March 18, 1958 G. O. HUNSINGER 2,827,510

ELECTRIC CABLES FOR TRANSFORMER LEADS AND THE LIKE

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Fig. 1

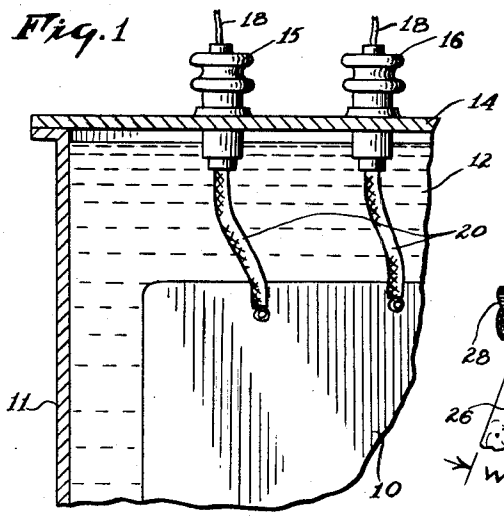


Fig. 2

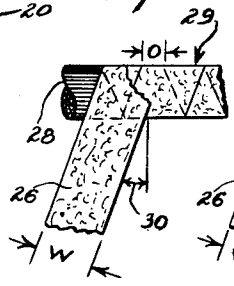


Fig. 3

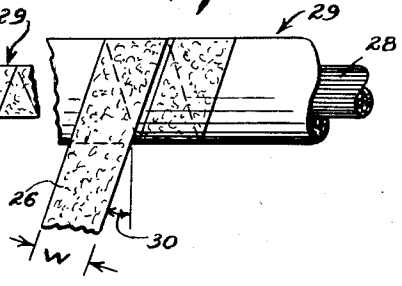


Fig. 5



Fig. 4

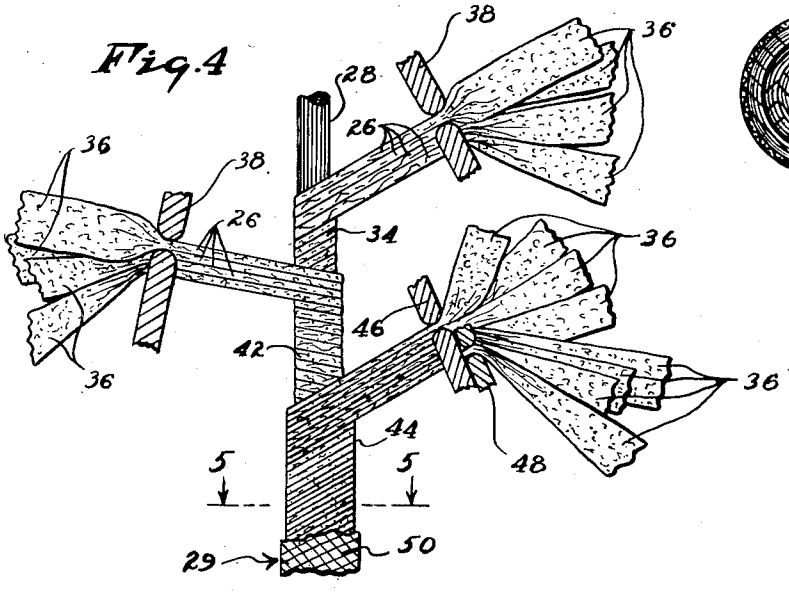
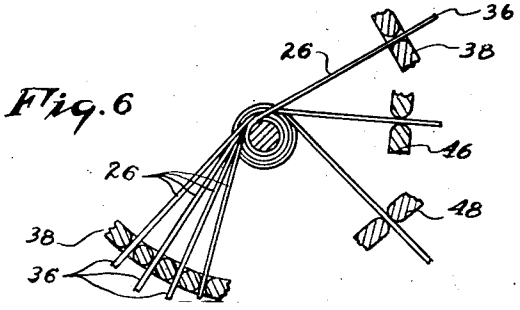


Fig. 6



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ELECTRIC CABLES FOR TRANSFORMER LEADS AND THE LIKE

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11 Claims. (Cl. 174—122)

This invention relates to conductors having untreated, crumpled paper insulation. The invention is primarily concerned with transformer leads which are placed in oil when in use. The primary purpose of the crumpled paper is to provide insulation of a maximum radius, and to leave a substantial volume of voids into which the oil enters to supply the dielectric strength for the insulation.

