Oct. 8, 1940. R. W. LUNT 2,217,284

ELECTRIC CABLE

Filed Sept. 7, 1938

Fig. 1.

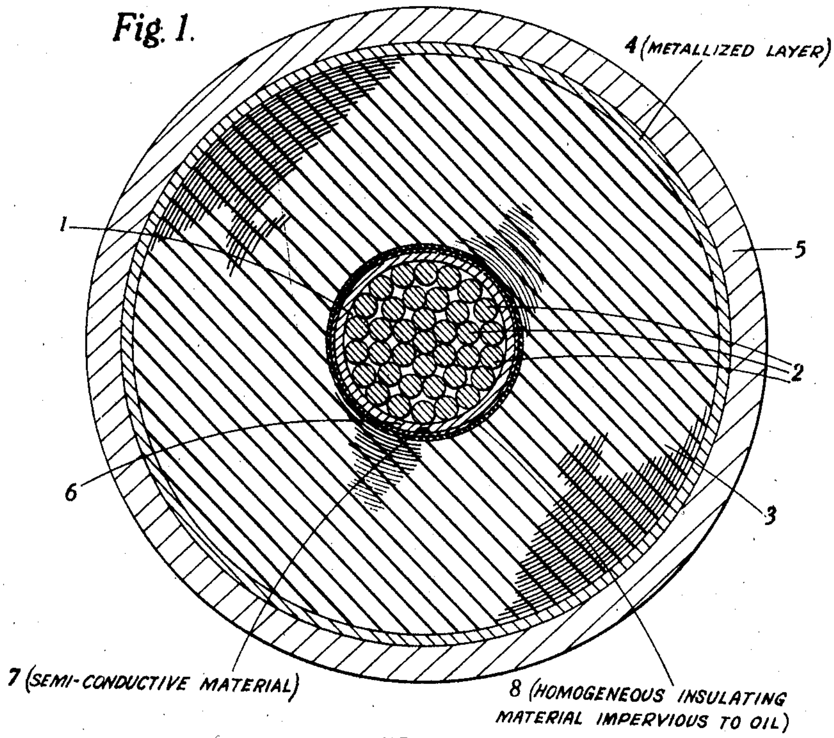
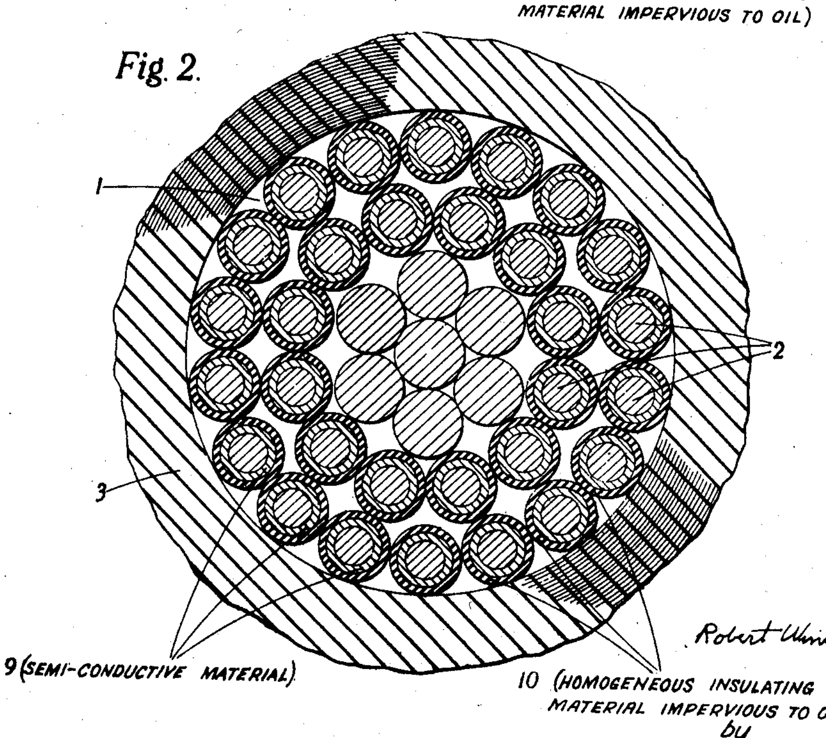


Fig. 2.



