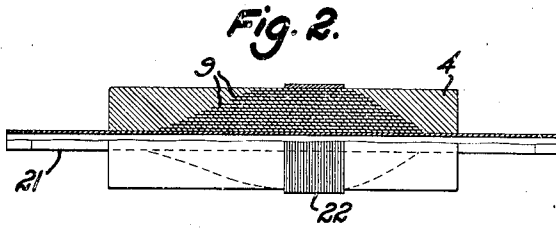
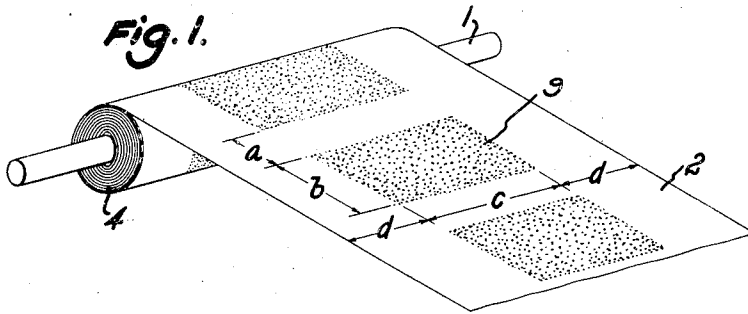
Aug. 14, 1945.

H. KAPPELER

2,382,065

APPARATUS FOR PRODUCING WOUND CONDENSERS

Original Filed May 15, 1940 2 Sheets-Sheet 1



INVENTOR

Hans Kappeler,
BY
Pierce & Scheffler
ATTORNEYS

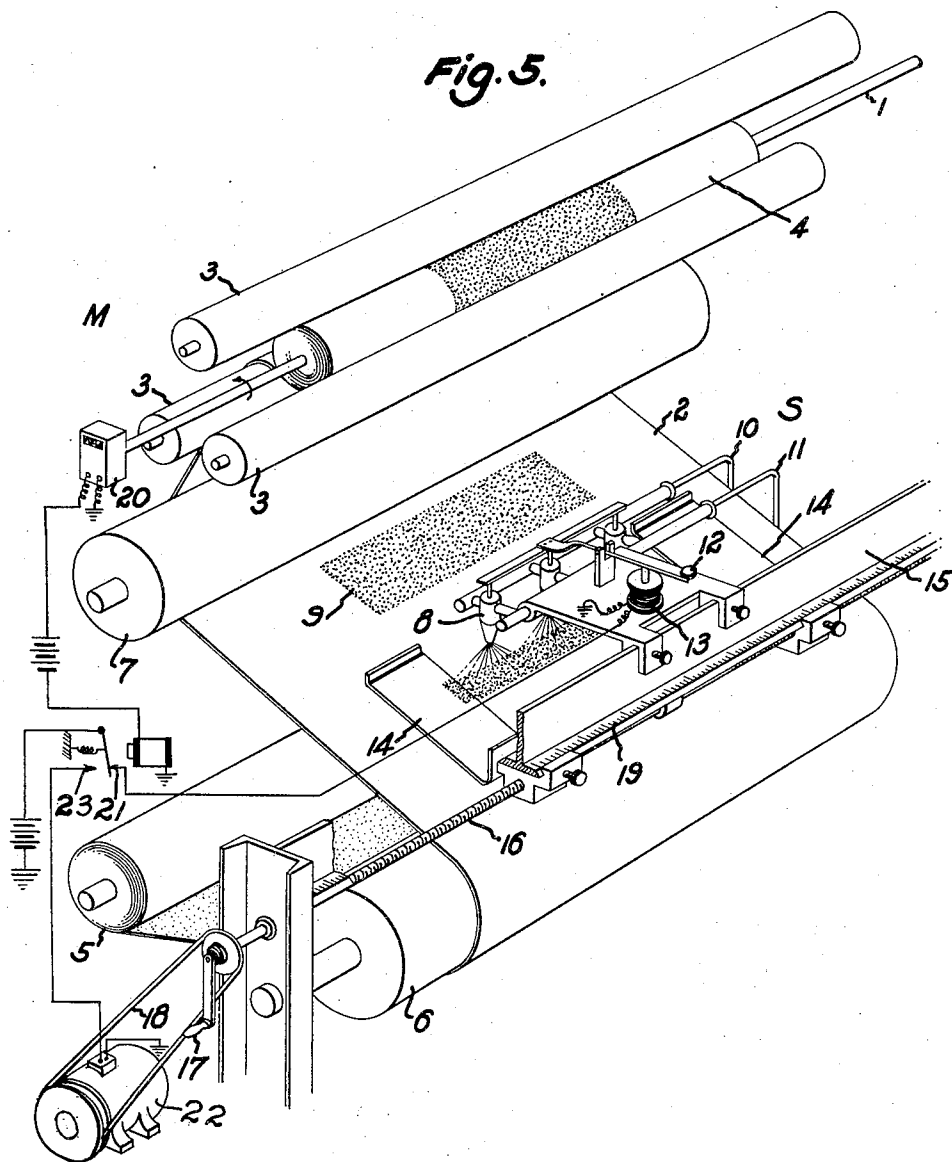
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Hans Kappeler,
BY
Pierce & Schaffler
his ATTORNEYS

