Aug. 9, 1949.

H. W. LORD

2,478,633

ELECTRIC COIL

Filed March 19, 1946

Fig. 1.

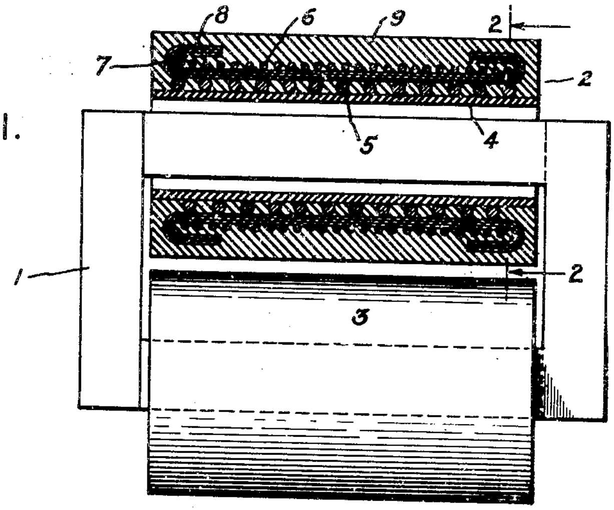


Fig. 2.

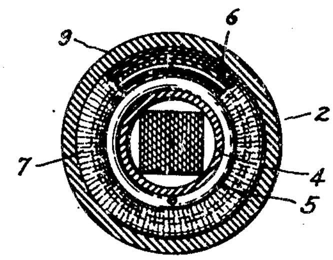
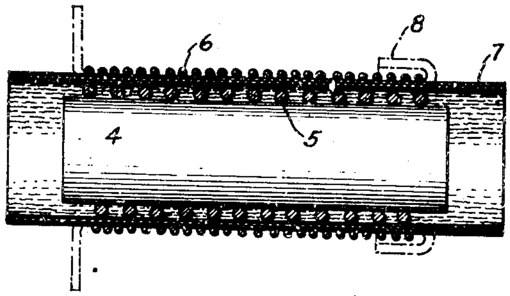


Fig. 3.



Inventor
Harold W. Lord
by Ernest C. Britton
His Attorney

Patented Aug. 9, 1949 **2,478,633**

UNITED STATES PATENT OFFICE

2,478,633

ELECTRIC COIL

Harold W. Lord, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application March 19, 1946, Serial No. 655,560

3 Claims. (Cl. 175—21)

1

This invention relates to electric coils and more particularly to an improved method of insulating such coils.

Multi-layer electric coils usually have spacing means of solid insulation between the conductor layers. This co-called layer insulation usually extends beyond the edges or margins of the conductor layers it separates so as to increase the creepage distance between those layers. A comparatively recent way of treating coils, especially relatively small coils such as are used in the communication and control fields as distinguished from the electric power consumption and distribution fields, so as to improve their dielectric and mechanical properties is to impregnate them with a polymerizable material containing no volatile solvent. The impregnation is made very complete by a vacuum-pressure process and the material is then polymerized by means of heat into a rock-hard, strong, stable, void-free and water-resistant matrix in which the conducting and insulating layers are solidly embedded. However, the above described thermosetting material, which for the sake of brevity will hereafter be referred to as solventless varnish, has a tendency to shrink when it hardens and this shrinkage often produces minute cracks which usually start at the layer insulation and sometimes extend out to the margins of the matrix, the cracks following the contour of the layer insulation. Consequently, it has heretofore been necessary to extend the margins of the insulating matrix considerably beyond the margins of the conductor layers so as to provide adequate creepage distance through the cracks between the margins of the conductor layers and the margins of the coil or matrix. This abnormally wide coil margin results in an uneconomical design which for certain applications, such as pulse transformers, is also inefficient. Furthermore, the cracks provide a path for moisture to penetrate into the interior of the coil and thus further reduces its dielectric strength.

In accordance with this invention the cracking of the matrix at the layer insulation is eliminated, thus making it possible substantially to reduce the width of the coil margins so as to provide a shorter and more efficient coil of equivalent dielectric strength. This is accomplished by extending the margins of the layer insulation a substantial distance beyond the edges of the conductor layers and then folding the extended margin of the layer insulation up and back over the top conductor layer. In this way any crack following the contour of the layer

2

insulation will in effect be doubled back on itself and will be turned inwardly instead of outwardly toward the coil margins. However, the tendency toward cracking at the margins of the layer insulation is practically eliminated because the margin of the layer insulation now extends radially instead of axially as heretofore, and the layer insulation is mechanically much stronger in directions along its surface than in a direction perpendicular to its surface.

An object of the invention is to provide a new and improved insulated electric coil.

Another object of the invention is to provide a new and improved layer insulation for coils which have been impregnated in polymerized solventless varnish.

A further object of the invention is to provide a new and improved method of insulating an electric coil.

Still another object of the invention is to provide a new and improved method of preventing cracks in the polymerized solventless varnish in which a multi-layer coil is embedded.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing Fig. 1 is a part sectional view of an electrical apparatus having two coils constructed in accordance with the present invention, Fig. 2 is an end sectional view of one of the coils shown in Fig. 1 taken on line **2—2** thereof, and Fig. 3 is a sectional view illustrating the principal step in practicing my novel method.

