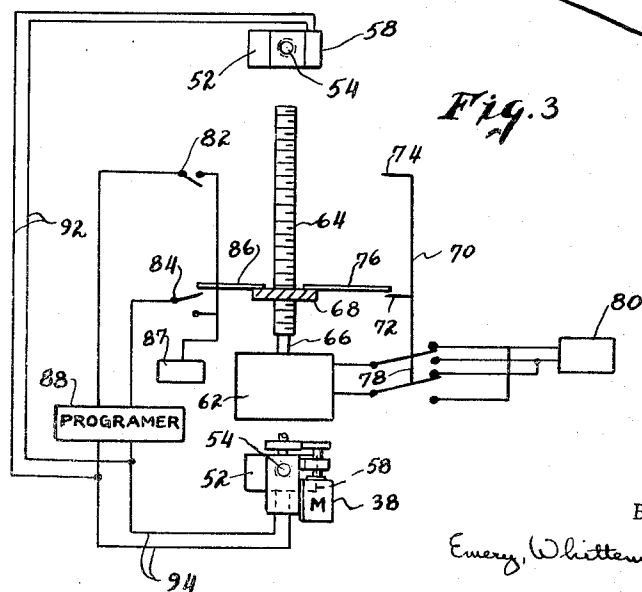
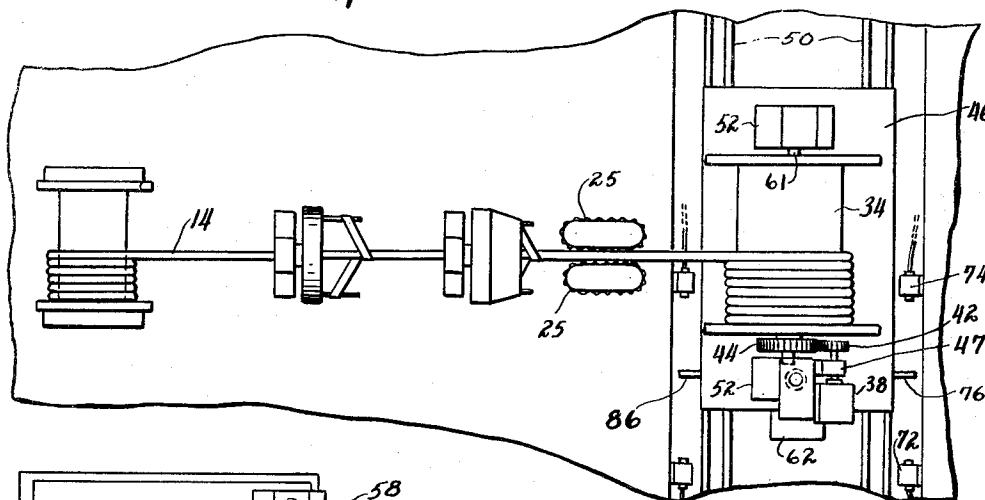


