April 2, 1940. H. H. RACE 2,195,998

HIGH TENSION ELECTRIC CABLE AND METHOD OF MAKING THE SAME

Filed March 8, 1938

Fig. 1.

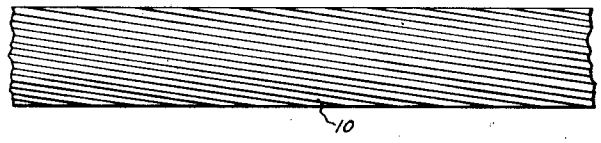


Fig. 2.

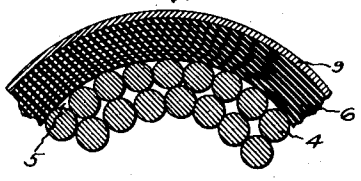


Fig. 3.

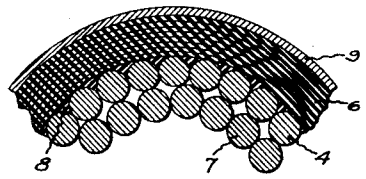


Fig. 4.

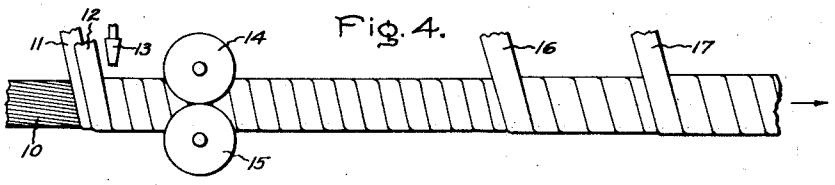


Fig. 5.

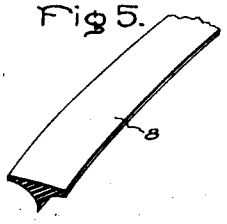


Fig. 6.

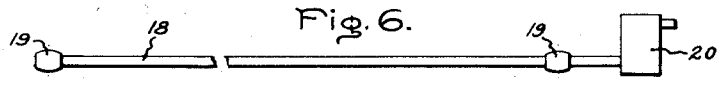
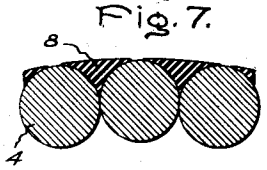


Fig. 7.



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UNITED STATES PATENT OFFICE

2,195,998

HIGH TENSION ELECTRIC CABLE AND METHOD OF MAKING THE SAME

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Application March 8, 1938, Serial No. 194,568

2 Claims. (Cl. 173—244)

It has long been known that high tension stranded cables insulated with fibrous material are subject to ionization and corona effects which manifest themselves at different places in the cable and specifically in the region of the outermost layer of the strands. This, I have ascertained by elaborate investigation and tests, is due to the fact that the insulation which is wrapped around the conductor does not fill the outermost strand spaces but on the other hand with the strands defines approximately V-shaped spirally disposed spaces extending lengthwise of the cable. Upon dissecting cables as ordinarily constructed, it will be found that in many cases the paper has turned darker in the region where it contacts with the peripheral surface of the strands. Such a darkening of the paper is evidence of the fact that ionization and corona has taken place to a greater or less degree. This trouble is initiated by ionization of the oil or compound contained in the V-shaped spaces which are the regions of maximum electrical stress.

It has been proposed to prevent ionization and corona in the region of the V-shaped spaces above mentioned by applying a smooth exterior metal covering for the strands and in electrical contact therewith, such for example as thin metal tapes applied in overlapping relation. It has also been proposed for the same purpose to use tapes made of fibrous material and to so metalize them before application to the conductor as render them conducting or at least semi-conducting. Irrespective of the kind of covering so applied, the V-shaped strand spaces exist and should a fault occur in the covering, the oil or compound in any of the spaces so formed is subject to ionization and later the cause of corona effects. Such coverings have the effect of somewhat increasing the diameter of the cable, and are a source of added expense both initially and in the manufacture of the cable.

My invention has for its object the method or process of manufacturing high potential cables whereby ionization and corona due to the presence of oil or compound as such in the strand spaces of the outer layer of the conductor underneath the surrounding insulation, is prevented.

