Oct. 22, 1935. N. L. MORGAN 2,018,461

MULTIPLE CONDUCTOR SECTOR ELECTRIC CABLE

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FIG. 1

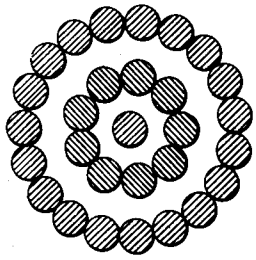

FIG. 2

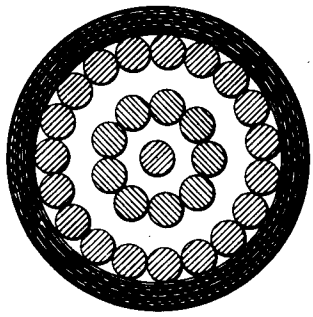

FIG. 3

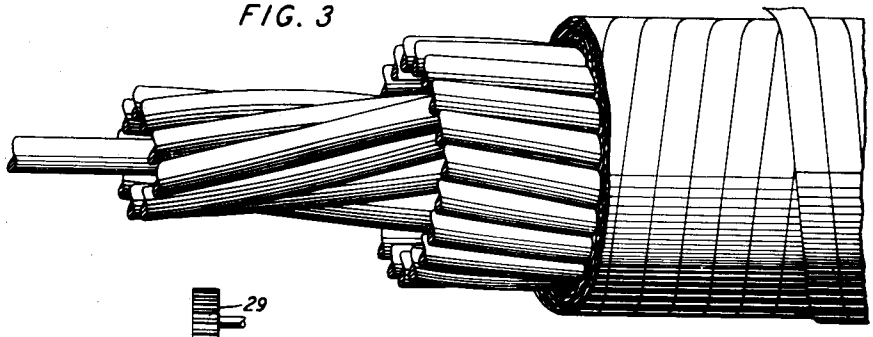

FIG. 4

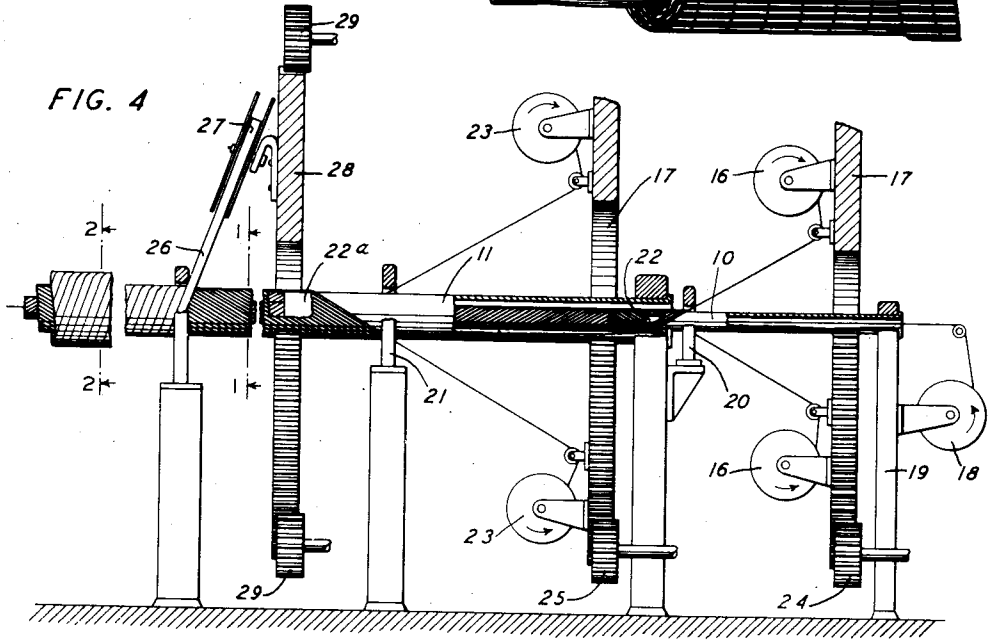

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FIG. 5

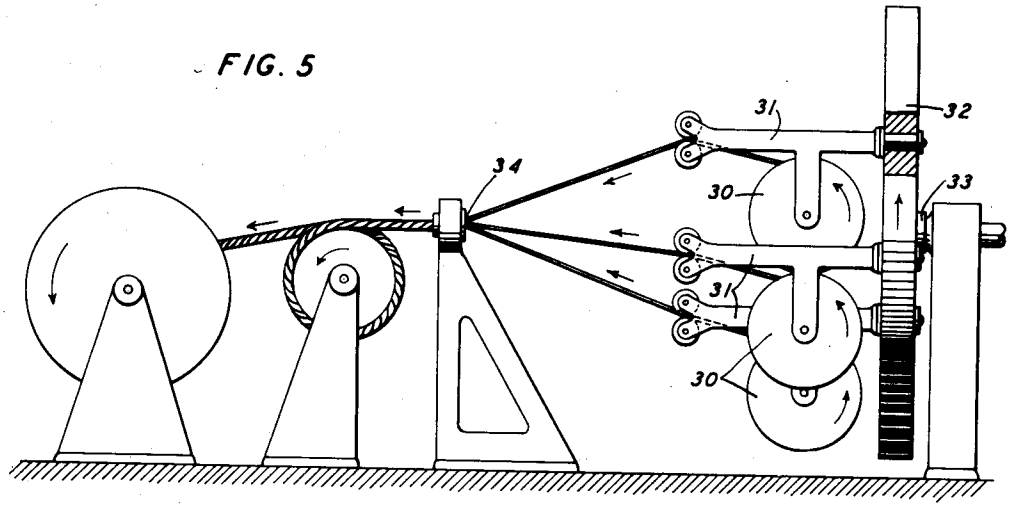


FIG. 6

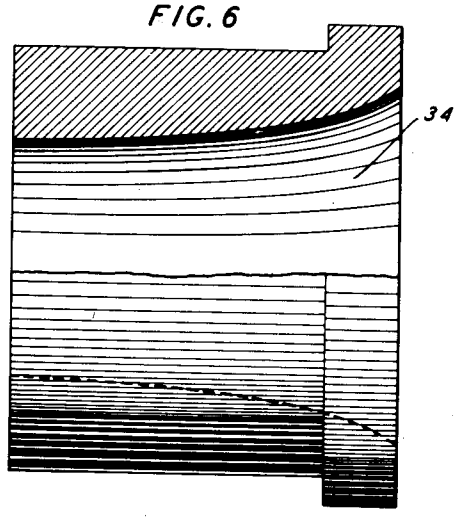


FIG. 7

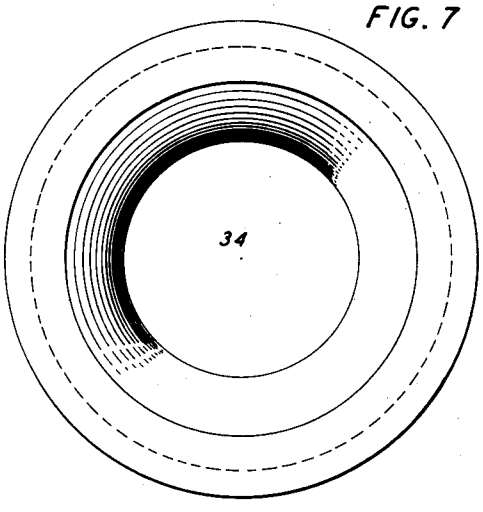


FIG. 8

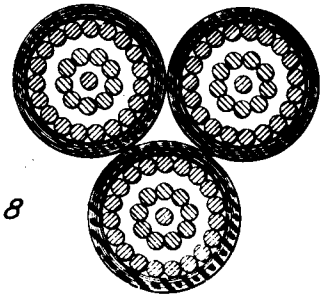
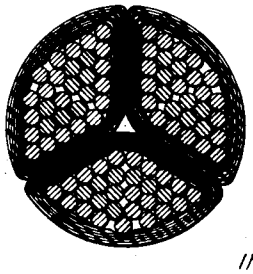


FIG. 9



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UNITED STATES PATENT OFFICE

2,018,461

MULTIPLE CONDUCTOR SECTOR ELECTRIC CABLE

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Application November 13, 1931, Serial No. 574,697

2 Claims. (Cl. 173—264)

This invention relates to improvements in multiple conductor electric cables having sector-shaped conductors, and more particularly to the method of making such cables.