O. G. GARNER
METHOD AND APPARATUS FOR FABRICATION OF
PAPER TAPE INSULATED CABLES

2 Sheets-Sheet 1

Filed July 2, 1959



INVENTOR.
OSCAR G. GARNER

BY

Emery, Whittemore, Sandoe & Graham

ATTORNEYS

Sept. 5, 1961

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2,998,692

Filed July 2, 1959

2 Sheets-Sheet 2

Fig. 4

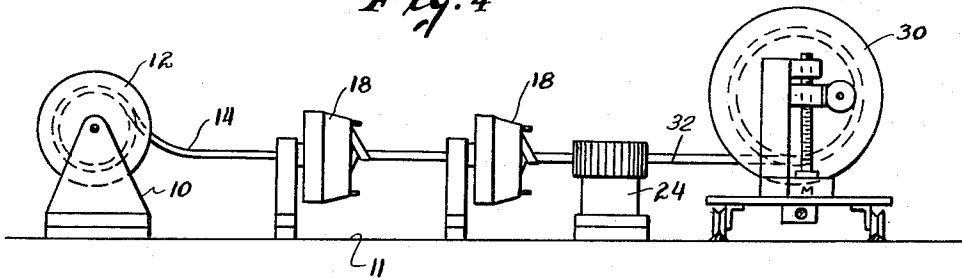


Fig. 5

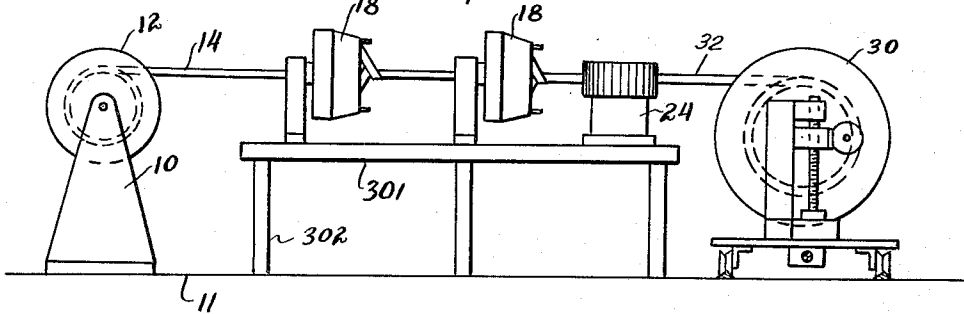
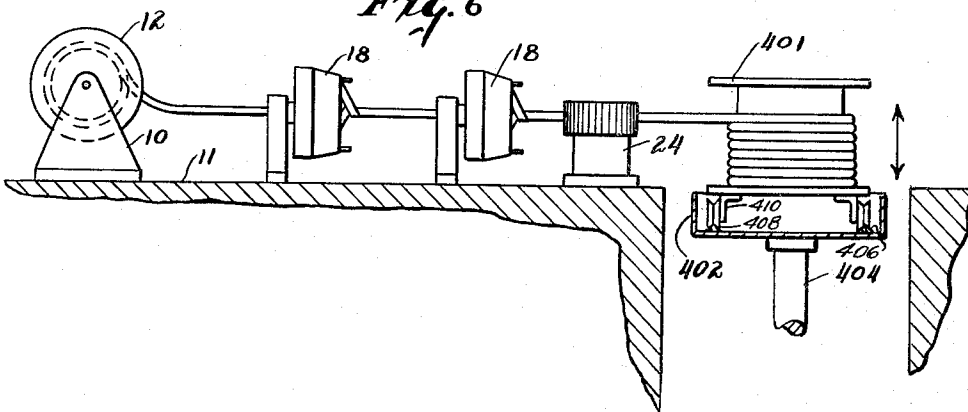


Fig. 6



INVENTOR.
OSCAR G. GARNER

BY
Emery, Whittemore, Sandoe & Graham
ATTORNEYS

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METHOD AND APPARATUS FOR FABRICATION OF PAPER TAPE INSULATED CABLES

Oscar G. Garner, Westfield, N.J., assignor to General Cable Corporation, New York, N.Y., a corporation of New Jersey

Filed July 2, 1959, Ser. No. 824,579

2 Claims. (Cl. 57—3)

This invention relates to the method of fabricating high voltage paper insulated cables and, more particularly, to the method and apparatus for take-up of such cables from the tape winding heads.

Fabrication of high voltage electric cables using a plurality of overlying, helically wrapped paper tape layers as insulation over a conductive core is known to the art. The conductor, usually copper or aluminum, and usually stranded, is fed through the requisite number of paper taping heads which wrap continuous paper tapes in overlying helices of predetermined pitch around the conductor. A plurality of helical wraps are applied to the conductor to give the requisite dielectric strength in the completed cable.

The tapes preferably are applied under controlled humidity conditions to permit precise control of uniformity throughout the cable insulation. The paper tapes, a few mils in thickness, are applied under tension and to an aggregate thickness which may approach an inch, or even more. After covering the conductor with the required number of paper tape layers, the cable may be impregnated with oil by standard vacuum impregnation procedures. The ultimate quality of the paper insulated, oil-impregnated high voltage cable depends, in important part, upon the precision with which the process of applying the paper tapes is carried out. Wrinkling or tearing of the wrapped tapes opens small spaces in the insulation which will be subject to ionization when the cable is in service, and which may ultimately result in insulation failure.