For a consideration of what I believe to be novel and my invention, attention is directed to the accompanying description and the claims appended thereto.

In the accompanying drawing which is illustrative of my invention, Fig. 1 indicates a short piece of stranded cable; Fig. 2 is a diagrammatic view illustrating the usual construction of paper insulated cable; Fig. 3 is a cross-section of my improved cable on an enlarged scale showing the external strand spaces filled with compressed fibrous insulation; Fig. 4 illustrates the application of moist paper to fill the strand spaces and also the application of insulating material; Fig. 5 is a perspective view of a strand space filler made of fibrous material; Fig. 6 shows a length of sheathed cable with a vacuum pump for removing moisture and air therefrom, and Fig. 7 is a greatly enlarged view showing how the compacted moist material completely fills the strand space.

Referring first to Fig. 2, 4 indicates the conductors of a stranded cable of which there may be any desired number of strands and of layers of strands. The strands are arranged to form long pitch spirals, as indicated in Fig. 1, with the result that between each two strands there is a long substantially V-shaped space 5, commonly referred to as a stranded space. As heretofore constructed, these strand spaces are assumed to be filled with liquid such as degasified oil in the case of a fluid-filled cable, or with compound in the case of a solid type cable. A failure in a manufacturing operation or during use of the cable may result in one or more pockets or dry spots being formed in the strand spaces and thereby increases the danger of failure. The insulation 6 is applied layer by layer to the desired thickness for the voltage of the cable. It will be observed that the insulation does not and under the circumstances cannot fill the said strand spaces but on the contrary rests on the peripheral surfaces of the strands. Thus it will be seen that each strand space is defined by the peripheral surfaces of the two adjacent strands and the overlying body of insulation. It is in these V-shaped strand spaces that ionization of the oil or compound takes place with the ultimate result of causing corona effect which in turn causes deterioration of the insulation. If the effect is pronounced, it will in time result in cable failure.

According to my invention, these V-shaped strand spaces instead of being empty or filled only with oil or compound are filled with hard packed fibrous insulation, such as paper, for example, which in the subsequent process of manufacture of the cable are fully impregnated with oil or compound. It is well recognized that impregnated paper has a higher dielectric strength than oil or compound alone or paper alone. It

will thus be seen that my improved cable embodies the best engineering practice in this particular. As previously indicated in connection with Fig. 2, paper applied in the usual condition of dryness will not fill the spaces no matter how tightly it is wrapped around the conductor. I depart radically from the established practice of using dry paper tape and use paper tape which contains a large percentage of water vapor or moisture to make it soft and workable. I may use one or more such layers, desirably at least two with overlapping joints so as to ensure a complete covering without any intervening spaces between turns. While the tapes are moist and well softened by water or other vapor, they are subjected to relatively heavy external compression pressure which has the effect of forcing or squeezing the moist paper into the V-shaped strand spaces and completely filling them. After the moist paper tapes are forced into the strand spaces, the insulation for the conductor, whether it be paper or equivalent material, may be applied in the usual way.

The presence of any appreciable amount of moisture within a cable is, of course, highly detrimental for operating conditions and cable manufacturers definitely limit it to the smallest amount consistent with satisfactory making operations. In fact, the best practice calls for applying the paper in a room where the percentage of moisture is accurately controlled and limited to a determined small amount. The excess moisture in my case can be removed by the usual technique of drying before impregnation. It is customary in the manufacture of paper insulated cable to subject it to the effects of vacuum, or to both vacuum and heat, to remove moisture and air contained in the insulation and strand spaces as fully as possible prior to impregnation, and such treatment will likewise remove the excess moisture contained in the paper that has been compressed into the strand spaces. Thus it will appear that the removal of the excess moisture does not require an extra operation in the manufacture of the cable.

In Fig. 3 is shown a section of a part of a cable wherein **4** indicates the outer layer of strands of conducting material, such as copper. Inside of these strands are other strands **7** of which as many may be provided as desired to carry the current for which the cable is intended. **8** indicates the triangular-shaped portions of the moist paper which have been forced into the outer strand spaces by external pressure. Over the numerous strips or portions **8** is wound the necessary customary insulation, and the latter is enclosed in an impervious lead or equivalent sheath **9**.

