May 10, 1938. H. ROST 2,116,643

ELECTRIC CABLE

Filed July 19, 1933

Fig. 1.



Fig. 2.

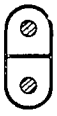
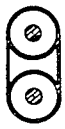


Fig. 3.



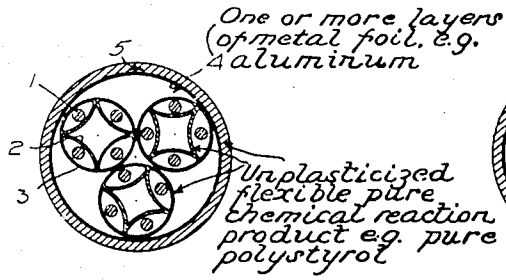


Fig. 4.

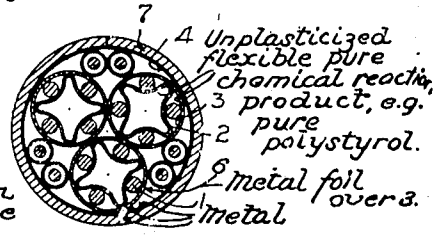


Fig. 5.

Fig. 6.

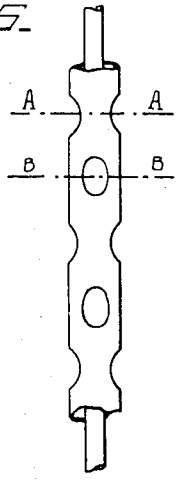


Fig. 7.



Fig. 8.



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UNITED STATES PATENT OFFICE

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ELECTRIC CABLE

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In Germany February 15, 1932

8 Claims. (Cl. 173—265)

This invention relates to improvements in electric cables.

Present day cables for telephony, telegraphy and low tension currents in general have many deficiencies, among which are the following:

The great hygroscopic content of the paper insulation of the individual conductors causes absorption of moisture from air with a corresponding lowering of the insulating efficiency and increase of capacity between conductors.

Expensive machinery is necessary to create a vacuum or drying of the air, paper and cable before the cable sheath is put on, with corresponding loss of time.

During jointing and repairing of paper insulated cables, the utmost precautions must be observed, so that the paper does not absorb moisture and usually a hot cable compound is poured over the joint, in order to avoid absorption of moisture as much as possible.

Uneven insulation will result, as paper normally contains 7 to 12 per cent. of moisture while paper specially dried inside the cable contains at least 0.5 per cent. moisture. In the neighborhood of a joint, this moisture content is materially increased by absorption when the cable sheath is removed and this is specially the case when the air is charged with moisture. The joint proper will have very different values of dielectric constant of the impregnated insulating material, as well as the capacity and insulation between the conductors, when compared with the dry cable. Possibilities of unbalances and cross currents will eventually exist between different conductors of such a cable.

Cables, the conductors of which are insulated with vulcanized rubber, impregnated cotton, silk, etc., have too great a capacity with corresponding limitation of the speed of transmission.

Cables have also been proposed in which the conductors are surrounded by air and enclosed in a paper insulation or an insulating material consisting of vulcanized rubber, ebonite or gutta percha.

The lead sheath is heavy with very low tensile strength. The lead lacks an elastic limit, and on that account repeated temperature variations leave microscopic fractures in the sheath. The lead crystallizes or ages. On account of the great softness of lead, the sheath is exposed to all kinds of damage, for instance when the cable is pulled in and out of underground ducts, mounted on or taken down from aerial pole lines. There are also in many countries plagues of small beetles that perforate the lead sheath.

According to the present invention, the above-mentioned inconveniences are entirely eliminated, a cable for communication purposes being manufactured in the following way:

Each metallic conductor is provided with an insulation consisting of one or more layers of insulating tape of a non-hygroscopic, homogeneous, synthetic organic compound, which are wound loosely and spirally around the conductor, with or without the application of adhesive to the overlap, preferably in the form of a solvent of the film, or alternatively the insulation may consist of one or more continuous sleeves of cylindrical or other section of such insulating material placed over the conductor, which sleeves are formed by means of one or more mouthpieces by extrusion of the compound, which at high temperatures is plastic and when cooled becomes solid. Between the conductor and respective sleeves air spaces are left. Depending upon the material one sleeve can be extruded at a time or several simultaneously by one or several mouthpieces, as shown in the annexed drawing in which—

Fig. 1 is a transverse section of a single conductor cable;

Figs. 2 and 3 are transverse sections of twin-conductor cables;

Figs. 4 and 5 are transverse sections of multi-conductor cables;

Fig. 6 is a perspective view of an insulating sleeve enclosing a conductor and provided with protuberances for centering the same;

Figs. 7 and 8 are transverse sections on lines B—B and A—A of Fig. 6, respectively.

The insulating material consists of an organic tough, flexible, homogeneous, waterproof and plastic compound of synthetic origin, which is non-hygroscopic and contains no hydroxyl groups, for instance:

Polymerization products obtained from chemical compounds comprising the vinyl group ($-CH:CH_2$), like polymerized vinyl-benzene, polystyrol, etc.