While the art has attempted to prevent the formation of undesirable spaces in the paper insulation by such means as applying the tape with a slight gap between successive laps, by precise tensioning of the paper as it is wrapped on, and by the selection of the proper width of paper tape, such steps have not completely eliminated ionizable spaces from the paper insulation. I have found that the usual method of paying cable from the paper taping heads to the take-up reel introduces successive bends in opposite directions. Such bending of the paper in the dry state aggravates and/or causes wrinkling, cracking and tearing of the edges of the paper tapes and introduces longitudinal creasing into the paper tapes, each of which increases the air spaces in the insulation.

I have found that restriction of the bending of the cable after it leaves the paper taping head to a single bend as it is applied to the take-up reel greatly improves the quality of the finished cable. Bending of the dry cable only once as it is applied to the take-up reel is insufficient to produce damage in the applied paper laminations. Impregnation of the cable with oil at this point sufficiently reduces the friction between paper laminations so that the cable can be bent subsequently without harmful disturbance of the paper layers.

In conventional practice the conductor is fed through a plurality of paper taping heads from a pay-off stand. The paper taping heads apply the requisite plurality of helical paper wrappings thereto. The paper taping heads are desirably located in a controlled atmosphere room to maintain the tapes in a controlled dry state during application to the conductor. Often the cable is pulled from the paper taping heads by a rotatable capstan around which several turns of the cable is taken. As the cable

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is payed onto and off from the capstan, it is subject to bending in a first direction and to subsequent bending in the opposite direction.

A take-up stand carries a take-up reel upon which the paper covered conductor is wound. All of the equipment is usually mounted on an assembly floor. Although the paper taping heads and the capstan are mounted on a common center line, the insulated cable has been allowed to form a catenary between the capstan and the take-up reel. In some cases guide rollers are employed to transverse the cable onto the take-up reel. In either case, the paper wound cable is bent in a direction opposite to bend of the cable as it is payed onto the take-up reel.

As the cable is bent first in one direction and then the other, when the convolutions are dry and exert high frictional forces on adjacent convolutions, the paper wraps are liable to become wrinkled, torn at the edges, and become displaced from the desired position. The air spaces in the cable insulation is increased and the insulation quality of the paper layers is reduced.

It is, therefore, the object of this invention to provide an improved method and means for the take-up of paper insulated, oil-impregnated, high voltage cable in which the integrity of the insulation is preserved.

In accordance with this object I have provided in a preferred embodiment of this invention a caterpillar type capstan for pulling the cable through paper taping heads. The caterpillar type capstan is aligned with the axis of the paper taping heads to pull the cable from the heads in a straight line without bending the cable as it moves along its axis. A take-up reel is driven to maintain controlled tension in the cable as it is payed from the capstan. The take-up reel tension and position is controlled to move the cable always along a straight line after application of the first paper tape until it is bent on the take-up reel. The take-up reel is of large diameter to minimize bending. The cable is impregnated with oil while still on the take-up reel. The cable may then be removed from the reel for the application intended opening only to normal bending precautions.

It is somewhat difficult to definitively explain the exact reason for the startling improvement in the insulation integrity by this improved method of fabrication, but the following theory is consonant with observed results.

Since the cable is moved in a straight line, the position and tension of the overlapping paper tape laminations remains the same as that applied by the paper heads. When the cable is wound on the take-up reel, the bending of the cable necessarily will cause some displacement of the tapes relative to each other and individually from the desired positions due to the variation in friction between wraps. However, oil impregnation while on the reel will introduce a lubricant between the laminations, allowing the tape laminations to return to the position in which the tapes were laid by the paper heads on subsequent unreeling of the cable. Thus, the insulation integrity corresponds with the design values since the spaces in the cable insulation are reduced to the design values.