UNITED STATES PATENT OFFICE

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APPARATUS FOR PRODUCING WOUND CONDENSERS

Hans Kappeler, Zurich, Switzerland, assignor to
Micafil Ltd., Works for Electrical Insulation
and Winding Machines, Zurich, Switzerland, a
joint-stock company

Original application May 15, 1940, Serial No.
335,340. Divided and this application July 15,
1941, Serial No. 402,553. In Switzerland August
12, 1939

2 Claims. (Cl. 91-45)

This invention relates to wound condensers for high voltage purposes, and is concerned with the provision of an improved wound condenser, with a method of forming the same, and with an apparatus for carrying out said method. In particular, the invention has specific relation to so-called "lead-through" (or "lead in") insulators or "condenser lead-through devices."

Wound condensers for high voltage purposes consist of a wound up insulation web into which a metal layer is wound each time after a certain number of layers of insulation. The length of the metal overlay is about equal to the circumference at the place concerned. In the same way, lead-in insulators are constructed with potential gradient control by means of metal inserts—the so-called condenser "lead-in" devices.

It has been found that all hard paper condenser lead-through devices—consisting of wound up insulation webs and wound-in metal foils—possess such strong electric fields at the edges of the metal foils, in operation with nominal voltage with ordinary stress of the dielectric of about 12 kv. per cm., that the dielectric adjacent the edges of the metal foils does not remain constant but on the contrary is gradually affected. The result of this is that the insulation is utilized electrically in a poorer manner, since it must be calculated with reference to the strong marginal fields and therefore must be made thicker than would be necessary otherwise. The fact that small spacing of adjacent metal inserts has favorable effect was known, it is true, but it heretofore was generally the practice to select spacings of from 2 to 4 mm. between adjacent inserted metal layers, and in exceptional cases down to 1.5 mm. The exact relationship between thickness of layer, voltage on the layer, and corrosion effect of the edge was not known prior to the present invention, and a thorough investigation making use of continuous experiments, a year long, was necessary for ascertaining that relationship.

The present invention is predicated on the knowledge of the conditions under which one is in position to utilize the dielectric completely without edge corrossions occurring. It is based on the knowledge of that voltage under which no edge corrosion phenomena occur even with stress lasting for years. This limiting voltage has been found to be identical with that which can be ascertained by a simple experiment, the so-called corona discharge voltage, i. e., that voltage at which—even assuming that the edges of the layers are in the air—a sound or an in-

crease in losses occurs for the first time upon increasing voltage. Since the edges of the conducting inserts are embedded in solid dielectric—generally, in paper and artificial resin—this discovery was surprising. It shows that it must be assumed that the edges are surrounded in the closest proximity with a fine air film of about normal pressure, although this cannot be determined with ordinary testing methods.

The invention comprises making the thickness of the dielectric between adjacent conducting layers so small, with a minimum stress of the dielectric of 10 kv. per cm. that the voltage occurring between the layers in question is not greater than the corona discharge voltage corresponding to this thickness of insulation.