Flexibility of the insulation is an important advantage because some transformer leads require bends of fairly short radius; and with paper insulation sharp bends which break the insulation leave the outside curve of the conductor with an insulation covering of less radial thickness than intended. The danger of such breakage of the insulation is increased when conductors have greater radial thickness of insulation because there is increased distortion of the insulation at greater distances from the neutral axis of the bend.

It is an object of the invention to provide an improved, paper insulation of greater flexibility than paper insulation of the prior art. Another object of the invention is to obtain a maximum radial thickness of insulation with more voids for the admission of oil into the insulation.

The insulation of this invention can be wound in a single pass or in multiple passes through spinning heads of a machine for applying the insulation to the wire conductor. It can be applied with the same or different angles of lay. For greater flexibility the different layers of insulation may be wound with the same angle of lay. This requires that the spinning head, which applies outer layers of insulation, run somewhat more slowly than those which apply the inner layers. In order to compensate for the greater radius of the outer layer of paper insulation, when using the same angle of lay, this invention supplies more paper to the outer layer; and in the preferred construction, the additional paper is obtained by crumpling more strands into the same unit length of conductor. This permits the use of strands of the same width for all of the reels of the spinning heads.

Other objects, features, and advantages of the invention will appear or be pointed out as the description proceeds.

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views:

Fig. 1 is a fragmentary, sectional view of a transformer showing the way in which the transformer leads of this invention are connected between the core and terminals of a transformer;

Fig. 2 is a diagrammatic view showing the relative advances of a helical wrapping for inner layers of small radius;

Fig. 3 shows the different pitch of the insulation when the same angle of lay is used for outer layers of larger radius than in Fig. 2;

Fig. 4 is a diagrammatic view showing the way in which multiple strands of untreated paper are transversely crumpled and wrapped around a conductor and around inner layers while passing through a spinning head;

Fig. 5 is a greatly enlarged, transverse sectional view taken on the line 5—5 of Fig. 4; and

Fig. 6 is a reduced scale, diagrammatic view showing the relation of the paper dies to the conductor when looking along the axis of the conductor.

Fig. 1 shows a transformer core **10** enclosed in a housing **11** which is filled with oil **12**. The housing has a cover **14** and terminals surrounded by insulators **15** and **16** attached to the cover. Only two such terminals are shown, but it will be understood that there are usually others at spaced regions across the transformer housing. Power lines **18** extend from the insulators **15** and **16**. Within the transformer the power lines are connected to the windings of the core **10** by transformer leads **20**.

Figs. 2 and 3 are diagrammatic views showing the way in which a strand of crumpled paper is wrapped on cables of different diameter in a helix that has the same angle of lay for the layer of large radius as for the layer of small radius.

In Figure 2 a crumpled paper strand **26** is wrapped directly on a stranded metal conductor **28**. The strand of paper insulation **26** is supplied to the conductor **28** at an acute angle to the conductor so as to wrap in a helix about the conductor. This angle of the helix, or angle of lay, is designated by the reference character **30**. Each convolution of the strand **26** has a width W and overlaps the preceding convolution by a distance O. In the actual construction of the first layer of insulation, four strands of paper insulation **26** are used in the first layer of insulation in order to obtain more overlapping and a greater radial thickness for this first layer of insulation, but the single strand shown in Fig. 2 illustrates the principle.

Fig. 3 shows a crumpled paper strand **26**, having the width W, applied to the cable **29** as part of one of the outer layers of insulation. The strand **26** is applied to the cable in Fig. 3 with the same helical angle, or angle of lay **30**, as in Fig. 2; but because of the increased radius of the cable **29** there is no overlapping of the successive convolutions of the strand **26**.

With this invention, the desired overlapping of the convolutions of successive strands of insulation is obtained by using more strands for a layer of insulation which has larger radius. By using eight strands of crumpled paper **26** instead of the single strand shown in Fig. 3, this invention obtains the desired overlapping of successive strands and also obtains a substantial radial thickness for this layer of insulation with increased radius.

Although the preferred embodiment wraps successive layers of insulation, in opposite directions, that is, with alternate right and left-hand helixes, the flexibility of the insulation is improved by having the angle of lay, particularly of those layers which wrap in the same direction, equal for all layers.

