July 12, 1938. H. ROST 2,123,746

INSULATED CABLE

Filed Aug. 30, 1933

Fig. 1.

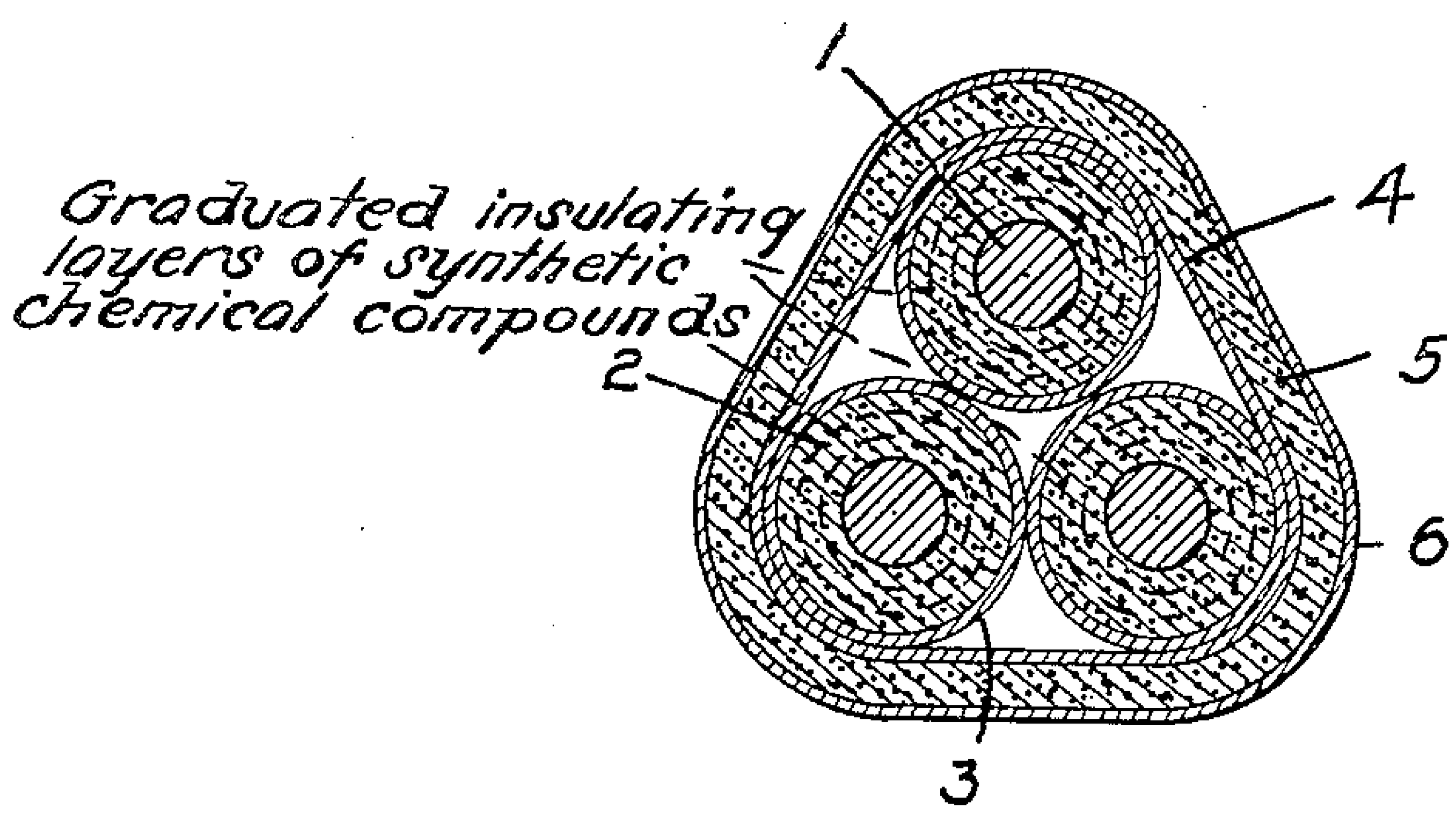


Fig. 2.