Sector-shaped conductors for insulated power cables may be made in several ways known in the art. One well known method, which is old in the art, comprises first stranding a plurality of wires into different layers, each layer being round in shape, or substantially so, and having a space between it and the adjacent layer, then crushing the structure to sector shape between rolls, and finally insulating the individual conductor after the crushing operation. In manufacturing sector-shaped conductors in accordance with this method the component wires of each layer are usually stranded or spiralled to form a helix; the helices or layers of wires being stranded all in one direction throughout the conductor. The conductor, after being crushed to sector shape, is usually insulated by wrapping on tapes of insulating material, such as paper or cambric, with a suitable pitch or lay. The multiple conductors, after being insulated, are then stranded and twisted together to keep them in proper relation to each other with the points of the sectors pointing toward the center of the cable.

Another method known in the art consists in passing a plurality of wires through a sector die, the wires, as they pass through the die, being spirally wound around the core and laid up collectively in sector cross-section. Here again, the conductors are insulated after being formed into sector shape; the multiple conductors being twisted while being stranded together to keep the points of the sectors pointing toward the center of the table.

It has been found that the twisting of the sector-shaped conductors sets up stresses both in the wires and in the insulating tapes that are desirable to avoid. If the wires of the conductor are all stranded in one direction, they all tend to become either loosened or tightened depending on the relative direction of stranding the multiple conductors together. A tightening action tends to reduce the diameter of the conductor, with a consequent softening of the insulation and a weakening of its electrical properties. If alternate layers of wires are stranded in opposite directions, one layer tends to tighten and the next to loosen and occupy a larger space. This action often causes the conductor to depart from its original sector shape. The same tightening and loosening actions occur in the insulation with the result that the tapes tend to become wrinkled and creased and, especially in the longer lengths of conductors, the insulation becomes weakened in its electrical properties.

During the process of manufacture of the cable, it is usual, according to present day practice, to have the stranding together of the insulated conductors done on a different machine from that which insulates them. The method of the present invention may be practiced by having the stranding and insulating done on different machines. As a matter of convenience these steps are shown herein as being performed in succession upon a single machine although they may be performed successively upon different machines. Both methods are within the scope of the invention.

The residual forces present in the sector-shaped conductor and its insulation due to the methods of manufacture outlined above frequently prevent the conductors from taking their proper relative position in the cable and, in some cases, a sector may become completely turned over, that is, the point of the sector conductor may point away from the center of the cable. This results in the cable being somewhat larger over certain sections of its length. These residual forces also tend to prevent the cable from being dead, i. e., when laid on the floor it will tend to distort or untwist itself slightly so as to be relieved of the residual forces.

These difficulties are considerably reduced if not completely overcome by manufacturing cables in accordance with the principles underlying this invention.

An object of this invention is to provide an improved multi-core cable having sector-shaped conductors.

A feature of this invention lies in the method of insulating the individual conductors before forming them into sector shape.

A further feature resides in the method of forcing a plurality of insulated conductors through a die in one operation.

One advantage of this invention is that the residual forces inherent in sector-shaped cables manufactured by present day methods are greatly reduced by constructing a cable in accordance with this invention.

Another advantage of the present invention is that a cable is obtained which has harder insulation with somewhat higher electrical strength than those heretofore manufactured.

A further advantage lies in the fact that the component wires of the conductors take up their

proper relative positions causing sectors of proper shape.

Other objects, features and advantages will appear in the subsequent detailed disclosure.

