Feb. 5, 1929. **1,700,766**

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CONTINUOUSLY LOADED SUBMARINE CABLE

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Fig. 1.

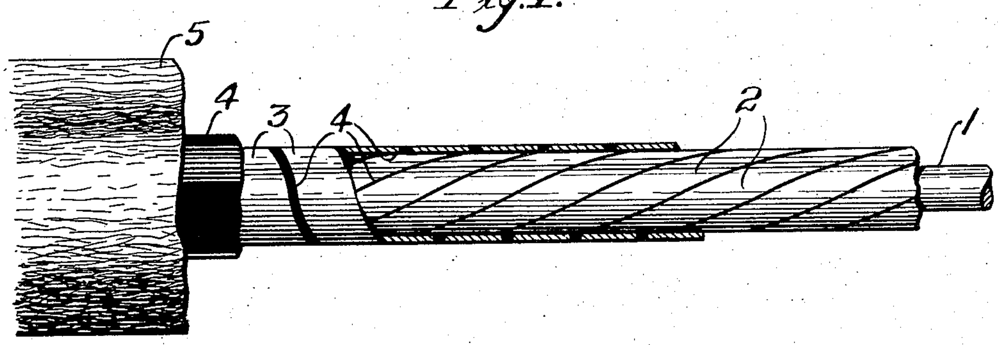
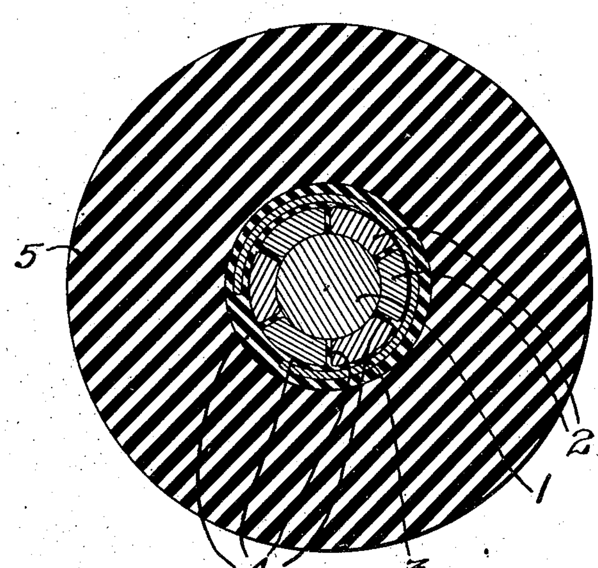


Fig. 2.



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UNITED STATES PATENT OFFICE.

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CONTINUOUSLY-LOADED SUBMARINE CABLE.

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This invention relates to continuously loaded submarine cables and more particularly to such cables in which the loading material employed exhibits high permeability at low magnetizing forces.

An object of the invention is to provide a cable construction such that the characteristics of the loading material will be retained when submerged in considerable depths of water.

Another object of the invention is to provide a method for insulating a loaded conductor in such a manner that the pressure applied to the loading tape when the cable is submerged will be uniform and that no strains or deformation in the loading material will result from the submergence of the cable to very great depths.

Another object of the invention is to provide a method for insulating a loaded conductor in such manner that it may be preserved during the process of manufacture and storage of the cable prior to submergence, in such condition that during laying and also during its submergence to very great depths for long periods of time, the pressure applied to the loading material will be uniform and that the said material will be subjected to no strains or deformation.

One of the features of the invention consists in including, in a cable having a loaded conductor, a quantity of a filling material which is in excess of the amount needed to fill all the interstices in the cable core and float the loading material, protecting it against strains or deformation, the excess amount of filling material constituting a reservoir which supplies material to fill any interstices which develop during the manufacture of the cable, its storage, laying or while it is in service.

Other objects and features of the invention will appear from a consideration of the following description taken in conjunction with the accompanying drawing and the appended claims.

It has been found that where certain materials having high permeability at low magnetizing forces are utilized in continuously loaded submarine cables insulated in the ordinary manner, there is a tendency for the loading material to be deformed by the extremely high water pressure to which the cable is subjected upon submergence. This deformation causes the permeability of the loading material to be reduced due to mechanical strain in the loading material, the strain being introduced as a result of non-uniform pressure being applied to the loading tape when pressure is applied by the water to the insulated conductor.

That the permeability of magnetic materials will change when they are subjected to mechanical strains has long been well known, but with iron, which is the only material which has been used heretofore for loading submarine cables, the change in permeability has been found to be very small so long as the strain is within the elastic limit. For instance, it has been found that pure iron with an initial permeability of less than 200 when stretched under forces up to 20,000 pounds per square inch suffers a change of permeability less than 5%. On the other hand, compositions of nickel and iron which exhibit extraordinarily high permeability at low magnetizing forces have been found to be extremely sensitive to mechanical strain. For example, when a strip of alloy of 70% nickel and 30% iron was stretched under a force of 6,000 pounds per square inch, the permeability fell from the very high initial value of 2,000 to a value of approximately 100, and a composition of 78½% nickel and 21½% iron with an initial permeability of about 3,500 was so modified by tension that with a force of 6,000 pounds per square inch its permeability dropped to less than 1,000, which, although still a very high value compared to that of iron, represents considerable impairment from the standpoint of its use as a loading material for submarine cables. In both these cases, and in fact in all cases which have been tried, it has been found that practically the original permeability is restored on release of the distorting force so long as the material has not been strained beyond its elastic limit, which, in the case of these compositions, is reached at a tension of the order of 45,000 pounds per square inch.