Referring to Fig. 4, **10** indicates the stranded conductor which may be hollow or solid depending upon its ultimate use. **11** and **12** indicate paper tapes which are applied directly over the bare strands. The tapes may be applied by the same machine which applies the final insulation, all that is required is to have the necessary number of paper carrying bobbins for the purpose on the revolving head of the machine. These bobbins may and usually would be duplicates of those used in applying the main insulation. For the tapes, whether for the strand spaces or the main insulation, it is desirable to use paper which has been carefully washed to remove impurities as completely as possible. Because moist paper tape is not so strong as the usual type of dry paper tape, a convenient way is to apply it in a dry state and subsequently to moisten it to the necessary extent. This may be done by means of a nozzle or equivalent device **13** which discharges water, steam or other vapor over the paper tapes **11** and **12** after application in sufficient amount to render them soft and pliable. Desirably the nozzle should be so shaped as to cause the water or vapor to act on the entire circumference of the tapes to facilitate moistening. As the conductor is pulled through the machine in the customary manner by a capstan, it is passed through roller dies **14** and **15** which are so shaped and positioned and under such pressure as to force the moist paper into the V-shaped strand spaces. Assuming that the strands are in contact, which should be the case in a well constructed cable, the inner or sharp end of the squeezed-in fibrous material should fully extend into that part of the conductor where each two of the strands are in sidewise contact throughout their respective lengths. Depending upon the compression pressure exerted by the dies, the paper tapes may be forced into the strand spaces, leaving only the high spots of the strands slightly exposed. If a lesser pressure is used, the moistened tapes may appear as a very thin, nearly transparent covering for the strands with the remainder filling the strand spaces. The dies may be cold or they may be heated to some extent in which case they will aid in removing a limited amount of the moisture. The mere fact that they act to compress the paper tapes may result in heating the dies to some extent. After the moist paper is applied and ironed into place by the dies, the insulation in the form of tapes is applied, of which **16** and **17** may be regarded as examples. The number of tapes will be governed by the voltage under which the cable is to operate. Desirably the insulating tapes are applied before the moist tapes are fully dried since by so doing they act as binding means therefor and also compress it and smooth out any slight irregularities that otherwise might exist. As will be apparent, the insulation as such may be of paper or other suitable material, following in this particular established cable practice.

In Fig. 7 is shown on a greatly enlarged scale round copper conductors **4** arranged in side-by-side contact with a filling **8** of paper in the V-shaped spaces between them. In this figure, the filling is arranged to terminate in a thin edge adjacent the highest part of each of the conductors.

As shown, especially in Fig. 4, the tapes **11** and **12** are spirally wrapped around the conductor yet after the die or ironing operation, it is noticeable that the bodies of the tapes in each strand space form practically a unitary structure.

In Fig. 6 is shown by way of example means employed in removing air and moisture from a sheathed cable. In this figure, **18** indicates a sheathed cable having sealing caps **19** at its ends, one of which is connected to a vacuum pump **20** of any suitable construction. If it be desired to evacuate the cable before applying the sheath, it may be done in accordance with the usual methods.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making high potential stranded electric conductor which comprises assembling bare metal strands in concentric layers to form the conductor with small outwardly opening spaces between the strands of the outer layer, spirally wrapping a thin body of relatively dry fibrous material over the strands, thereafter add-

ing sufficient moisture to the dry body to render it soft and pliable, applying sufficient external pressure by means of dies to the body to cause it to substantially fill the strand spaces of the outer layer of strands, applying insulation over the strands and body under sufficient tension to hold the moistened body in place, removing moisture from the body and the insulation, impregnating the fibrous body and the insulation, and enclosing the insulation in an impervious sheath.

2. The method of making stranded electric cables which comprises spirally applying over the bare strands of the conductor a body of fibrous paper, moistening the paper so applied to soften it, passing the so covered conductor through dies to force a portion of the paper into the strand spaces and also reduce the thickness of the paper overlying the outer surfaces of the conductor strands, applying insulation over the so compressed paper, and applying a sheath over the insulation.

HUBERT H. RACE.