The apparatus for and method of paper fabrication in accordance with this invention will be more clearly understood by reference to the following explanation and to the accompanying drawings of which:

FIGURE 1 is a side elevation, partially diagrammatic, of a line for cable fabrication in accordance with this invention in which the take-up reel stand is mounted below the assembly floor;

FIGURE 2 is a top plan of the cable fabrication line shown in FIGURE 1;

FIGURE 3 is a schematic diagram of control circuitry employed in the line shown in FIGURE 1;

FIGURE 4 is a side elevation of another embodiment of this invention in which the take-up reel stand is mounted on the assembly floor;

FIGURE 5 is a side elevation of another embodiment of this invention in which the cable feed is aligned with the top of a take-up reel mounted on the assembly floor; and

FIGURE 6 is a side elevation of another embodiment of this invention using a vertical take-up reel mounted below the floor line.

Referring to FIGURES 1-3, there is shown a pay-off stand 10 adapted to rotatably support a pay-off reel 12 on which is wound the bare conductor 14. The conductor is usually a copper or aluminum conductor and may be stranded. The conductor is fed through the requisite plurality of paper taping stands 16. Each of the paper taping stands carries a rotatable paper taping head 18 which spins about the cable applying a plurality of wrappings of paper tape 20 from spool 22 thereon.

Each of the heads may be provided with a plurality of spools carrying the paper tape of requisite physical and electrical properties. The spools maintain a predetermined tension in the tape and apply the tapes therefrom in overlying helixes extending along the cable. The edges of the tapes in each layer may be butted but are often separated by a predetermined amount to allow the completed cable to be flexed a predetermined amount before the edges contact. The overlying helix covers the separation in the underlying wraps. Thus, after the requisite number of tapes, of a few mils thickness, have been built up to an aggregate thickness varying with the application but often exceeding a 1-in. thickness, the required dielectric strength of insulation is afforded.

To control the physical properties of the tapes applied and, thus, to accurately control the paper insulation, the paper taping heads are desirably located in rooms in which the humidity can be accurately controlled.

A caterpillar-type capstan 24 is mounted with the tracks 25 thereof astraddle the wrapped cable to pull the cable from the paper heads at a predetermined controlled rate. The track velocity is related to the rotational speed of the paper taping heads to pull the wire therefrom at the proper rate related to the rate of tape application.

The capstan is aligned with the paper heads so that the cable is moved in a straight line along its axis without bending as it passes through the heads and the capstan.

A take-up reel 30 is mounted in cable receiving relationship to the cable being fed from the capstan so that the cable 32 extends in a straight line along the cable axis with the cable reaching the hub 34 of the reel in tangential relationship thereto. The take-up reel is driven to maintain a predetermined tension upon the cable to prevent a catenary sag therein between the capstan and the hub. I have found it satisfactory to drive the take-up reel by a constant speed motor 38. The motor turns a pinion 42 which coacts with a concentric gear 44 on the take-up reel to rotate the reel. A clutch 47 having a predetermined slip torque is interposed between the motor and the worm gear. Thus, tension applied to the cable by the driven reel is maintained at a constant predetermined value, but damage of overstressing the cable during temporary stoppage in cable feed is prevented. Other take-up drives co-ordinated with the feed of cable through the paper heads may also be employed in manner known to the art.

The take-up reel 30 is rotatably mounted upon a reel stand 46 movable transversely (that is, into and out of the plane of the paper) on wheels 48 guided by channel rails 50 installed below the assembly floor 11 of the cable assembly area. Vertically extending standards 52 are affixed to the reel stand 46 astraddle the reel. Each standard carries an upstanding screw member 54 journaled at the upper end thereof in bearing 56 and sup-

portedly engaged at the lower end by motor 58. Carried upon the screw member is a vertically traveling nut 60 which supportably engages the shaft 61 carrying the take-up reel to adjustably position the axis of the take-up reel. The reel drive motor 38 may conveniently be mounted on the nut to simplify the transmission between the motor and the reel.

