Sept. 24, 1935. C. E. BENNETT 2,015,063

ELECTRIC CABLE

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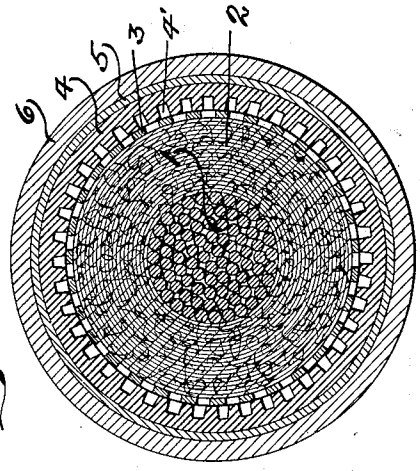


Fig. 2.

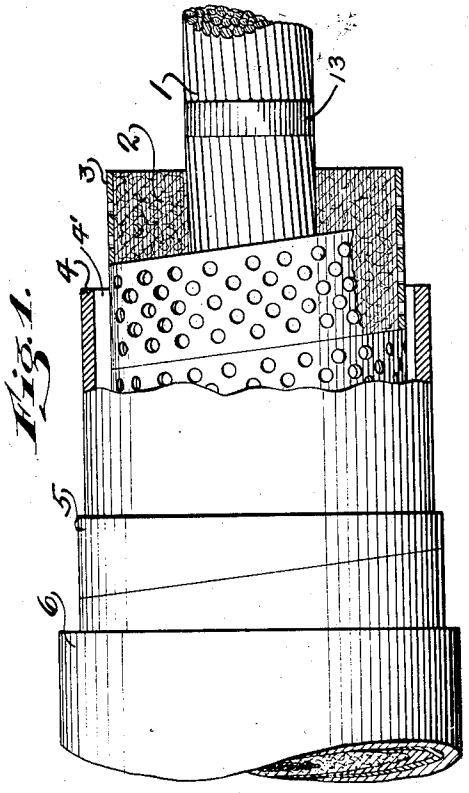


Fig. 4.

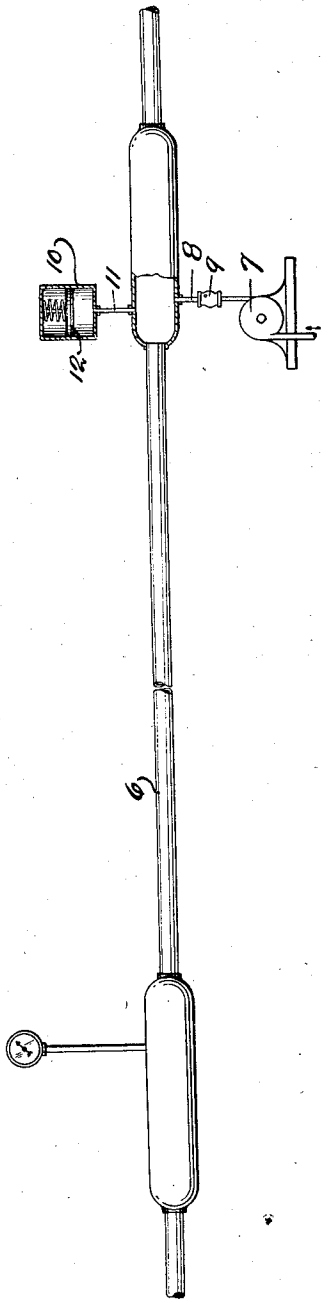


Fig. 3.

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Fig. 4.

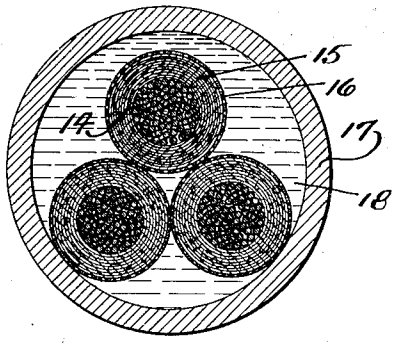


Fig. 5.

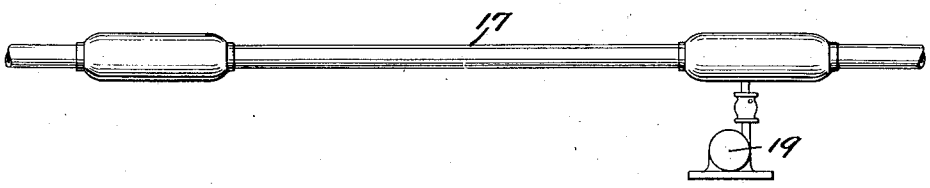
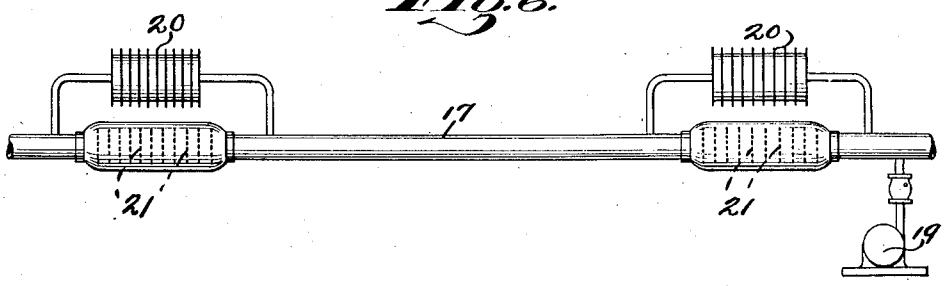


Fig. 6.