In accordance with this invention, the wires of the conductor are first stranded into layers which are substantially round in shape, leaving spaces between adjacent layers. The conductor is then wrapped with insulating tape while still in the round shape. The multiple insulated conductors are then stranded together without being twisted (that is to say, grouping the conductors in such manner that all points on the outer surface of a conductor bear the same relative position throughout the cable with respect to other points on the same conductor). This action prevents the tightening and loosening of the wires of the conductor and greatly reduces the creasing and wrinkling of the insulating tapes with an accompanying reduction in the residual forces.

The stranded insulated conductors are then formed by being forced together through one or more dies; the forming forces being transmitted to the conductor through its insulation. The circle of wires are thus caused to collapse at the expense of the spaces between the layers. It is to be understood that the forming forces are all radial to the cable causing the insulated conductor to take sector shape with all the sectors pointing towards the center of the cable at all points throughout its length, thus giving the cable a uniform diameter through its entire length. During the forming operation, the perimeter of the layers of wires remains approximately the same but small increases in the perimeter may cause the insulation to become tightened and stretched to a larger perimeter thereby taking up any looseness that may have taken place during the insulating and stranding operations. This tightening and stretching of the tapes (if and to the extent that it occurs) makes the insulation harder and tends to give it a somewhat higher electrical strength. In practice no important tightening or loosening of the insulating tape has been observed. A cable constructed in this manner has no appreciable residual forces in the conductor and insulation. For this reason, there is no noticeable tendency of the cable to distort or untwist itself.

Referring to the drawings:

Fig. 1 represents a cross-sectional view of a conductor prior to the application of the insulation thereon. This view shows the circular layers of wires with the annular spaces between the adjacent layers;

Fig. 2 shows the conductor of Fig. 1 with the insulation applied. This view is taken along the line 2—2 of Fig. 4 which illustrates a portion of a finished conductor prior to the forming operation;

Fig. 3 is a side perspective view of the conductor of Fig. 2. In this view the alternate layers of wires of the conductor are shown spirally wound in opposite directions;

Figs. 4 and 5 are diagrammatic illustrations of the essentials of the stranding machines utilized in making a cable in accordance with this invention;

Figs. 6 and 7 are side and front views respectively of the die used in changing the round conductors to sector shape;

Fig. 8 illustrates, in cross-section, a plurality of round conductors which go to make up a three-conductor sector cable, prior to the forming operation;

Fig. 9 shows the conductors of Fig. 8 after being forced through the die of Fig. 6 and pressed to sector form.

Referring to Fig. 1, there is shown a conductor in one stage of the process of manufacturing a sector cable embodying the principles of this invention. In the conductor, a plurality of helices of wires are shown stranded in opposite directions around a single wire forming the center or core with annular spaces between each adjacent layer of wires. Although it is desirable to have the component wires of each helix remain in a circle one or more wires in each layer might be allowed to fall in towards the center without interfering with the subsequent formation of proper sector-shaped conductors.

Surrounding the outermost layer of wires is a layer of insulation which may be applied directly to the conductor or by applying tapes of insulating material around or parallel with the conductor. These tapes may comprise paper, varnished cambric or other material applied to the conductor with a suitable pitch or lay, applied all in one direction or by reversing different layers of tapes. When paper tapes are employed, they are usually applied so that their edges abut while the edges of the cambric tapes overlap by a small amount. It is customary in the case of paper tapes to dry them after being applied to the cable and then have them impregnated. With regard to the cambric tapes, however, an insulating compound may or may not be applied between layers of tapes. The feature of first insulating the conductors and then forming them together is not limited to the use of paper or fabric insulation; rubber or rubber covered fabric may also be employed.

In Fig. 4 is shown one way of constructing a conductor of the type illustrated in Figs. 1, 2 and 3 by using apparatus well known in the art. A roll of wire 18 mounted upon a support 19 is arranged to rotate in the direction indicated in the drawing by the arrow, as the wire is drawn to the left by a capstan, not shown. This wire forms the center or core of the conductor and is adapted to pass through mandrels 10 and 11 upon which the successive layers of wires are helically stranded. These mandrels are hollow and are held in place by supports 20 and 21. If desired, the mandrels may taper slightly at the ends 22 and 22a where the wires of the layers leave the mandrel. The layers of wires retain their circular shape after leaving the mandrel since no pressure is exerted upon them at this time.