Robert Winstanley Lunt
Inventor
by Stebbins Blenko & Parmelee
Attorney

UNITED STATES PATENT OFFICE

2,217,284

ELECTRIC CABLE

Robert Winstanley Lunt, London, England, assignor to Callender's Cable and Construction Company Limited, London, England, a British company

Application September 7, 1938, Serial No. 228,768
In Great Britain September 28, 1937

6 Claims. (Cl. 174—25)

This invention relates to high tension electric cables comprising a conductor and a dielectric of paper or other fibrous material impregnated with oil, oil-compound or other insulating liquid, hereinafter for the sake of brevity termed compound. Cables of this type whether the solid part of the dielectric is paper or other fibrous material, will hereinafter be termed, for convenience, impregnated paper insulated cables.

In the specification of prior Patent No. 2,102,974 it has been indicated that breakdown of the dielectric of impregnated paper insulated cables is in the great majority of cases initiated at or close to the conductor in spaces containing gas and having the conductor as the inner boundary and the dielectric as the outer boundary.

In accordance with the present invention I provide a breakdown-resistant cable by interposing between the surface of the conductor and the innermost layer of the impregnated body of dielectric a thin, and preferably continuous, composite layer comprising an inner portion consisting of an artificially formed film of semi-conductive material and an outer portion consisting of homogeneous insulating material impervious to the compound used to impregnate the dielectric. The two parts of the composite layer are as far as possible in complete contact throughout their adjacent surfaces.

The improved protective layer is to be distinguished from a protective layer of known form consisting of a film or wrapping of homogeneous insulating material applied directly to a conductor whose surface carries a naturally-formed film of oxide. Such naturally-formed oxide films have a thickness of $1 \times 10^{-2} \mu$ or less and are much too thin to cooperate with the insulating film to modify the nature of an electric discharge in a gas pocket bounded on one side by the filmed conductor in the same way as does a relatively thick artificially formed film.

The semi-conductive inner portion of the interposed layer may, for example, be a thin adherent film of cuprous oxide of from 5–50 μ thick. Where the cable conductor is of copper, such a film may be produced by heating the conductor to a temperature of about 900° C. by drawing it through a furnace to which air is admitted at such a rate that a film of oxide of the required thickness is produced or by drawing the conductor through a bath of molten sodium nitrite at a temperature of about 530° C. at such a rate that a film of the desired thickness is formed and subsequently drawing it through a bath of hot water to remove any sodium nitrite adhering to the oxide coated conductor. Alternatively the semi-conductive inner portion of the composite layer may be a thin adherent film of graphite formed by coating the conductor with a colloidal suspension of graphite in water.

Of the numerous materials suitable for the formation of the outer portion of the interposed composite layer the following are mentioned by way of example: Insulating varnishes, gum dammar, and plastics, such as vinyl chloride, styrene and methacrylic ester.

A vitreous enamel which comprises an oxide of boron or one or more metal borates or silicates or a mixture of one or more metal borates with one or more metal silicates or a mixture of one or more metal borates and/or one or more metal silicates with one or more metal fluorides.

Siliceous material

It will be appreciated that in selecting a material for the outer portion of the composite layer due regard should be paid to the nature of the material constituting the inner portion and to the possibility of a chemical reaction between the two portions. For instance, where the inner semi-conductive portion is cuprous oxide it will generally be inadvisable to employ a vitreous enamel for the outer portion unless precautions be taken to limit the reaction between the oxide layer and the vitreous material whilst the latter is in the molten state.

Where the outer portion of the composite layer is a plastic, this portion may be formed by spraying the semi-conductive coating of the conductor with a solution of the plastic in a volatile solvent or by running the coated conductor through a bath of such a solution.

