Jan. 24, 1939. E. KIRCH 2,145,182

HIGH PRESSURE FLUID INSULATED ELECTRIC CABLE

Filed Sept. 16, 1936

Fig. 1.

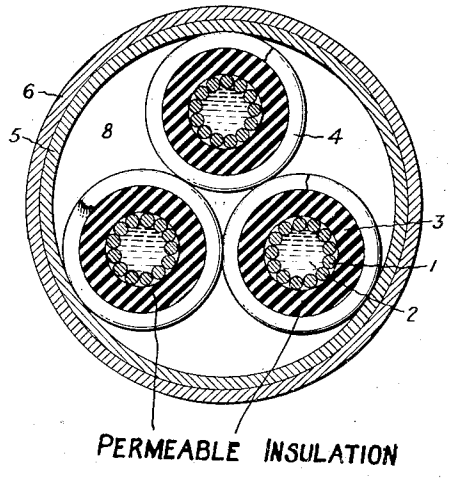


Fig. 2.

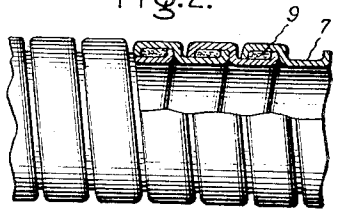


Fig. 4.

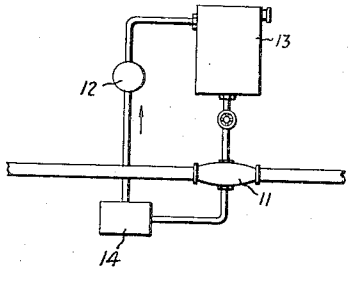
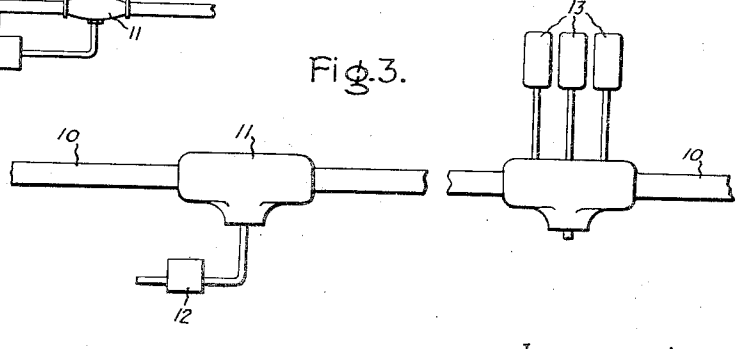


Fig. 3.



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UNITED STATES PATENT OFFICE

2,145,182

HIGH PRESSURE FLUID INSULATED ELECTRIC CABLE

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7 Claims. (Cl. 173—266)

It is known that by using increased pressure, the power of technical insulating materials to resist sparking over is increased with the result that the insulating covering of cables can be made thinner for a given degree of safety and in this way under some circumstances considerable reduction in cost can be attained.

A number of suggestions have already been made for pressure cables, that is to say, cables in which an increased pressure exists on the dielectric. The majority of these suggestions do undoubtedly conduce to a decided improvement from a technical point of view. On the other hand the expense necessary in all cases to enable a high pressure to be maintained in cables of the known type of construction are so great, that economic advantages cannot be secured, or if they are, only in a limited measure.

The present invention has for one of its objects the provision of an improved electric cable designed to operate under relatively high fluid pressures for the purpose of improving the dielectric strength of the insulation and in which the pressure exerted by the fluid is confined by flexible tube means immediately surrounding the insulation on the conductor and located inside of a lead sheath, said tube means protecting the sheath from the effects of the high pressure fluid without which injury to the sheath would result.

A further object of the invention is the provision of an electric cable designed to operate under relatively high fluid pressure which as a complete cable ready to be installed can be wound on and unwound from reels of ordinary construction.