Fig. 4 is a diagrammatic view illustrating the construction of the cable **29** with plural strands of crumpled paper in each layer of insulation, and more paper in the outer layer. This figure does not illustrate the way in which the strands are actually applied to the cable since a description of the operation of the apparatus for applying the crumpled paper is not necessary for a complete understanding of this invention.

The application of crumpled paper for insulation is known and for a complete understanding of this invention it is sufficient to understand that each strand of crumpled paper is applied with a tension which is limited to prevent removal of the crumpled effect. Too much

tension on the paper when wrapped on the cable would result in a mere folding of the paper with no substantial voids between folded portions of each strip.

One of the ways in which the tension is limited is by using strips of moderate width, preferably not over about 1 to 1¼ inches in width. Wider strips do not crumple as uniformly and sometimes jam in the dies through which they are pulled to crumple them.

Fig. 4 shows the stranded metal conductor **28** with a first layer **34** of crumpled paper insulation made up of four strips **36** which are crumpled into strands **26** by constricted dies designated generally by the reference character **38**.

The paper strips **36** are preferably untreated kraft paper. This first layer of insulation is applied directly over the bare metal conductor **28** with a right-hand lay in the illustrated construction. A similar layer **42** of crumpled paper insulation, made up of four strands **26**, is applied over the first layer **34** with a left-hand lay. The second layer **42** is also made up of crumpled, untreated kraft paper which is drawn through multi-dies, usually separate dies for the separate strips **36**. The reference character **38** designates representative diagrammatic die means for crumpling the paper.

An outer layer **44**, of crumpled paper insulation, which is also preferably made of untreated kraft paper, is applied over the intermediate layer **42**. In order to obtain comparable overlap of the crumpled paper strands in spite of the greater radius of the upper layer **44**, with the same helix angle as the other layers, more paper is used to make this layer.

This additional paper can be obtained by using strips **36** which are wider than those used for the other layers, but in the construction illustrated, strips of the same width are used with an increase in the number of the strips. Figure 4 shows die means **46** for crumpling and overlapping four paper strips **36**; and shows other die means **48** for crumpling and overlapping an additional four strips **36** which are overlapped as a group with the other strips which are crumpled by the die means **46**.

The layer **44** is applied with a right-hand lay at the same helix angle as the strands **26** of the first layer. Outside of the outer layer **44** of crumpled paper insulation, there is a braid **50** made of loosely woven cloth. This braid **50** provides some mechanical protection for the crumpled paper layer **44**, but there is ample space between the threads of the braid **50** to permit oil to pass through the braid and into the voids of the crumpled paper insulation.

The construction illustrated is economical to manufacture and has highly satisfactory insulating qualities for use in transformer leads, and other purposes where the cable is not subject to substantial mechanical abrasion.

Figure 6 is another diagram to show the application of the insulation in layers; and the same illustrative expedient for showing the die means is used as in Figure 4.

Some changes and additions in the illustrated embodiment can be made without departing from the invention as defined in the claims.

What is claimed is:

1. An insulated electrical cable including a metal conductor, a wrapping of untreated, crumpled paper applied directly to the surface of the conductor as the first layer of insulation, other layers of insulation outside of said first layer and each consisting of untreated, crumpled paper, each of the layers of insulation comprising a plurality of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips and helically wound, the outer layer of crumpled paper including more strips of paper than the inner layers.

2. An insulated electrical cable comprising a central metal conductor with multiple layers of crumpled paper insulation surrounding it, the inner layer of insulation bearing directly against the metal conductor and consisting of untreated crumpled paper, and a plurality of superimposed layers of insulation comprising similar untreated crumpled paper, each layer of insulation comprising multiple strands of the crumpled paper wrapped as helixes around the conductor, each strand including a haphazardly crumpled paper strip crumpled in directions substantially normal to the longitudinal edges of the strip, the outer layer of insulation having more strands of the crumpled paper than the inner layers.