It is true that this requirement leads to spaces of any desired size if the electric strength of the dielectric is not used completely, i. e., if the condenser is over-dimensioned. If, however, according to the present invention, the utilization is complete, the greatest radial spacing of adjacent overlays remains under 1 mm. in each case. With very efficient dielectric, the spacing can frequently be the thickness of a simple sheet of paper. It is then possible to make wound high voltage condensers or insulators, and condenser lead-through devices, by constructing the overlays as strips of conductive material in continuous sequence independent of the diameter of the roll, the insulating distances from each other in the direction of the circumference necessarily being at least large enough so that the appertaining partial voltages do not lead to jumping.

In its product embodiment, the invention resides in a wound condenser, for high voltage, of the type including a continuous web of dielectric and conductive overlays separated into discontinuous portions in the direction of the circumference of the wound device, e. g., hard paper condenser lead-through devices, characterized in that with a minimum stress of the dielectric of 10 kv. per cm. with the highest permissible permanent nominal voltage the number of conductive overlays in the radial direction is so large and, therefore, their radial spacing from each other is so small that with said permanent nominal voltage between adjacent overlays the value of the corona discharge voltage is not attained.

It may be stated that the radial spacing of the conductive overlays of the wound condenser is not in excess of 1 mm.; that said overlays are in the form of strips which are no wider (in the

direction of the circumference), and preferably are less wide, than the circumference of the roll diameter appertaining thereto; and that said overlays are arranged—independent of the diameter of the roll—in continuous sequence in the direction of the dielectric web and with so much relative insulating spacing between adjoining overlays that the same is at least sufficient for jump-proof absorption of the drop in voltage between adjoining overlays. This spacing may amount to more, or less, than one circumference of the roll at the place of the spacing, depending upon the properties of the invention and other variables. Thus, the spacing between two adjoining overlays may amount to one or two or more turns of the windings, or may amount to only a fraction of one turn.

The boundaries of the overlay strips running crosswise of the dielectric web may be parallel to the axis of the roll, or they may run in helical lines which form an angle of between 45° and 90° with the circumferential line of the roll. Preferably, those boundaries of the overlay strips which run in the direction of the web are substantially parallel to the edges of the web. Moreover, the overlay strips may extend over the entire width of the dielectric web or over only a portion of the latter, and may or may not be uniform in area and/or dimensions from one point in the roll to another: preferably, the lengths of the overlay strips (cross-wise of the web) progressively diminish from the center of the roll outwardly.

According to the invention, the thickness of the conductive overlays deposited on the insulation (dielectric) web amounts at most to a thirtieth part of the thickness of the latter. The overlays consist at least in part of carbon (e. g., graphite, lampblack, or the like) in a very finely subdivided—preferably “colloidal”—form, and may contain also very finely sub-divided metal.

The crux of the process embodiment of the invention resides in the step of applying (e. g., depositing) the conductive overlays on the web of dielectric itself as the latter is being wound up, the overlays so applied being in such thin layers that their thickness is not perceptible in practice. Thus, the conductive overlay may be formed on the dielectric web by applying spaced areas of conductive material on the untreated side of an insulation web the opposite side of which latter has been coated and/or impregnated with a resinous composition, e. g., shellac coating composition. For this purpose, the applying step may consist in spraying, printing or painting onto the insulation web spaced areas of a fluid composition comprising finely divided carbon with or without added finely divided metal; or the applying step may consist in depositing a thin layer of the conductive material on the insulation web by the aid of an electric field. The fluid carbonaceous composition may comprise an aqueous suspension of colloidal graphite (e. g., the products known in commerce under the notations “Aquadag”; “Hydrokollag,” etc.), or compositions similar to printer’s ink or to black India ink.

In all cases wherein the overlay is applied to the insulation web by spraying (or printing, or painting) thereon a fluid composition comprising the conductive material of the eventual overlay, the liquid medium is to be expelled from the coating layer before the web is wound up into a roll.

It is within the scope of the present invention to form the condenser or insulator from a plu-

rality of separate sheets of the insulation; also, to insert separate sheets (of insulating material) carrying the conductive overlays into the roll while winding up the continuous web of dielectric; in which case the latter may or may not itself carry conductive overlays.