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 drawing which is illustrative of my invention, Fig. 1 is a cross-section of a multi-core cable; Fig. 2 is a view partly in section of the flexible tube which surrounds each of the cores; Fig. 3 is a diagrammatic view of a part of a cable system, and Fig. 4 shows a suitable arrangement for conveying escaping fluid to the source of high pressure supply.

The characteristic feature of my invention is that use is made as an enclosure or seal for the dielectric under pressure of a flexible tube which is pressure-proof and composed of magnetic or non-magnetic material and which may be made by processes known per se. It is not indispensibly necessary that this tube should be perfectly fluid tight as it is surrounded by an impervious lead sheath, between which and the tube one or more longitudinal free spaces or ducts may be left which serve to convey any leakage from the pressure-proof tube to a suitable receptacle. The sheath may be provided in the usual way with an armouring of tape or wire of the kind well known per se. The hollow space or spaces or ducts left between the pressure-proof tube and the lead sheath which in this case functions merely as a corrosion-proof water-tight enclosure or seal for the core proper of the cable, must, if a pressure-proof tube of only limited thickness be used, be of such a size that the resistance of the hollow space or ducts to flow of fluid, even in cables of considerable length is considerably less than the resistance to passage corresponding to the permeability of the pressure-proof tube.

The construction of the pressure cable herein described should be such that even when high fluid pressures are used inside the dielectric the lead sheath is not subjected to a pressure or only to very low pressure so that under normal working conditions, it merely exercises the function of a watertight seal. In consideration, however, of a possible local defect in the pressure-proof tube the lead sheath may, however, under certain circumstances be conveniently provided in the usual way with one of the well known pressure protecting bandages or reinforcements so that in this case also it may not be damaged.

The inventive idea described embraces, of course, single and multiple conductor cables. In the latter case, each separate conductor is surrounded individually by a pressure-proof flexible tube and a common lead sheath is extruded over the conductors which are spirally arranged with a relatively long lay. In such case, as for example in an alternating current cable, the three conductors of which are each surrounded by a pressure-proof flexible tube, these latter may either consist of magnetic material or, if greater additional losses must be avoided for reasons of economy, of non-magnetic material. It may, however, be mentioned that the use of magnetic materials when applied in thin layers, as experiments have proved, cause only trifling additional losses, both at mean and heavy loads on the cable.

Cables of the kind described can be kept under pressure in all kinds of ways. One way, for example, is to put the core of the cable or the conductors of the cable under pressure by pressure vessels of a known kind, either with or without separation between the pressure medium, such as gas for example, and a more or less liquid or viscous insulating medium for example. The

insulating medium escaping through the pressure-proof but possibly not perfectly fluid tight flexible tube may be collected either in special containers attached to the fittings, such as joint enclosing sleeves or the terminals or in containers which are constructionally combined therewith. The escaping fluid may be conveyed therefrom either at long intervals or continuously by a hand pump or a mechanically driven pump, for example, and returned to the receptacle under pressure again. If the impregnating or pressure medium be continuously transferred from the space or duct between the pressure-proof tube and the lead sheath into the cable core or cores under pressure, small reservoirs which act merely as buffers will obviously suffice even when comparatively large leaks exist in the pressure-proof flexible tube. The supervision of the arrangement may be carried out by continuous or intermittent registration of the slight pressure in the space or duct between the pressure-proof flexible tube and the lead sheath.

The pressure-proof and flexible tube which surrounds the core of a single conductor cable or the separate cores of a multi-core cable may be produced in the manner known per se with the aid of appliances such as are used in the production of insulating tubes or in the art of sheathing conductors for installations. For example, tubes which are particularly advantageous for the purpose may be produced by folding a strip of sheet metal which is afterwards fluted, or the tubes may be made by a process which is now a very old one and in which bands are laid or wound round a mandrel and which are rendered flexible by passing them between a screw threaded bolt and a similarly screw threaded nut. Packing is effected by inserting oilproof non-metallic substances for example in the fold or between several concentric layers of a multiple layer tube and this may be carried out to any extent which is economical. It is also possible and under some circumstances preferable to make the pressure-proof, flexible tubes wholly or almost exclusively of insulating materials, for example by the well known winding, corrugating and stamping processes. The flexible tube is applied around the insulation of the conductor as the latter is fed through the tube forming machine.