In operation the take-up reel is adjusted vertically so that the straight line extension of the cable as it passes through the paper heads and the capstan will be tangential to the reel hub 34. Thus, no bend is introduced in the cable in the vertical plane. Similarly, the reel is positioned transversely so that the cable contacts the hub 34 at a point coincident with a straight line extension of the cable so that no bends are introduced in the horizontal plane.

At the start of assembly, it is usually advantageous to affix the cable to the reel hub at the position where the hub joins the radially extending reel flange. To maintain the straight line movement of the insulated cable as it is wound on the hub of the reel, it is necessary to move the take-up reel transversely at a speed related both to the cable diameter and to the speed of cable assembly. Proper synchronization will lay the cable upon the hub in a helix with contiguous turns.

To drive the reel transversely, there is provided a drive motor 62 which drives a threaded shaft 64 coupled to the motor shaft 66. The threaded shaft is in threaded engagement with a nut 68 which is affixed to the take-up reel stand to drive the stand transversely at a rate fixed by the thread pitch and speed of motor rotation. By relating the transverse drive rate to the cable feed rate and cable diameter, the cable will be laid upon the reel hub in a helical path with contiguous turns.

When the first helix reaches the flange of the reel, the transverse movement of the reel is reversed to allow laying of cable thereon in a second helix overlying the first. Reversal of the transverse drive is effected by limit switches, such as the mechanically operated limit switch 70, having operating end position flanges 72, 74 which extend into co-operating relationship with the operating lever 76 carried upon the reel stand 46. As the reel stand reaches its end position, the lever 76 will strike the end position flange 74 moving the double pole, double throw switch 78 to reverse the polarity of the connection from the power source 80 to the motor 62. It will be noted that electrically operated limit switches can be applied with equal effect.

In order to maintain the vertical alignment of the take-up reel with the straight line extension of the cable as the second layer of cable is applied, the vertical positioning of the take-up reel must be suitably altered to account for the changed effective reel diameter. To accomplish this there is provided momentary contact switches 82 and 84 which are operated by an operating lever 86 extending from the take-up reel stand. Power from source 87 is supplied to one terminal of each momentary contact limit switches in parallel. Thus, each time that the reel reaches the limit of its transverse movement, a switch will be closed and power will be applied to a programmer 88. The programmer 88 will apply power to motors 58 over leads 92 and 94 to drive the screw member 54 which coacts with the nut 60 to alter the vertical position of the axis of the take-up reel. The programmer 88 may simply be a timer to apply power to the motor over a predetermined interval related to the time interval necessary for change of the effective diameter of the reel.

It will be noted that in most manufacturing operations, the adjustment of the transverse and vertical position can be made manually by operator controlled motors. The necessity for applying a great number of paper laminations restricts the speed of cable travel sufficiently so that operator control is effective.

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After the cable is wound on the reel, it is impregnated with oil while still on the reel. The oil impregnation may be carried out in a standard vacuum impregnation chamber. The impregnation of the tape wraps will allow the wraps to return to the desired positions on the cable as the cable is unreel. Thus, displacement of the tapes and wrinkling and tearing thereof will be eliminated. The cable will then have a paper insulation having only the designated air spaces thereon. Thereafter, only the normal procedures for handling oil impregnated paper insulated cable need be followed as the cable is put into use.

In those applications where it is undesirable to sink the take-up reel below the floor line, the embodiment shown in FIGURE 4 may advantageously be employed.

In FIGURE 4 there is shown a pay-off stand 10 upon which is mounted a reel 12 carrying the conductor 14 wound thereon. The conductor is passed through paper-taping heads 18 for application of the requisite number of helical wraps of paper tape. A caterpillar-type capstan 24 pulls the cable from the paper heads with the cable moving in a straight line. A take-up reel 30 is mounted upon the floor 11 of the assembly area. In order to maintain the straight line movement of the wound cable, the reel is positioned so that the cable is tangential to the bottom of the hub 34 and is wound thereon by driven rotation of the take-up reel in a counter-clockwise direction. Other than reversal of direction of rotation, the take-up reel is identical with that set forth in the embodiment shown in FIGURES 1 and 2.