3. A flexible electrical cable for transformer leads that are to be immersed in oil when in service, said cable comprising a stranded metal conductor, a plurality of layers of crumpled paper insulation surrounding said conductor including a first layer of crumpled paper made of a number of individual strips of paper crumpled and contiguous to one another and forming with one another a wrapping strand wound in a helix in direct contact with the surface of the conductor and with some overlapping of the rearward edge of each convolution and the forward edge of the next convolution, a second layer of crumpled paper made of a number of individual and contiguous strips wrapped over the first layer in a manner similar to the wrapping of the first layer on the conductor but with an opposite direction of lead of the helix, and a third layer of crumpled paper insulation made of a greater number of individual strips than the first layer, the strips having the same direction of lead and substantially the same helix angle as the strips of the first layer of insulation but the greater number of strips of the third layer forming a wider wrapping strand to compensate the greater radius of the third layer without change in the helix angle, the additional strips of the third layer adding substantial additional width and each wrapping strand of the third layer having some overlapping of the rearward edge of each convolution and the forward edge of the next convolution, and a porous braided cloth cover over the outside layer of crumpled paper for admitting oil freely into the open spaces provided by the crumpling of the paper.

4. A transformer lead including a central metal conductor, a layer of insulation comprising a plurality of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips and applied directly to the surface of the metal conductor as the first layer of insulation, a plurality of other layers of insulation over the first layer and each comprising similarly crumpled paper strips wrapped as helixes around the conductor with the helixes of the successive layers of insulation being wound to the right and left, respectively and with all layers of insulation, except the extreme outer layer comprising untreated crumpled paper, a braided cloth cover comprising the extreme outer layer of insulation with loosely woven mesh for admitting oil freely to the voids by the crumpled paper, the outer layer of paper insulation including more strips of paper than the other layers.

5. An insulated conductor comprising a central metal conductor, a first layer of insulation applied directly to the surface of the metal conductor and consisting of a plurality of strands of helically-wound, transversely crumpled, untreated paper, each strand including a haphazardly crumpled paper strip crumpled in directions substantially normal to the longitudinal edges of the strip, a plurality of outer layers of insulation consisting of other strands of similarly crumpled, untreated paper, successive layers of the insulation having the strands wrapped as right and left hand helixes, respectively, and the outer layer of crumpled paper insulation having strands of the same original width as the inner layers but with more strands for each unit length of the conductor to compensate for the greater radius of the outer layer of crumpled paper insulation.

6. An insulated electrical cable including a metal con-

ductor wire, a first layer of insulation applied directly to the metal conductor wire and consisting of strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, other layers of similar insulation outside of the first layer, the subsequent layers of insulation being also made of strands of similarly crumpled paper strips, the lay of the strands of the successive layers being of the same angle, but the outer layer of crumpled paper insulation containing more paper per unit length of conductor than the inner layers to compensate for the greater radius with the same angle of lay of the strands.

7. An insulated elcertical cable comprising a central wire, a first layer of insulation applied directly to the surface of the wire and consisting of untreated strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, a plurality of other layers outside of the first layer, said other layers consisting of similar strands of untreated, crumpled paper, each of the layers of insulation having its strands helically wound with substantially the same helix angle and with successive layers having right and left hand leads, respectively, the outer layer of crumpled paper insulation consisting of substantially twice as many strands of paper to compensate for the greater radius with the same helical angle for the strands, and a braided cover overlying the outer layer of crumpled paper insulation.

8. An electrical cable comprising a central metal conductor, a number of layers of insulation applied to the surface of the wire and consisting of untreated strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, successive layers having the same number of strands of paper and with a different angle of pitch and the successive layers having the same direction of lead, and a braided or woven cover overlying the outer layer of crumpled paper insulation.

9. An electrical cable comprising a central metal conductor, a number of layers of insulation applied to the

surface of the wire and consisting of untreated strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, successive layers being applied with the same number of strands of paper and with a different angle of pitch and with successive layers applied with alternate layers having left and right hand lead, and a braided or woven cover overlying the outer layer of crumpled paper insulation.

10. An electrical cable comprising a central metal conductor, a number of layers of insulation applied to the surface of the wire, and consisting of untreated strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, each layer being applied with a different angle of pitch and with the successive layers applied with the same directions of lead, the outer layers comprising more strands of paper than the inner layers, and a braided or woven cover overlying the outer layer of crumpled paper insulation.

11. An electrical cable comprising a central metal conductor, a number of layers of insulation applied to the surface of the wire and consisting of untreated strands of haphazardly crumpled paper strips crumpled in directions substantially normal to the longitudinal edges of the strips, the successive inner layers being applied with the same number of strands of paper and with a different angle of pitch and with successive layers applied with alternate layers having left and right hand lead, the outer layer comprising more strands of paper than the inner layers, and a braided or woven cover overlying the outer layer of crumpled paper insulation.

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