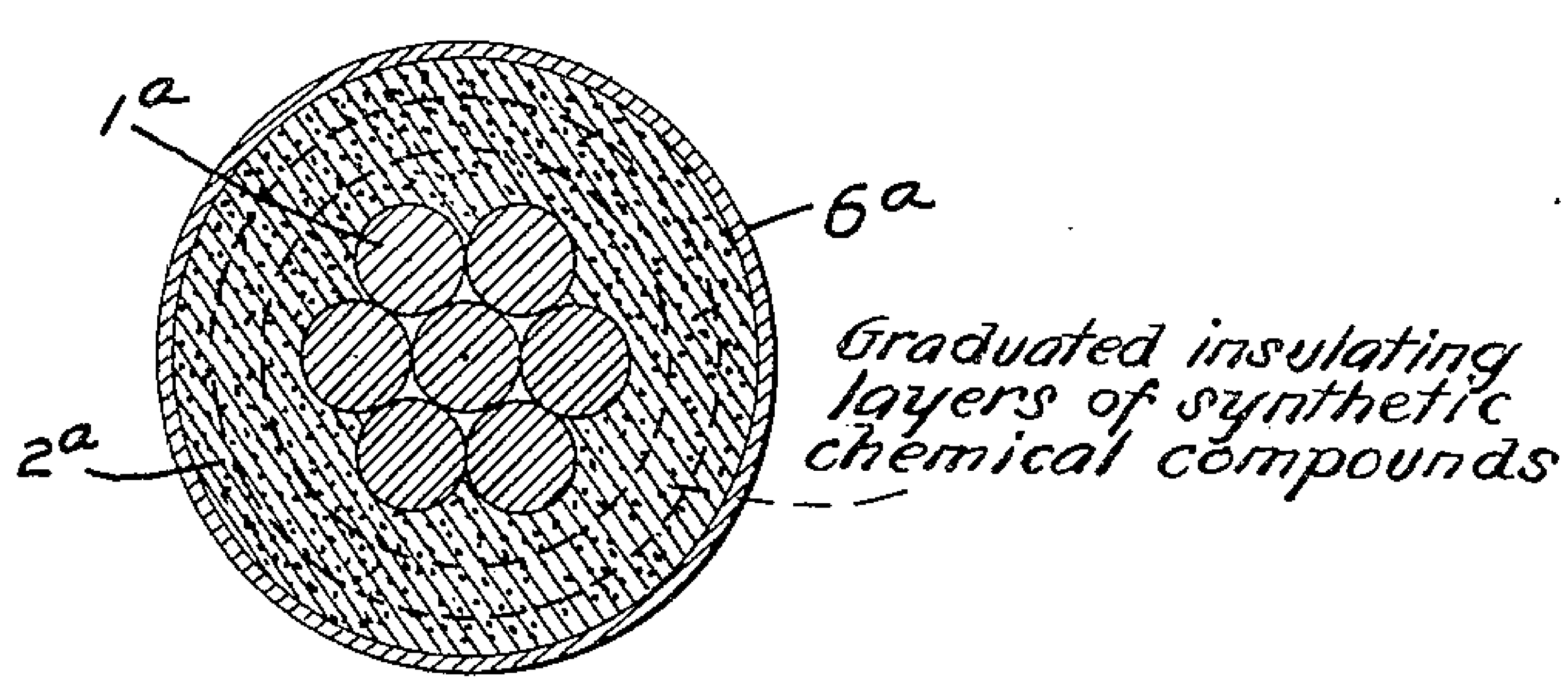
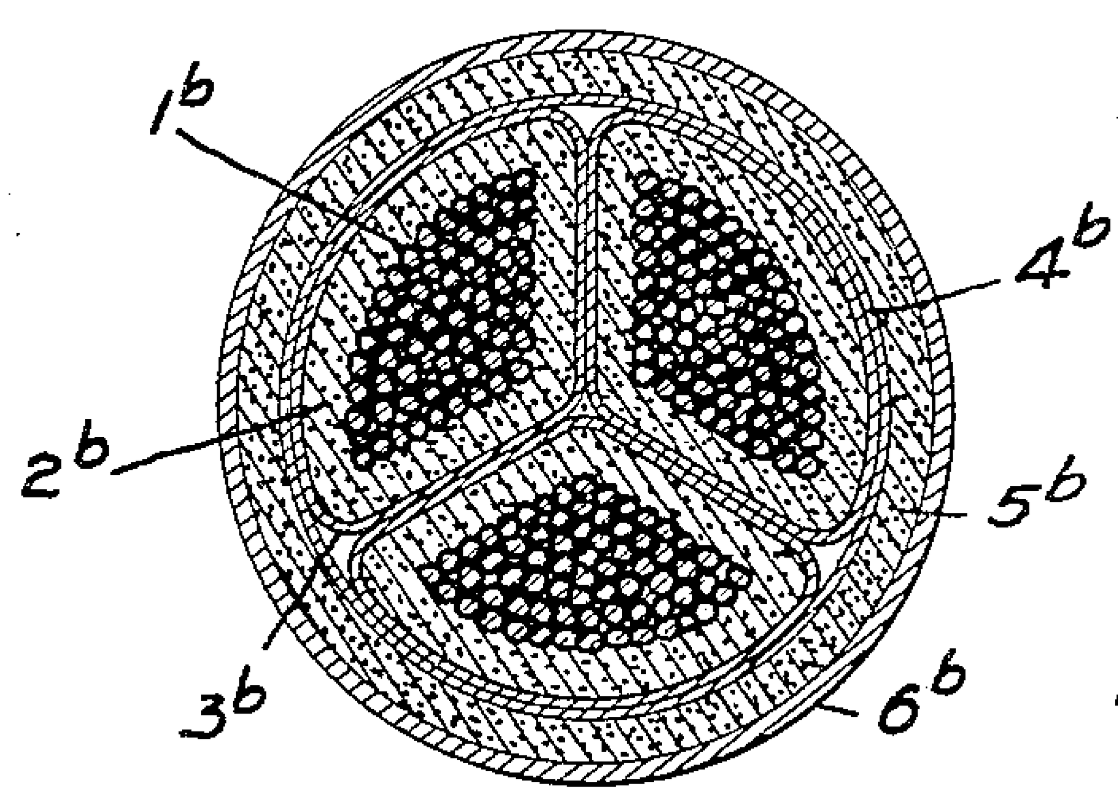