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2,015,063

ELECTRIC CABLE

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Application July 29, 1931, Serial No. 553,714

1 Claim. (Cl. 173—264)

My invention relates to an improvement in electric cables, and has for one of its objects the provision of a construction whereby ionization due to defects in the insulation surrounding the conductor is overcome and the operation of the cable improved.

It is well known to those skilled in this art that in cables comprising a conductor covered with an insulating envelope or sheath of permeable material filled or impregnated with a liquid insulation, and an enclosing lead sheath, when voltage and current are applied heating results causing expansion of the impregnating liquid. When the load is taken off the cable, allowing the cable to cool, capillary action is relied on to return the insulating liquid to its original position in the insulating envelope. It has been found, however, that this action is insufficient, resulting in many instances in ultimate break down.

The present invention provides a construction wherein these defects are overcome in a practicable manner, means being provided whereby radial pressure is applied directly to the exterior of the cable insulation, this construction taking the form of a reservoir surrounding the cable insulation and containing an insulating liquid maintained at a relatively high pressure at all times, preferably a pressure as high as the maximum pressure generated or built up in the cable by reason of the expansion of the liquid insulation above referred to, not less than five atmospheres, for example. In this way a force additional to capillary action is available for the return of the insulating fluid of the structure to its original position and I am assured that the insulating envelope will be thoroughly impregnated and filled at all times with insulating material and the formation of voids and dry spots (the cause of ionization and break down) avoided.

My invention also by the same token insures a relatively high pressure at the exterior of the conductor which increases the dielectric strength of the liquid insulating medium of the cable and makes for improved operation of the cable by eliminating ionization.

My invention may take various forms.

In the accompanying drawings Figs. 1, 2 and 3 illustrate one embodiment of my invention,

Fig. 1 being a longitudinal section of a cable constructed in accordance with this invention;

Fig. 2 a cross section; and

Fig. 3 an elevational view of the cable as actually installed.

Figs. 4, 5 and 6 show another embodiment of my invention,

Fig. 4 being a cross section of the cable;

Fig. 5 a longitudinal view; and

Fig. 6 a longitudinal view similar to Fig. 5 with a cooling system added.

Referring first of all to the embodiment of my invention as illustrated in Figs. 1, 2 and 3: 1 designates the conductor of a single conductor cable of the stranded type. This type of conductor is known in the art as a stranded solid conductor, as distinguished from a hollow core conductor. Surrounding the stranded solid conductor 1 is an insulating envelope 2 of permeable material, this envelope taking the usual form, for example, paper impregnated with a suitable insulating material. Immediately surrounding the insulation 2 is a permeable tape 3, conveniently perforated metal, and about this assembly is a fluted reservoir sheath or envelope 4 of lead, for instance, or other suitable material, the passages 4' thus formed extending along the exterior of the permeable tape 3 and insulation 2 and providing a reservoir for a supply of insulating liquid always maintained under pressure, as will be hereinafter brought out. While the reservoir sheath 4 is illustrated as of lead it may be of other suitable material, as will be understood. In any event it must be of such character as to withstand the pressures I propose to employ, without distortion. If necessary and to this end I apply a reinforcing metal tape about the exterior of this sheath 4 as shown at 5, this tape being mechanically protected by an outside lead sheath 6 which may be the usual sheath employed in cable structures.

As above noted the spaces or passages 4' between the flutes of the fluted sheath 4 are to be kept filled at all times with a fluid insulating material under high pressure, for example a minimum pressure of substantially fine atmospheres, and in this connection, as diagrammatically illustrated in Fig. 3, it will be seen that I provide a pump 7 connected by a suitable pipe 8 to the interior of the reservoir sheath 4, the passage of material through this pipe or conduit 8 being controlled by a check valve, diagrammatically shown at 9. This pump 7 will supply a liquid insulating medium or compound of any suitable kind such as oil, for example, to the interior of the reservoir sheath 4 at a relatively high pressure. This pressure of course may be varied within wide limits; say for example from seventy-five pounds minimum to two hun-

dred pounds maximum or even higher. The material in the reservoir sheath 4 is kept at the desired pressure by a regulator 10 of any suitable type, this regulator preventing building up of excess pressures within the reservoir when the cable is in operation. The regulator 10 may take the form of a cylinder communicating through a pipe 11 at all times with the interior of the reservoir sheath 4, the cylinder being provided with a spring-loaded piston 12 which recedes or moves outwardly of the cylinder when the pressure in the reservoir 4 starts to build up beyond that for which the apparatus is designed.