A constructional example according to the invention is shown in Fig. 1 consisting of a corded or twisted three conductor cable with hollow conductors for the supply of the pressure medium for the insulation.

Each conductor of the three conductor cable comprises a copper conductor 1, a central channel 2 for the supply of the impregnating or pressure medium, permeable insulation 3 such as wrapped on paper tapes and a pressure-proof flexible tube 4 which surrounds the insulation 3 and which may not exhibit the feature of absolute fluid tightness. As shown in the drawing, the tube 4 consists of a number of different layers. These layers consist of bands which are formed into the tube 4 by being wound on to a mandrel and fluted between a screwthreaded bolt and a correspondingly screwthreaded nut and thus converted into a flexible pressure-proof tube. The tubes are in contact with each other and the spaces between them and the inner wall of the sheath define relatively large ducts offering low resistance to flow of leakage fluid.

The thin layers of the band 7 forming the tube 4 may be composed of magnetic material such for example as sheet iron or the like if additional losses are to be avoided. In order that the tube shall act in the most perfect manner possible as a separator between the impregnating oil or gas under high pressure within it and the lead sheath 5, oil-proof bands 9 of non-metallic packing material are inserted in the tube between the said band layers. The lead sheath 5 is extruded over the cable cores or conductors which are corded or twisted together according to established practice, each being separately surrounded by a pressure-proof tube 4. The sheath is surrounded by a pressure-proof armouring 6.

In Fig. 3, 10 indicates sections of cables constructed according to my invention and jointed in any suitable way, the joints being located in casing 11. In addition to serving as coverings for the joints, they act as containers or sumps to receive any fluid which may escape from the flexible pressure-proof tubes into the ducts 8. The ducts are in free communication with the casing and any fluid contained therein is at ground potential and hence not subject to electrical stresses. Leakage fluid from the casings may be conveyed to a storage container or to the source of supply for the central channels 2 of the conductors by a pump 12 which may operate intermittently or continuously as desired. Fluid under the desired high pressure is supplied to each of the channels 2 by suitable means, of which the tanks 13 may be considered as an example. If oil is to be used as the pressure medium, it may be forced therefrom by gas under pressure or by any other suitable means. If gas is used as the pressure medium, any suitable means may be employed to maintain the desired determined pressure. Because the conductors operate at relatively high potentials and the tanks or other supply means are at ground potential, the fluid whether it be liquid or gas will be supplied to the channels 2 by suitably insulated feeding joints which may be the same or essentially the same as those now available.

In Fig. 4 is shown an arrangement of parts for returning fluid escaping from the flexible pressure tube or tubes back to the source of supply as previously indicated. The joints of the conductors of the sections are located within the casing 11 and any leakage of fluid from the flexible tubes passes therefrom into a reservoir 14 which as stated above may be a part of the joint casing. From the reservoir fluid is conveyed by the pump 12 into the high pressure supply tank 13, the latter being connected to the channels within the conductors through a suitable conduit that may contain a suitable valve, if desired.

The advantages of cables according to this invention may be more briefly summarized below:

In accordance with the character of the lead and notwithstanding the use of a high pressure inside the core of the cable under normal working circumstances, the lead sheaths are not or only slightly subjected to pressure and may therefore be of small dimensions. The sealing of the cable core is effected, therefore, in contradistinction to cables housed in iron tubes, by a lead tube which cannot be surpassed as regards resistance to corrosion as experience has shown.

The cost of the pressure-proof tube used for the cable is small particularly when it is not required to be absolutely fluid tight.

Cables of the kind described can be sent out of the works ready for use so that no tedious and costly additional fitting work is necessary at the place where they are to be laid.

In all, the use of the constructional elements

of the kind described and in the order mentioned makes only a minimum of expenditure for costly materials necessary.