Fig. 3.



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INSULATED CABLE

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Application August 30, 1933, Serial No. 687,439
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8 Claims. (Cl. 173—266)

My invention relates to improvements in electric conductors and cables, and more especially to insulating means for high tension conductors and cables.

Several types of insulation are at present in commercial use, each having certain features of advantage but each also being attended by greater or less disadvantage in use. Among the best known and most widely used insulating means are paper, both dry and impregnated, and thin oils.

Unimpregnated, dry, paper with air as a dielectric absorbs moisture from the air, with corresponding lowering of the insulation value. Dry paper has a working voltage limit of about 20,000 volts only, as above this potential the occluded air is ionized, ozone is formed, and creeping currents begin to form across the insulating material, gradually destroying the paper. It is, moreover, difficult always to obtain pure paper of uniform quality free from acid and impurities.

Impregnated paper also varies greatly in quality unless the impregnation is perfect, and air pockets are formed inside the cable with the resulting danger of ionization.

Cables insulated with impregnated paper are more easily subject to high temperatures and danger of breakdown on account of hot spots. The distribution of the dielectric potential is uneven by reason of the combination of different dielectrics of irregular composition, like impregnated paper, free compound and air.

The conduction of heat to the surface of the cable is also irregular, and hot spots are easily formed because of the ionization of air pockets and the corresponding lowering of the insulation resistance the consequent increase of temperature easily causes a partial breakdown. Chemical changes of the paper and the oil cause the oil to decompose, forming partially solid compounds with liberation of hydrogen and carbonic acid, from which water is gradually formed, with complete destruction of the insulation as a result.