In those applications where it is desirable that the cable be wound upon the reel in the clockwise direction and that the reel be floor mounted, the embodiment shown in FIGURE 5 may advantageously be employed.

In FIGURE 5 there is shown the cable conductor 14 paid from a pay-off reel 12 mounted upon a pay-off stand 10 extending from the floor 11. The paper-taping heads 18 are mounted upon a platform 301 which is mounted above the assembly floor 11 upon standards 302. The capstan 24 is similarly mounted upon the platform and is aligned to maintain a cable movement along a straight line along the longitudinal axis of the cable as it is pulled through the head by the capstan 24. A take-up reel 30 rotatably driven to maintain tension upon the cable which is wound thereon is positioned upon the assembly floor 11 so that the cable is tangential to the hub 34 thereof.

In many applications, particularly those applications in which the cable is of extremely large size a vertical mounting for support of the cable is desirous. In such applications the embodiment shown in FIGURE 6 may be advantageously employed.

In FIGURE 6 there is shown a pay-off stand 10, the conductor reel 12, the paper-taping heads 18 and the caterpillar-type capstan 24 mounted on the floor 11 of the assembly area. The take-up reel 401 is vertically mounted. The take-up reel is rotatably mounted upon a vertically movable reel stand 402. The reel stand 402 is moved vertically at a rate dependent upon cable diameter and cable feed rate by a suitable elevator mechanism such as a hydraulic lift applied to supporting shaft 404 to lay the cable on the reel in a helix having contiguous turns. The reel stand is provided with a circular track 406 on which wheel 408 moves for reel rotation. The wheel may be affixed to the reel by brackets 410 and the reel

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drive by a controllable torque drive mechanism (not shown).

The take-up reel is positioned transversely (perpendicular to the paper) so that the cable is laid upon the hub thereof tangentially thereto to provide straight cable drive throughout the heads until it reaches the take-up reel.

As the cable is applied to the hub of the take-up reel, it will be seen that it coats with the upper turn of the helix already laid on the reel. Thus, the immediately proceeding turn supports the cable along its length to aid in maintenance of the straight line movement of the cable.

Since each cable turn of a helix starting at the top flange would fail to receive such support, the possibility of cable sag would be increased. Such sag would cause the cable to be bent first in one direction and then in a second direction, causing insulation layer failure. Thus, the embodiment shown in FIGURE 4 is most useful with applications where the take-up reel will carry but a single helix of the cable. The elevator suspension is thus simplified.

It will be understood that the invention may be variously embodied and modified within the scope of the subjoined claims.

What is claimed is:

1. In combination, paper taping heads for applying a plurality of overlying, helically wrapped paper tapes to a conductor, a caterpillar type capstan for pulling said cable through said paper taping heads, said capstan being aligned with said paper taping heads to maintain said cable in a straight line as it moves therethrough, a take-up reel having a hub, said take-up reel being aligned with said paper heads and said capstan so that said cable extends in a straight line into tangential relationship to said hub as cable is laid thereupon, means to move said take-up reel axially in a direction transverse to the straight line cable movement to lay said cable along said hub in a helix, and means to reverse the axial movement of said reel as said cable reaches the flanges thereof and in which the vertical position thereof is simultaneously adjusted so that the cable maintains its straight line relationship from the paper taping heads through to the take-up reel.

2. The method of taking up paper insulated cable on a take-up reel which comprises pulling said cable from the paper taping heads in a straight line and continuously adjusting the winding position of said take-up reel to maintain the cable always in a straight line until it reaches said reel, which method includes moving the take-up reel transversely to lay cable on said reel in a helix without bending the cable transversely, and adjusting the vertical position of the take-up reel when said cable helix reaches a flange on said reel and simultaneously reversing the transverse movement of said reel to apply said cable in an overlapping helix without bending said cable from a straight line movement until it is wound on said reel.

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