The apparatus improvement resides broadly in providing a winding machine for making insulation windings, with apparatus for applying (depositing) conductive overlays on the dielectric web being advanced to the winding mechanism. The overlay-applying apparatus—hereinafter to be more fully described—preferably is so constructed and arranged as to be capable of being set alternately into and out of operation during the winding operation in adjustable sequence and adjustable path length, the actuation of said apparatus being provided by manual control or automatic control—preferably, controlled by a revolution counter on the winding machine. Thus, the overlay-applying apparatus may be actuated to operate during, say, one revolution of the winding mechanism and to be thrown out of operation during a predetermined interval (which may amount to less than one revolution or one or more revolutions) of the winding mechanism.

For limiting the length of the overlays (in the direction of the axis of the roll), there may be and preferably are employed covering on masking members located over the path of the insulation web, which masking members are slidable in the direction of the axis of the roll: their relative positions with respect to the web may be adjusted, manually or automatically, either continuously (from beginning to end of a roll) or intermittently. If desired, the overlay-applying apparatus may be provided with means providing relative locking between the adjusting device for the masking members and the control of the overlay-applying means per se.

In its preferred form, the overlay-applying apparatus includes one or more pressure-actuated spray nozzles for applying onto the insulation web areas of fluid coating composition yielding conductive layers. The spray nozzles may be so arranged that the cross-sections of their jets partially overlap: the jets may, if desired, be given an oval cross-section. The nozzles are controlled by a common lever mechanism which (as has been indicated hereinbefore) may be actuated in response to movement of the mandrel of the insulator roll. The nozzles are provided with the fluid composition and compressed air by means of any suitable conduits from respective sources.

The invention will be further described with reference to the accompanying drawings, in which

Fig. 1 is a perspective view illustrating schematically the method of forming the improved lead-through device of the invention;

Fig. 2 is an axial sectional elevation of a partially completed condenser in accordance with one form of the article of the invention;

Fig. 3 is a view similar to Fig. 2 but illustrating another form of the condenser;

Fig. 4 is an exaggerated, axial, sectional elevation of a completed condenser in accordance with the invention; and

Fig. 5 is a fragmentary perspective view illustrating apparatus suitable for carrying out the improved method of the invention.

Fig. 1 illustrates formation of a condenser. According to the same, overlays 9, with relative spacing a and with a width b smaller in the circumferential direction than the circumference at

that diameter of the roll, are applied on the paper web 2 to be wound up on mandrel 1 and coated on one side with artificial resin solution. The length c of the overlays in the direction of the axis can be limited at a distance d from the edge of the paper according to Fig. 1. The overlay could, however, be applied over the entire length in the direction of the axis, and the finished roll subsequently turned down conically, or in another suitable shape, approximately as in Fig. 4. This latter figure shows a condenser lead-through device, in solid view below, and in lengthwise section above, the turned down winding 4 being applied on the lead-through tube 21 and being encircled outside with the socket element 22. In addition, the overlays can be allowed to increase or decrease in their axial length according to any definite rule desired so that a condenser lead-through device according to Fig. 2 is the result, the outer shape of which is cylindrical, it is true, but whose control inserts 9 become smaller from the inside toward the outside. A wound high voltage condenser can be provided according to Fig. 3 with conducting inserts 9 of equal length or nearly equal length in the direction of the axis but staggered in relation to each other.

When, however, the conducting inserts are arranged in such small radial spacings, a number of practical difficulties are encountered. Both metal foil sheets and metallized paper result in such considerable increase in the radial thickness that the parts outside the overlays are under too slight winding pressure. By equalizing papers that are allowed to run in beside the layers only a partial compensation of the thickness is possible in practice and this complicates the process of manufacture to a practically impossible extent.

The invention, therefore, comprises a process of applying the conducting inserts on the insulation web of the wound condenser itself in such a thin layer that their thickness is not perceptible in practice. This is the case when their thickness amounts at most to $1/30$ of the thickness of the insulation web. In practice this can be attained for instance by applying carbon suspended in liquid on the insulation web after which the liquid is volatilized. The carbon is to be divided up as colloiddally as possible, in the form of lampblack or, even better, graphite. A suitable suspension, for instance, can be obtained in trade under the names of "Aquadag," "Hydrokollag," etc., but likewise certain types of India inks and printing inks can be employed. The colloidal graphite suspension can have the finest metal powder mixed with it. The conducting layer can be sprayed, printed, or painted on the insulation web, or applied thereto by an electric field. The liquid can be water or another suspension carrier.