Thin oils are used as an impregnating compound, especially for high tension conductors and cables, to fill up all air pockets and facilitate the heat dispersion. As oil, however, has a considerably greater coefficient of expansion than paper and lead, expansion chambers outside the cable must be installed. It is evident that a cable with such outside chambers is both expensive and difficult to install and maintain.

The principal object of my invention is to provide insulation which obviates the defects of existing forms of insulation, and I accomplish this object by placing about each conductor and in intimate contact with its entire surface an insulating sheath comprising a plurality of layers having their dielectric constants graduated from the innermost layer to the outermost layer and consisting of electrically insulating homogeneous (isotropic) thermoplastic synthetic chemical reaction products, without heterogeneous inclusions. Examples of substances suitable for the purpose of my invention are as follows.

Compounds consisting of polymerization products of hydrocarbons or derivatives thereof, containing the vinyl-group (—$CH:CH_2$), for instance, polymerization products of: Acrylic acid, styrol, vinyl-esters, vinyl-ethers, vinyl-alcohol, etc.

Compounds of polymerization products of vegetable oils, cyclic ketons, methylene ketons, etc.

Compounds consisting of polymerization products of acetylene derivatives.

Compounds of a condensation product obtained from a polymerized compound containing the vinyl-group (—$CH:CH_2$) with an aldehyde expelling compund, like polyvinyl-alcohol with a formaldehyde.

Compounds of a cellulose derivative like cellulose-ester, cellulose-ether, etc., in which one or several hydroxyl groups have been expelled, for instance cellulose-benzyl-ether, cellulose-ethyl-ether, etc.

I preferably apply the successive layers around the conductor by extrusion, as in this manner each layer may be made of suitable hardness and specific inductive capacity (dielectric constant), in order that the conductor may have the desired flexibility and also in order to properly grade the potential within the sheath, so that each composite layer will have suitable dielectric constant and the sheath as a whole being suited to the voltage for which the conductor or cable is constructed.

The first layer of highest insulating resistance and lowest specific inductive capacity is applied in intimate contact with the conductor and if the latter be made up of strands, the compound will fill all the interstices on the outside of the conductor, leaving no air spaces between the outside surface of the strand and the insulation proper.

Each succeeding layer of thermoplastic compound of the proper grade is applied preferably by extrusion, the preceding insulating layer, in that case, being kept at a temperature, such that the new thermoplastic layer is bonded to the previous layer, all layers thus forming a solid sheath without voids or gas pockets, but each layer being of different composition from the others.

The layers may be applied in continuous operation for instance by extrusion, preferably simultaneously, so that the different layers while still soft after leaving the extrusion nozzles are easily fused together. Different machines may of course be used for applying the several layers, the cable conductor continuously passing from one machine to the other, and the temperature of each layer being such that fusing easily takes place to the new layer, when extruded.

In order to facilitate the conduction of superfluous heat occasioned by temperature rise within a cable containing one or several conductors and also in order to give to all conductors the same potential with respect to one another and to the sheath, each conductor insulated as described above may be provided with one or several continuous tapes or foils, preferably of aluminum, and the cable core provided with one or several similar continuous metal tapes in metallic contact with those of the individual conductors.

The cable core thus prepared is provided with an exterior electrical and mechanical protection, consisting of a tough and flexible organic synthetic compound of the same or similar linear coefficient of expansion as the composition of the compound used in the insulation sheath of the electric conductors, which compound is applied by extrusion. The advantage obtained is that the outside sheath is not an electric conductor, and cannot be damaged by stray electric currents circulating in the subsoil, if the power cable be a subterranean one.

A cable constructed in accordance with my invention will avoid the difficulty now experienced with high tension cables, owing to the dangerous stresses of the metallic outside sheath, when owing to the presence of heat the interior insulation expands more than the outside sheath permits.

These stresses are entirely avoided in cables according to the present invention, as the electrical insulation compound of the conductors and that of the outside sheath have about the same linear coefficient of expansion.

If the outside sheath of thermoplastic compound lacks the requisite mechanical strength to withstand abrasion when being drawn into and out of conduits or ducts, said sheath may be provided with a steel tape and/or jute jacket.