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

1. A cable designed to operate under high fluid pressures comprising a conductor having a fluid conveying channel therein, a filling of fluid under relatively high pressure in the channel, a body of permeable insulation tightly surrounding the conductor which is impregnated by fluid from the channel and maintained under high pressure thereby, a means for confining the fluid within the channel and insulation comprising a pressure resisting flexible tube which although intended to be fluid tight is or may be subject to small outward leakage of fluid, a unitary lead sheath surrounding the tube and receiving any leakage fluid therefrom, and means having sufficient capacity to receive any fluid leaking from the tube and contained in the space between it and the sheath to prevent the building up of substantial fluid pressure in said space.

2. A cable designed to operate under high fluid pressures comprising a conductor having a fluid conveying channel therein, a filling of fluid under relatively high pressure in the channel, a body of permeable insulation tightly wrapped around the conductor which is impregnated by the fluid from the channel and maintained under high pressure thereby, a pressure resisting flexible tube which snugly surrounds the insulation to prevent the escape of fluid from the channel and insulation comprising spirally wound turns of tape having interlocking side portions, packing material located between the said side portions to prevent leakage, a unitary lead sheath surrounding the tube receiving any leakage therefrom, and drainage means for the sheath to prevent building up therein of fluid pressure of a value such as to stretch the sheath.

3. A cable designed to operate under high fluid pressure comprising a conductor having a fluid conveying channel therein, a filling of fluid under relatively high pressure in the channel, a body of permeable insulation tightly wrapped around the conductor which is maintained under pressure by the fluid from the channel, a pressure resisting flexible tube which snugly surrounds the insulation and prevents the outward escape of fluid from the insulation, a unitary lead sheath surrounding the tube for receiving any leakage therefrom, duct means operating at ground potential located between the tube and sheath to receive leakage fluid from the tube, and means receiving fluid from the duct means of sufficient cubical capacity to prevent building up of pressure therein to cause stretching of the sheath.

4. A cable designed to operate under high fluid pressure comprising a number of conductors, each having a central fluid conveying channel, a filling of fluid under relatively high pressure for each of the channels, a body of permeable, impregnated insulation tightly wrapped around each of the conductors which is maintained under pressure by the fluid in the channel thereof, a pressure-resisting flexible tube for each conductor which snugly surrounds the insulation thereof and normally prevents the outward escape of fluid from the insulation enclosed thereby, the said tubes being in surface contact with each other, a circular lead sheath surrounding the conductors, the inner wall of which and the peripheral walls of the tubes defining between them ducts operating at ground potential to receive any leakage fluid from the tubes, and means for continuously removing any leakage from the interior of the sheath.

5. A cable designed to operate under high fluid pressure comprising a conductor having a fluid conveying channel therein, a filling of fluid under relatively high pressure of the channel, a body of permeable insulation tightly surrounding the conductor which is maintained under pressure by the fluid in the channel, a pressure-resisting flexible tube which surrounds the insulation and normally prevents the outward escape of fluid from the insulation, a lead sheath which surrounds the flexible tube and is protected thereby from the effects of the relatively high pressure fluid in the channel and insulation, said tube and sheath between them defining a longitudinally extending duct, a container in free communication with the duct to receive leakage fluid from the flexible tube and duct to prevent building up therein a pressure tending to distort the sheath, and a means for removing fluid from the container.

6. A cable designed to operate under high fluid pressure comprising a conductor having a channel filled with high pressure insulating fluid, insulation on the conductor acted upon by the fluid, a pressure confining tube enclosing the insulation for resisting the tendency of the fluid to escape therefrom as it expands due to temperature changes, and an impervious sheath surrounding the tube which with the tube defines a duct, said duct normally being empty but capable of receiving and conserving fluid which may leak through the pressure confining tube, and means for withdrawing leakage fluid from the duct to prevent appreciable pressure therein.

7. A cable comprising a conductor, insulation thereon, impregnating fluid for the insulation, a pressure resisting flexible tube enclosing the insulation, an impervious sheath enclosing the tube, the tube and sheath defining between them a fluid duct, and means draining the duct of any impregnating fluid which may leak through the wall of the flexible tube.

ERNST KIRCH.