Where the semi-conductive coating on the conductor is graphite, the coated conductor may be given an insulating coating of vitreous enamel of the type above described by drawing it through a bath of molten constituents of the enamel, the temperature of the bath and hence the viscosity of the enamel, and the rate of travel of the conductor being adjusted to give the required thickness of coating. For example a bath of fused borax maintained at a temperature of from 850°–950° C. may be used and, by adjusting the rate of travel of the conductor, a thin layer, for instance, a layer of 5–50 μ thick may be obtained. Alternatively the constituents of the vitreous coating may be fused and the product subsequently ground to a fine powder, preferably to a particle size less than the thickness of the coating required, and applied to the graphite coated conductor in the form of an aqueous paste which is then subjected to heat, first to drive off the liquid and then to fuse the residue and convert it into a coherent vitreous layer. For example, the conductor may be coated with a paste of finely ground glass resulting from the fusion of a mixture consisting of 100 parts by weight of borax and 10 parts by weight of silica and the coated conductor drawn through a furnace to raise the coating to a temperature of about 900° C. to convert the coating into a vitreous layer. Or the conductor with its semi-conductive coating of graphite may be electrolytically coated with a thin film of metal e. g. copper which is afterwards completely oxidised, and the oxide coated conductor be subjected to either of the aforesaid processes for obtaining a coherent vitreous layer, with the result that the oxide layer re-acts with and is dissolved in the vitreous layer whilst it is in the molten state. For example, a conductor provided with a semi-conductive layer of graphite and with an outer layer of electrolytically deposited metal may be heated to a temperature of about 900° C. by drawing it through a furnace to which air is admitted at such a rate that a film of oxide of about 5 μ thick is formed. The oxide coated conductor can then be drawn through a bath of molten borax, maintained at a temperature of from 850°–950°, at such a speed that the oxide layer is completely converted into copper borate with the result that a conductor having an inner coating of graphite and an outer vitreous coating comprising a mixture of fused borax and copper borate is obtained. Yet another way in which the outer portion of the composite layer may be formed is by electrophoretically depositing on the graphite coated conductor a thin coating of the vitreous material in a powdered state from a suspension thereof and subsequently converting this coating into a coherent layer by the application of heat. This last said method of forming a layer of vitreous material on a substratum is described and claimed in the specification of British Patent No. 484,777 dated September 26th, 1936, and granted to N. V. Phillips' Gloeilampenfabrieken.

Where the outer portion of the composite layer is of siliceous material this portion may be formed by applying to the semi-conductive inner portion of the composite layer, a silica varnish comprising a solution of silica, preferably a solution of silica in a non-aqueous solvent or a mixture of such solvents or a mixture of such a solution and an undecomposed ester of silicic acid, and allowing the siliceous coating to dry. Such solutions can be made, as described in the specification of British Patent No. 290,717, dated February 16th, 1927, and granted to G. King and R. Threlfall, by reaction between an ester of silicic acid and water in the presence of a solvent for the ester which is also adapted to carry water either in solution or suspension or in the presence of a mixture of such solvents. A silica varnish that has been found to be very satisfactory is the partially decomposed solution of pure silicon esters described in Example 1 of the specification of the aforesaid patent and there referred to as "the basis solution", diluted with an equal volume of toluene. The conductor with its semi-conductive coating may be given an adherent coating of siliceous material to form the outer portion of the composite protective layer by drawing it through a bath of the silica varnish at room temperature and at such a speed as to yield a film of the required thickness. For instance, with the basis solution referred to above a coating having a thickness when dry of about 40μ is obtained by drawing through at a speed of the order of 1 ft./sec. It appears important to prevent access of moisture to the coated conductor during the setting of the film in order to restrict loss of elasticity. Accordingly, it is preferred to dry the coated conductor in an oven and to take precautions to exclude water vapour and dust therefrom both during the drying process and subsequently until protected by the superposed paper insulation. At a temperature of 110° C. a drying period of 45 minutes suffices.

In cases where stranded conductors are employed the conductor may be given a smooth surface of non-re-entrant form, for instance, by applying to the stranded conductor a metal tape wrapping, and the composite protective layer be applied to the outer surface of the metallic smoothing layer. In cases where the application of the composite layer does not involve the use of high temperature the smoothing layer may comprise a thin lead sheath. Alternatively the composite protective layer may be applied to each of the individual wires forming the outermost layer or two outer layers of the stranded conductor prior to their incorporation into the conductor.

The accompanying drawing shows two examples of high tension cable constructed in accordance with the present invention. In the drawing.