The above-mentioned polymerization products and particularly those which like polymerized vinyl benzene belong to the group of substituted benzenes of which each substitute radical comprises a vinyl group are especially suitable insulating materials for conductors for communication purposes in accordance with the present invention. Particularly suitable are also those substances which like polystyrol belong to the group of aryl olefines. These materials, in the pure state, have a very high insulating resistance,

an extraordinary low phase angle difference, and an exceptionally low dielectric constant thus causing very small dielectric losses. Moreover, the above mentioned materials are substantially non-hygroscopic and therefore have stable electric properties, which remain unchanged by moisture.

In order to lessen the capacity between the conductors the surface of the insulating film or sleeve may be embossed or provided with regular protuberances and recesses, whereby greater air spaces are obtained around the respective conductors.

In this way the advantage is also obtained in certain cases that the conductors are in contact with the insulation over a small portion only of their length, and can be located in the middle of the respective sleeves and at the same distance from the walls of the sleeve, as shown in Figs. 6, 7 and 8.

In order to keep the capacity as low and even as possible between the pairs of twin- or quad-groups and in order to avoid irregularities of the distance between the respective conductors and groups of conductors, which irregularities would cause cross-currents, any of the arrangements shown in Figs. 2, 3, 4 or 5, may be used, which figures only are examples of how the conductors can be placed in order to be located at predetermined and equal distance from each other, but other combinations may be used to obtain the same result. Fig. 1 shows an electric conductor provided with a cylindrical sleeve. Fig. 2 shows two conductors arranged in the form of a twin-group with an insulating partition between the respective conductors, and both conductors enclosed in a common cover. The cover and the partition can be extruded simultaneously around the respective conductors, whereafter the whole group is formed before the plastic compound has got entirely solid.

Fig. 3 shows another form of twin-group, similar to that of Fig. 2, but with greater distance between the conductors in order to lessen the capacity between them.

Figs. 4 and 5 show examples of how quad-groups can be arranged according to the extrusion method, whereby the individual conductors always keep the same distance between each other and between the conductors of adjoining groups, and whereby the greatest possible air spaces are obtainable. 1 is a conductor, 2 is a continuous, preferably hollow, insulating core of suitable cross section of a synthetic organic homogeneous plastic compound, and provided with longitudinal recesses for the reception of the conductors, as shown in Figs. 4 and 5.

Simultaneously or immediately after the formation of the sleeve by extrusion through a suitable mouthpiece, the corresponding conductors are positioned in their respective places and are spirally twisted together with the sleeve, whereupon each group of conductors is provided with a common external insulation.

The quad-group, thus arranged and twisted, is passed through another mouthpiece of suitable section, and a common sheath for the four conductors is extruded, or the group is covered with insulating material in any other known way.

The drawing shows only three quad-groups, but the cable can of course be made with any number of conductor or groups.

In Fig. 4, 3 is an insulating sleeve around a quad-group. 4 represents one or more layers of metal foil, preferably of aluminium, wound about the cable core formed of any number of conductor groups. 5 is an outside sheath of an organic, homogeneous plastic compound.

In Fig. 5, which shows a modification, 6 represents one or more layers of metal foil around an insulated group of conductors. 4 represents one or more layers of metal tape wrapped around the cable core. 7 is an outside metal sheath, preferably of aluminium, in which latter case it is formed around the core by a previously annealed tape of aluminium parallel to the core and of such a width that the edges meet and the seam is welded according to the electrical resistance welding principle, according to which the metal continuously melts or is fused between the electrodes, while the cable is passed through the welding machine.

Figs. 6, 7 and 8 show the insulation around a conductor provided with regular swellings and recesses, whereby the conductor is kept in the centre of the sleeve. Naturally any other section of sleeve can be embossed on the surface between the conductor and the sleeve, whereby the conductor has a minimum of contact with the insulating material and corresponding lower capacity.

The insulating foil generally delivered from the casting machine in broad continuous tape form, after having passed between special rolls for embossing, should immediately pass through a cutting machine, which will cut the thin foil in the necessary number of foils of desired width.

From the cutting machine the individual foils are passed through a forming machine where each individual foil is formed by means of a mouthpiece into a cylindrical tube around each corresponding electrical conductor, which is passed through the mouthpiece at the same time as the tube is formed.

When forming the cylindrical insulation tube around the conductor, the edges of the foil overlap and are stuck together by simultaneously adding a suitable solvent to one of the edges, whereafter the edges are pressed together and the conductor is now insulated and can, after the solvent has evaporated, be rolled on a spool.

Should more insulating layers or tubes be needed, the process can be repeated and a conductor already provided with one layer can pass through another forming machine where more tape-foil is formed and glued around the already insulated conductor.

When the capacity of the cable is smaller the tape foil can be placed on spools and be employed in one or more layers in the same way as paper insulated conductors are now covered in modern cable works with sufficient overlap with or without application of adhesive to the overlap, or the tubes can be formed with longitudinal overlapped glued seams parallel to the conductor, in the same way as in the continuous process above described.