It will be understood that pumps 7 may be installed at intervals along the cable and when employing stranded solid conductors improved results are obtained by employing stops 13 to stop the conductor and prevent the flow of oil along the interstices between the strands thereof. The stops may take different forms such as a metallic filler, of a soft material, similar to tin foil, or of special melting point alloy that will make the conductor a solid section as distinguished from stranded but which will not detrimentally affect its flexibility. Again some non-metallic material such as a semi-hard compound may be employed.

A tin foil, or other low melting point tape may be wrapped on the conductor, this foil melting when the cable is going through the impregnating cycle to form more or less of a wall about the conductor strands. The strands may be filled with an asbestos dust or gypsum powder then wrapped with a soft low melting point tape that will weld to form a continuous tube around the strands when sufficient heat is applied. This will do away with any expansive oil that may stay in the strands of the conductor. In fact any material may be employed to provide these stops so long as the material is of such a nature as to prevent the flow of the insulating fluid along the interior of the conductor and does not detrimentally affect the flexibility of the cable. Of course where the conductor is not stranded but is of solid section then the stops are not beneficial.

It will be appreciated from all of the foregoing that when a cable constructed in accordance with this invention is placed in operation the liquid insulating medium contained in the permeable insulating envelope or sheath is caused to expand due to the heat generated, as above explained. With prior cables of the solid conductor type as distinguished from hollow core cables, capillary action is relied on to restore the liquid insulating medium to its original position in the paper tape on the cooling cycle, this liquid insulation being displaced on the heating cycle as will be understood. Capillary action is insufficient, however, to restore the liquid insulation to its original position, and it is a recognized fact that such failure is the cause of ionization and breakdown due to the voids formed in the insulation. My invention provides, however, for maintaining a high pressure in the reservoir sheath 4 at all times so that on the cooling cycle instead of mere capillary action I have this pressure available for forcing the liquid insulating material into the insulation 2, with the assurance that voids or dry spots cannot be formed in the insulation, and hence breakdown or failure of the cable from this source will be eliminated, and with the further advantage of the increase in the dielectric strength of the liquid insulating material in the insulation 2 resulting from maintaining the same under the high pressures I employ.

In the embodiment illustrated in Figs. 4, 5 and 6 I have illustrated a modification of my invention, the principle illustrated, however, being the same as that of Figs. 1, 2 and 3.

Referring to this embodiment of my invention, 14 designates the conductors of a multi-conductor cable which as in the case of Figs. 1, 2 and 3 may be either of the solid or stranded type. Each conductor is insulated by an envelope or sheath of permeable material such as insulation impregnated paper tape designated 15. On the exterior of this insulating envelope or sheath I prefer to apply a perforated metal tape 16 similar to the tape 3 of Fig. 1. The assembly is placed in a pipe or conduit 17 such as employed in any "draw-in" system, the space around the insulated conductors, designated 18, providing a reservoir for a suitable insulating fluid such as oil maintained under relatively high pressure by a pump 19. This embodiment of my invention, therefore, comprehends maintaining relatively high pressure on a liquid insulating medium directly in contact with the insulation of the conductors so as to prevent migration of the insulating medium in the insulating envelope due to expansion of the insulating material by reason of the heat generated when the cable is operated, thereby eliminating voids and gas pockets and the danger of breakdown and failure from this source.

A regulator such as the regulator of Fig. 3 may be employed in this embodiment of my invention for maintaining the pressure of the insulating material in the reservoir constant. In this construction I also provide for cooling of the liquid insulating material in the reservoir, this structure taking the form of radiators 20 through which the oil or other liquid insulating material is circulated. As many of these radiators may be installed along a length of cable as may be found necessary. Preferably the radiators are installed at the joints in the cable and I prefer to employ baffles such as shown at 21 at these joints for increasing the amount of oil passing through the radiators.

This method of cooling may be varied if desired by pumping the insulating material or oil longitudinally from one end of a cable line to a reservoir at the other end. When the reservoir fills up the pump is stopped and it will then return to the pumping station by gravity, or aided by some pressure means. In other words, a surge from pump to tank and back again may be found to be the best operating cycle.

Each time the oil passes through the radiator it is cooled and the surges can be of long or short intervals according to the cooling required.

It will be appreciated that in this embodiment of my invention also the various forms of stop mechanism above referred to may be employed to prevent travel of fluid insulating material along the interior of the conductors.

It will be understood that changes may be made in the details of construction above referred to within the scope of my invention.

What I claim is:—

The method of improving the dielectric properties of an oil filled electric cable of the solid stranded conductor type, which method comprises maintaining a body of insulating liquid under a minimum pressure of approximately five atmospheres in contact with the exterior surface of

the permeable impregnated insulating envelope surrounding the cable conductor, while preventing longitudinal flow of the liquid insulating medium of the cable along the interior of the conductor, to impose pressure on the insulating liquid in said envelope which is confined to a direction inwardly radially of the insulating envelope of the cable conductor, said pressure promoting maintenance of the permeable insulating envelope of the conductor filled with impregnating liquid and increasing the dielectric strength of the impregnating liquid of the insulating envelope.

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