The invention is illustrated in the accompanying drawing, by way of example merely, in which Figures 1, 2 and 3 are cross sectional views of different forms of conductors or cables having my invention applied thereto.

Figure 1 shows a section of a 3-phase cable, in which 1 is a conductor, 2 is the insulating sheath made up of a plurality of layers of homogeneous insulating synthetic compounds, 3 represents metal tape around each conductor, 4 is a metal tape or tapes around the several conductors, 5 is an outside sheath of the same linear coefficient of expansion as the insulating compound of the conductors, and 6 is the outside steel tape or armor.

Figure 2 is a section of a single phase cable, wherein 1ª is a conductor composed of several wires, 2ª is the insulating sheath formed of composite layers of homogeneous insulating synthetic compound in intimate contact with the whole outside surface of the conductor, and 6ª is the outside steel tape or armor.

Figure 3 is a section of a 3-phase cable having sector shaped conductors, 1ᵇ; 2ᵇ is the insulating sheath of composite layers of insulating synthetic organic compound, in intimate contact with the conductor; 3ᵇ is a metal foil around each insulated conductor and in intimate contact with the insulation; 4ᵇ denotes one or more metal tapes around the cable core, and in contact with the individual metal foils of the conductors; 5ᵇ is an outside sheath of organic compound of the same linear coefficient of expansion as the insulating compound of the conductors; and 6ᵇ is the outside steel tape or armor.

By means of this invention the following great advantages are obtained:

Air pockets do not exist, and therefore ionization cannot take place, nor can ozone be formed at high tensions.

Higher temperatures, which are the concomitants of greater load, may be present without danger of breakdown, owing to the graded insulating layers and the compound used.

Smaller dimensions of cables as compared to paper insulated cables, are usuable for the same load.

Dangerous stresses to the outside sheath are avoided, inasmuch as this sheath has the same linear coefficient of expansion as the compound of the insulation of the conductors.

Chemical and electrolytical corrosion of the cable sheath is entirely absent.

While I have described my invention in detail it will be understood that considerable modification thereof may be made without departing from the spirit of the invention as defined by the appended claims.

I claim:

1. An electric power cable comprising an electric conductor and a composite insulation sheath of graduated dielectric constant surrounding the conductor, said insulation sheath being composed of a plurality of homogeneous layers, each of which consists of an organic, electrically insulating, polymerized, solid, chemical compound, free from heterogeneous inclusions, each of said layers possessing a dielectric constant differing from that of the other layers, the innermost layer being intimately united with and clinging closely to the said conductor, and each succeeding layer being intimately united with the preceding one, all recesses inside the cable being filled out by said layers to avoid gas pockets.

2. An electric power cable comprising an electric conductor and a composite insulation sheath of graduated dielectric constant surrounding the conductor, said insulation sheath being composed of a plurality of synthetic homogeneous layers each of which consists of a polymerized chemical compound of a hydrocarbon derivative comprising at least one vinyl group, each of said layers possessing a dielectric constant differing from that of the other layers, the innermost layer being intimately united with and clinging closely to the said conductor, and each succeeding layer being intimately united with the preceding one, all recesses inside the cable being filled out by said layers to avoid gas pockets.

3. The power cable claimed in claim 1, in which said innermost layer has the lowest dielectric constant as compared to the other layers, the dielectric constants of the layers ascending from the center of the cable outwardly.

4. The power cable claimed in claim 1, in which said chemical compounds are polymerized substituted ethylene derivatives.

5. The power cable claimed in claim 1, in which one of said chemical compounds is a polymeriza-

tion product of a substituted benzene comprising a vinyl group.

6. The cable claimed in claim 1, in which said chemical compound is a polymerized substituted aliphatic hydrocarbon product of the paraffin series in which a substitute radical comprises a vinyl group.

7. The power cable claimed in claim 1, in which one of said chemical compounds is a polymerized substituted ethylene derivative.

8. The cable claimed in claim 1, in which one of said chemical compounds is a polymerized substituted aliphatic hydrocarbon product of the paraffin series in which a substitute radical comprises a vinyl group.

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