Referring now to the drawing and more particularly to Fig. 1, there is shown therein by way of example a pulse transformer of the type which is used in high frequency communication circuits. This transformer is shown as comprising a two-legged magnetic core **1** on the respective legs of which are mounted duplicate coils **2** and **3**. As these coils are duplicates, only coil **2** will be described in detail. This coil consists of an inner spool **4** of solid insulating material on which is wound an inner conductor layer or winding **5** which may be the low voltage primary winding of the pulse transformer and thus is shown as having relatively few turns of relatively large cross section conductor. Over the inner conductor layer **5** is wound an outer conductor layer which may be the high voltage secondary winding of the transformer and which is shown as having a relatively large number of turns of relatively small cross section conductor. The layers **5** and **6** are separated by layer insulation 7 which may consist of several layers of paper, preferably crepe paper. The ends or margins of this layer insulation are folded outwardly and back over the edges of the outer layer as shown at 8. The entire coil is insulated and integrated by solid homogenous insulation 9 which was originally liquid and in which the various coil parts have been impregnated prior to hardening of the insulation.

The reason it is preferable to use crepe paper for the layer insulation 7 is that as the margins of the layer insulation are bent outwardly its radius is increased, and therefore, its circumference will have to increase and this can only be accomplished by stretching of the layer insulation or else by slitting it in a number of places. However, it is preferable to use material which will stretch rather than slitting inelastic material because the slits will tend to produce weaknesses in the insulation. Furthermore, once the outwardly bent margins have moved past the radial plane of the coil, the resilience of the crepe paper will contract the folded over ends 8 and hold them snugly against the outer surface of the outer conductor layer 6.

Fig. 2 shows how the layer insulation 7 extends all around the coil between the conductor layers 5 and 6 and how it is folded outwardly so as to enclose the ends of the outer conductor layer 7.

Fig. 3 shows how the edges or margins of the layer insulation 7 are formed. First the layer insulation may be wound several times around the inner conductor layer 5 so as to produce a laminated cylinder of solid insulation. The length of this cylinder is substantially in excess of the length of the conductor layers. After the outer conductor layer 6 has been wound on, the protruding margins of the layer insulation 7 are folded radially outward until they are in substantially a radial plane of the coil as shown by the dashed lines at the left and then the folded out extensions are folded back over the edges of the coil 6 until they assume the position shown at 8 in Fig. 3.

The impregnation of the coil may be carried out in any suitable and well known manner. For example, the coil may be placed in a chamber which is surrounded by a helical pipe and the interior of which is connected to pipes for filling it and for subjecting it to a vacuum and to greater than atmospheric pressure. Typically, the parts as shown in Fig. 3, with the layer insulation folded back to the dotted position shown at 8, are placed in this chamber and steam or other suitable heating fluid is passed through the helix to heat the interior of the tank. At the same time, the interior tank is evacuated. These operations are for the purpose of completely drying the insulating spool 4 and the layer insulation 7 and also removing any other moisture which may be in the coil. After a suitable drying time has elapsed a cooling fluid is passed through the helix for reducing the temperature in the tank. This is to prevent premature setting of the solventless varnish which is presently to be admitted. The vacuum is, however, still maintained on the inside of the tank. The polymerizable material containing no volatile solvent is then introduced into the tank under vacuum. This material may be of any suitable type such, for example, as comprising a resin obtained by the esterification of an alpha, beta unsaturated organic acid with a polyhydric alcohol and an organic substance which contains at least one polymerizably reactive allyl group, or any other specific example which is described in British Patent 540,168, dated October 8, 1941. The vacuum is now released, thus allowing atmospheric pressure to drive the liquid into the solid insulation parts 4 and 7, thus thoroughly impregnating the entire coil structure. If necessary, the pressure can be raised above atmospheric by applying high pressure nitrogen to the tank. After a suitable length of time elapses so as to insure thorough impregnation, the tank is opened and the coil is removed to a baking oven where it remains long enough for the solventless varnish to be polymerized into a hard, strong matrix in which the coil parts are embedded.

It will be observed from the drawing that by folding the layer insulation outwardly, there is in effect a barrier of solid insulation which is adjacent the ends or margins of the layer insulation and which extends in a radial direction instead of in the usual axial direction of the layer insulation. This feature alone will materially reduce the tendency for cracking to occur. However, it is preferable to have the ends of the layer insulation long enough so that they can also be bent inwardly again to the positions 8.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications 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 electric coil comprising, in combination, at least two conductor layers, layer insulation extending between said layers, said layer insulation being curved around and back over the edges of the outer layer, and a matrix of hardened liquid insulation by which said layers have been impregnated, said insulation being characterized by shrinkage as it hardens and cools, said matrix of insulation completely surrounding said conductor layers with its boundaries extending beyond the curved back portions of the layer insulation.

2. An electric coil comprising, in combination, at least two substantially coaxial conductor layers, resilient layer insulation extending between said layers, said layer insulation being curved around and back over the edges of the outer layer, and a matrix of hardened solventless varnish by which said layers have been impregnated, said varnish being characterized by shrinkage as it hardens and cools, said matrix of hardened varnish completely surrounding said conductor layers with its boundaries extending beyond the curved back portions of the layer insulation.

3. An electric coil comprising, in combination, at least two substantially concentric conductor layers, crepe paper layer insulation extending between said layers, said layer insulation being curved around and back over the edges of the outer layer, and a matrix of polymerized insulating material containing no volatile solvent by which said layers have been impregnated, said insulating material being characterized by shrinkage as it hardens and cools, said matrix of polymerized insulating material completely surrounding said conductor layers with its boundaries extending beyond the curved back portions of the layer insulation.

HAROLD W. LORD.

(References on following page)

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,427,324	Priestley	Aug. 29, 1922
1,485,289	Peterson	Feb. 26, 1924
1,675,419	Myers	July 3, 1928
1,970,406	Vienneau	Aug. 14, 1934
2,116,318	Miles, Jr.	May 3, 1938
2,194,338	Vienneau	Mar. 19, 1940
2,435,093	Mitschrich	Jan. 27, 1948