Figure 1 is a cross-sectional view of a cable with one form of composite protective layer, and

Figure 2 is an enlarged cross-sectional view of the central part of a cable with a second form of composite protective layer.

In each case the cable illustrated comprises a conductor 1 consisting of a plurality of component wires 2 stranded together. The stranded conductor is insulated by an impregnated body of paper insulation 3. On the surface of the latter is a metallised layer 4 and the whole is enclosed in an impervious metal sheath 5. In the form of construction shown in Figure 1 the conductor is given a smooth surface of non-re-entrant form by applying thereto a thin metal sheath 6. On the outer surface of this sheath 6 is provided a composite protective layer comprising an inner portion 7 of semi-conductive material and an outer portion 8 of homogeneous insulating material. It is to be understood that the drawing is not to scale and that the thickness of each portion of the protective layer, which may, for instance, be about 40μ, has been greatly exaggerated in order that the composite nature of the layer may be clearly shown. In the form of construction disclosed in Figure 2 of the drawing the metallic smoothing layer 6 is dispensed with and the composite protective layer is formed by providing each wire 2 of the two outer layers in the stranded conductor 1 with a thin inner coating 9 of semi-conductive material and an outer coating 10 of homogeneous insulating material. The thicknesses of these coatings 9 and 10 have also been greatly exaggerated in order to show them more clearly.

What I claim as my invention is:

1. A high tension electric cable comprising a conductor, an impregnated body of fibrous insulation surrounding said conductor, an impervious sheath enclosing said body of insulation and a composite protective layer for said body of insulation interposed between the surface of said

conductor and the inner surface of said body, said composite protective layer comprising an inner portion consisting of an artificially formed film of semi-conductive material and an outer portion consisting of homogeneous insulating material impervious to the compound used to impregnate the dielectric.

2. A high tension electric cable comprising a stranded conductor, consisting of a plurality of individual strands, a plurality of composite protective layers, one for each of the outside strands of the said conductor, an impregnated body of fibrous insulation surrounding said stranded conductor, and an impervious sheath enclosing said body of insulation, said composite protective layers each comprising an inner portion of semi-conductive material and an outer portion of homogeneous insulating material impervious to the medium with which said fibrous insulation is impregnated.

3. A high tension electric cable comprising a stranded conductor, a smooth surfaced metallic layer surrounding said stranded conductor and electrically connected thereto, a composite protective layer provided on the outer surface of said metallic layer, an impregnated body of fibrous insulation surrounding said composite protective layer, and an impervious sheath enclosing said body of fibrous insulation, said composite protective layer comprising an inner portion consisting of an artificially formed film of semi-conductive material and an outer portion consisting of homogeneous insulating material impervious to the medium with which said fibrous insulation is impregnated.

4. A high tension electric cable comprising a conductor, an impregnated body of fibrous insulation surrounding said conductor, an impervious sheath enclosing said body of insulation and a composite protective layer for said body of insulation interposed between the surface of said conductor and the inner surface of said body, said composite protective layer comprising an inner portion consisting of a film of semi-conductive material having a thickness of about 5–50μ and an outer portion consisting of homogeneous insulating material impervious to the compound used to impregnate the dielectric.

5. A high tension electric cable comprising a stranded conductor, consisting of a plurality of individual strands, a plurality of composite protective layers, one for each of the outside strands of the said conductor, an impregnated body of fibrous insulation surrounding said stranded conductor, and an impervious sheath enclosing said body of insulation, said composite protective layers each comprising an inner portion consisting of a film of semi-conductive material having a thickness of from about 5–50μ and an outer portion of homogeneous insulating material impervious to the medium with which said fibrous insulation is impregnated.

6. A high tension electric cable comprising a stranded conductor, a smooth surfaced metallic layer surrounding said stranded conductor and electrically connected thereto, a composite protective layer provided on the outer surface of said metallic layer, an impregnated body of fibrous insulation surrounding said composite protective layer, and an impervious sheath enclosing said body of fibrous insulation, said composite protective layer comprising an inner portion consisting of a film of semi-conductive material having a thickness of from about 5–50μ and an outer portion consisting of homogeneous insulating material impervious to the medium with which said fibrous insulation is impregnated.

ROBERT WINSTANLEY LUNT.