The apparatus shown in Fig. 5 as constructional example for the manufacture works according to the spraying process. It consists of the known hard paper winding machine M, a spraying apparatus S being placed in advance of the same. The paper has already been coated with a film of resin composition or similar dielectric composition, in another machine in the ordinary way. The paper web runs on to the winding mandrel 1 in order gradually to form a solid cylindrical roll 4. 3 are heated pressure rolls that cause the resin film on the paper to soften, adhere and subsequently harden. The revolutions of the winding mandrel are counted by the counting mechanism 20 connected to a switch contact apparatus 21. From the feed roller 5, the paper 2 runs over the reversing roll 6 and the

preheating roll 7 to the machine part M. Between the rolls 6 and 7 is found the spraying device for applying the conducting inserts. The conducting substance, for instance colloidal graphite suspended in water, is sprayed through nozzles 8 on the paper web 2 in such fashion that layers 9 result. 10 is the compressed air connection for the nozzles, 11 the feed line for the spraying liquid, 12 the actuating lever for the nozzles that is controlled automatically by the magnet coil 13 by means of the contact apparatus 21 of the winding counter 20. Circuit making and breaking means actuated by a counting mechanism, and which may be considered as suitable for embodiment in the circuit disclosed, is shown in U. S. Patent No. 1,001,409 granted August 22, 1911, to E. P. Jennings, Jr.

Two movable cover plates 14 for limiting the sprayed coating in the direction of the axis are guided on a fixed supporting rail 15. The spindle 16 serves for adjusting the cover plates by hand crank 17 and in certain cases by automatic drive 18 from a constant speed motor 22; the latter for the case where the axial length of the coating is to be changed during the winding in a predetermined manner, for instance for producing a roll according to Fig. 2 or Fig. 3. A shifting device working automatically intermittently and controlled, for example, by switch mechanism 23 can be provided, however, so that when the spray nozzles are not in operation, the cover plates will be automatically shifted. For adjustment by hand, the millimeter scale 19 is provided.

If it is desired to spray the whole width of the paper, no cover plate 14 is needed. For automatic advancing speed of the two plates 14 differing from each other, use is made preferably of two spindles 16 each driving one cover plate 14.

In an arrangement using stationary nozzles, the latter are preferably given an oval outlet for the jet cross-section, so that a rectangular coating is produced by overlapping juxtaposition of the jets. The spraying mechanism can, however, consist likewise of one or a plurality of nozzles that either travel in the direction of the axis so that a coating with helical-line boundaries is the result, its boundaries forming an angle between 45° and 90° with the circumferential line of the roll, or else they could travel in an inclined line so that a coating bounded by lines parallel to the axis is the result.

Obviously, a number of insulation webs could be allowed to run into the winding machine simultaneously, i. e., parallel only one of them being furnished with the conducting coatings, or the paper could be permitted to enter the machine in sheet form. Sheets or insulation strips provided with conducting coatings could likewise be inserted in the insulation web during the winding operation.

If the lateral boundary is adjusted intermittently during the winding operation, a lock mechanism between the control apparatus for the nozzles and the shifting device can be provided so that the nozzles cannot spray during the shifting and so that the cover plates cannot be shifted during the actual spraying.

In addition, it is easily possible to arrange a number of spraying devices S one beside the other in the direction of the axis in order to be able to make a number of wound condensers at the same time on the same winding machine M.

This application is a division of my application Serial No. 335,340, filed May 15, 1940.

I claim:

1. In an apparatus for forming wound condensers of the type including a feed roll for a web of insulation and a winding mechanism including a winding mandrel, the combination therewith of rotation-responsive means operatively associated with the winding mandrel, means operatively intermediate the feed roll and winding mandrel for depositing onto such web coatings of a fluid composition comprising finely divided conductive material, and means actuated by said rotation-responsive means for controlling said coating-depositing means to oper-

ate intermittently to thereby apply to such web in a regular sequence of spaced areas a plurality of conductive inserts.

2. The improved apparatus defined in claim 1, in which the coating-applying means includes at least one covering member positioned over the path of such insulation web and shiftable in the direction of the axis of the roll, and in which means are provided for intermittently moving said covering member during the feeding forward of such roll to thereby vary the extent of said areas in such axial direction.

HANS KAPPELER.