Other rolls of wire 16, 16 and 23, 23 mounted upon gears 17 carry the individual wires which go to make up the different layers. Although only two rolls have been shown mounted on each gear, it is to be understood that there are as many rolls on each gear as there are wires forming a layer. The gears carrying the rolls of wire are driven by pinions 24 and 25 and cause the wires to be spirally wound around the mandrel as they rotate, one in a clockwise direction and the other in a counterclockwise direction; the preferred lay-up being with one layer wound in one direction and the next in the reverse direction and so on in alternative arrangement. The rolls and mandrels are axially aligned, the successive mandrels increasing in size to accommodate the conductor as its size is increased by the addition of each layer.

Upon leaving the outermost mandrel, layers of insulating tape are applied to the conductor. The tape is carried on a spool 27 mounted upon rotating gear 28 driven by pinions 29, 29. Although only one spool of tape is shown, it is understood that there may be as many spools of tape as it is desired to have layers of insulation applied to the conductor. After the insulation is applied to the conductor, the whole is wound while still in a round shape, on to a drum by means of a capstan.

Fig. 5 illustrates the manner in which three such insulated conductors are drawn through a die to form the sector cable. Three drums 30, each carrying a length of conductor such as illustrated in Figs. 2 and 3, are mounted on a gear 32 which is adapted to rotate upon an axis 33. The drums are adapted to remain in a vertical position as indicated in the drawings as the gear rotates so that no twisting occurs as the individual conductors are pulled through the die 34 by the capstan 35. As the conductors are spirally wound about one another, all points on the outer surfaces of any one conductor bear the same relative position throughout the cable with respect to other points on the same conductor. This method of operation is well known in the art.

The round conductors are changed to sector shape as they are forced through die 34 which is of suitable size; the forming forces being transmitted to the conductors through the insulation. These forces, being radial to the cable, cause the circles of wires of each conductor to collapse at the expense of the spaces between the layers. Each insulated conductor is thus forced to take a sector shape with all the sectors in the cable pointing toward the center at all points throughout its length, thus giving the cable a uniform diameter throughout its entire length. It is to be noted that in the finished article the component wires of each sector conductor still retain their circular form and are not deformed by the forming operation.

In preferred practice several dies in tandem are employed to make the forming more gradual and to prevent tearing and wrinkling of the insulating tapes. The die 34 is therefore typical of any die structure consisting of either a single die or a plurality of dies in tandem. Ordinarily each die will have a smaller orifice than the preceding. The word "die" as employed in the claims signifies any die structure consisting of one die or a plurality of dies in tandem. The cable may be pulled through the several dies in successive operations but to do this in a single operation is preferred.

In Fig. 9 is shown the shape the individual conductors of the cable of Fig. 8 take when forced through the die during the forming operation. In actual practice, an overall outer insulation may or may not be placed around the cable and protected with an outer covering such as a lead sheath. The cable is then considered ready for use in the field.

In a cable constructed in accordance with the present invention there are no appreciable residual forces either in the conductors or in the insulation and, for this reason, there is no tendency on the part of the conductors to move from their proper positions in the cable.

What is claimed is:

1. A method of manufacturing multi-core electric cables having sector-shaped conductors which comprises stranding the component wires of each individual conductor into helices with spaces between layers of adjacent helices of wire, the alternate layers of said helices being stranded in opposite directions, wrapping insulating tapes around said conductors while still in substantially round shape, then stranding said conductors together and forcing them together through a die to obtain the sector form in one operation.

2. The method of manufacturing a single conductor for a multi-core sector cable which comprises first stranding a plurality of concentric layers of wires around a single central wire leaving spaces between adjacent layers, insulating the conductor by surrounding it with insulating material and thereafter forcibly deforming the conductor with respect to its cross-section by forcing it into a sector shape.

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