Most of the above specified synthetic resins have excellent electric qualities, which specially fit them for insulation purposes.

After the individual conductors have been insulated in any of the above-mentioned ways, they are twisted in pairs and formed into cables in known manner, unless special section groups of two or four conductors already twisted are used, in which latter case the respective groups are only formed into cables.

If desired, the groups of two, four or more conductors can be provided with windings of metal

foil, whereby induction or cross-currents between conductors of different groups is avoided.

The cable once formed is provided with a strip or foil of thin soft aluminium or other suitable metal, wound spirally around the core in order partly to protect the conductors from outside damage and partly to serve as a shield against induction.

The cable core thus protected may be provided with an outside insulation sheath of organic compound, tough and flexible, of suitable composition and thickness, which is applied by extrusion or otherwise, such compound being hot and plastic before extrusion and afterwards hardening to a suitable degree of hardness and elasticity. The material to be employed may be of any of the above specified synthetic resins which is sufficiently tough and flexible to permit of tensioning and bending of the finished cable.

Should an electrically insulating outside sheath not be necessary, a metal sheath, preferably of aluminium, is applied. A previously annealed tape of aluminium is thus formed around and parallel to the cable core. The longitudinal seam is welded by the electrical resistance welding process, whereby homogeneity and an excellent seam are obtained.

The great advantages possessed by cables made in accordance with the present invention are as follows:

The insulating material is a non-hygroscopic one, for instance polystyrol, vinyl-benzene etc. In this manner all drying processes are eliminated and there is no danger of the insulation absorbing moisture from the air.

On account of the good and homogeneous electrical insulation properties a better and more constant transmission is obtained than with paper insulation, and unbalance will be greatly reduced.

It is also possible to increase the distances between repeaters on long distance communication cables, with resulting reduced costs.

The weight of a finished cable is only a small fraction of that of a corresponding lead covered cable, which results in low transportation costs, whilst the whole cable is more easily handled.

Electrolytic corrosion of the sheath is avoided entirely, as a sheath of organic compound is non-conducting and this circumstance is very important in maintaining a cable plant.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A cable for communication purposes, comprising a flexible insulating sleeve, a flexible electric conductor enclosed in said sleeve, the latter consisting of a pure polymerization product of a substituted benzene, in which each substitute radical comprises a vinyl group, said polymerization product being an unplasticized, synthetic, organic product which is homogeneous, isotropic, and substantially non-hygroscopic, and free from hydroxyl groups.

2. The cable claimed in claim 1, in which said substituted benzene is a polymerized vinyl-benzene.

3. A cable for communication purposes, comprising a flexible insulating sleeve, a flexible electric conductor enclosed in said sleeve, the latter consisting of a pure polymerization product of an aryl olefine, said polymerization product being an unplasticized, synthetic, organic product which is homogeneous, isotropic, and substantially non-hygroscopic, and free from hydroxyl groups.

4. The cable claimed in claim 3, in which said polymerization product consists exclusively of polystyrol.

5. An electric quad-cable for communication purposes, comprising an outer insulating sleeve, a plurality of inner sleeves disposed inside the outer sleeve, a hollow insulating core of substantially quadrangular, equilateral cross section disposed inside each one of said inner sleeves, each insulating core providing recesses between the core and the surrounding inner sleeve in order to form air spaces between the core and the inner sleeve appertaining thereto, and a plurality of electric conductors disposed in said recesses on each core and at equal distances from one another to form quad-circuits, whereby a large portion of each of said conductors is exposed to the surrounding air, the said inner sleeves and cores consisting of a polymerized vinyl-benzene.

6. A cable for transmission of intelligence and other purposes, comprising an insulating sleeve and an electric conductor disposed inside said sleeve, the latter consisting of an unplasticized layer of polystyrol of sufficient thinness to assure flexibility.

7. A cable for transmission of intelligence and other purposes, comprising an insulating sleeve and an electric conductor disposed inside said sleeve, the latter consisting of a thin, flexible, unplasticized foil of pure polystyrol.

8. An electric quad-cable for communication purposes, comprising an outer insulating sleeve, a plurality of inner sleeves disposed inside the outer sleeve, a hollow insulating core of substantially quadrangular, equilateral cross section disposed inside each one of said inner sleeves, each insulating core providing recesses between the core and the surrounding inner sleeve in order to form air spaces between the core and the inner sleeve appertaining thereto, and a plurality of electric conductors disposed in said recesses on each core and at equal distances from one another to form quad-circuits, whereby a large portion of each of said conductors is exposed to the surrounding air, the said cores and inner sleeves consisting of pure, unplasticized polystyrol and the said outer sleeve consisting of metal surrounded by an envelope of polystyrol.

HELGE ROST.

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CERTIFICATE OF CORRECTION.

Patent No. 2,116,643. May 10, 1938.

HELGE ROST.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 5, foreign filing date, for the words "In Germany February 15, 1932" read In Sweden July 26, 1932; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of July, A. D. 1938.

Henry Van Arsdale,

(Seal) Acting Commissioner of Patents.