The ordinary method of insulating submarine telegraph and telephone conductors which are to be submerged at great depths, is to apply first to the conductors a coating of Chatterton's compound to give adhesion between the conductor and the gutta percha which is later applied. The Chatterton's compound is usually applied by drawing the conductor continuously through a bath of the hot compound just previous to its being drawn through the extruding machine which applies the gutta percha in one or more layers around the conductor. This method has been found to serve satisfactorily for submarine telephone conductors continuously loaded with iron wire and it has been found that in such a case the iron loading wire retains its magnetic permeability when the cable is submerged, as would be expected. It has been found, however, that when conductors loaded with nickel-iron compositions of high initial permeability are insulated in this manner and subjected to pressure comparable with those encountered at the bottom of the ocean, the inductance of the loaded conductor is greatly reduced. For a more complete description of these nickel-iron compositions, reference is made to Patent No. 1,586,884, issued June 1, 1926, to G. W. Elmen and Patent No. 1,586,874, issued June 1, 1926, to O. E. Buckley. For example, a conductor loaded with 70% nickel and 30% iron in the form of a helical tape .006″ thick and .125″ wide and insulated in the ordinary manner with Chatterton's compound and gutta percha suffered a reduction of inductance from about 30 milhenries per nautical mile to less than 5 milhenries per nautical mile when the insulated conductor was subjected to a water pressure of 6,000 pounds per square inch. In another instance, a conductor loaded with 78½% nickel and 21½% iron of the same dimensions and insulated in the same manner suffered a reduction from about 60 milhenries per nautical mile to less than 20 milhenries under the same treatment. It will be noted that the changes in inductance suffered by the loaded conductors correspond roughly to the changes in permeability of the magnetic materials when subjected to the simple mechanical strain of tension. From this behavior it has been determined that the loss of inductance of the cables results from strains introduced as a result of non-uniform pressure being applied by the gutta percha to the loading material when uniform pressure is applied by the water to the gutta percha. The effect of the non-uniform pressure is to introduce strains of deformation in the loading material. That this is the case is further borne out by the fact that if the loaded conductor is subjected to pressure in a manner to insure uniform pressure being applied to the loading material, no observable change of inductance is produced.

One way of neutralizing this tendency to reduce inductance is disclosed and claimed in Patent No. 1,586,875, issued on June 1, 1926, to O. E. Buckley.

The present invention contemplates overcoming the tendency of the loading material to be deformed by pressure under service conditions by suitably filling the interstices, not only between the adjacent turns of the loading tape and between the tape and the conductor, but also between the strands of the conductor itself, if the conductor be of the stranded type, and providing on the outside of the loading tape a relatively thick coating of filling material to constitute a reservoir which will constantly supply filling material throughout the length of the cable to any points of low pressure and fill interstices which may not have been filled prior to the application of the gutta percha covering, or which develop during the fabrication, storage, laying and use of the cable.

A filling material suitable for this purpose should be one that will be fluid and remain fluid during the fabrication of the entire cable, during its storage and laying, and also at temperatures and pressures to which the cable is subjected while in service. The material should also have a suitable viscosity to form a layer thick enough to constitute the reservoir above mentioned which will retain its position on the loading material during the manufacture of the cable. Such a material should not be deleterious to either the copper or other metal constituting the conductor, to the loading material or to the gutta percha covering, or other insulation. The material should also have insulating qualities approximating the insulating qualities of the gutta percha or other insulating material. When gutta percha is used, which is usually applied at temperatures between approximately 50° centigrade and 75° centigrade, this material should be of such character that it will have sufficient viscosity to hold itself in place during application of the gutta percha. In use, a core of this type may be laid at various depths in sea waters where it will not infrequently encounter temperatures around zero degrees centigrade, and as a consequence the filling material, in order to flow and fill the interstices in the core as previously described, should be sufficiently fluid at temperatures as low as that mentioned. The filling material should furthermore be of such character that after long periods of time it will still be sufficiently fluid to fill the interstices of the core and serve as a means for floating the loading tape and guard it against strains or deformation. Finally, the material should be of such character that it will not readily mix with the gutta percha or other insulating material or harden materially with age, due to diffusion of its more mobile constituents into the insulating material or otherwise.

One material incorporating all of the characteristics above referred to comprises, a liquid bitumen consisting largely of malthenes and so refined as to be free from appreciable matter volatile below 200° centigrade. The term "malthenes" is commonly used to define those constituents present in asphalt which are soluble in petroleum ether (benzine) having a low boiling point. Such liquid bitumen has a penetration not less than twenty-five units at 0° centigrade as measured by a standard penetrometer of the New York Testing Laboratory design, using a 100 gram load acting for five seconds on a standard needle. It will probably be found that liquid bitumen of this type will have an ash content below one-tenth per cent, and that the material will be soluble in petroleum ether to the extent of ninety per cent or more. The insoluble constituents are likely to consist of hard brittle asphalt like substances. If desired these may be removed and discarded during the process of refining.

In order to apply the filling material, above described, in such a manner that all of the interstices of the loaded conductor will be filled therewith, the loaded conductor may be drawn through a bath of the filling material and wiped with a wiper of such diameter as to leave a coating of the filling material from .005″ to .010″ thick on the outside of the loading material. The gutta percha or other insulating covering is applied on top of this filling material, and as the former contracts, it will force the filling material into all of the interstices of the loaded conductor, the amount of fillng material applied, however, being sufficient to leave a surplus between the loading tape and the gutta percha, or other insulation to serve as a reservoir for the purpose heretofore described. In some cases it may be found desirable to fill the interstices of the loaded conductor with the filling material by the use of the method of vacuum impregnation, whereby the air is first removed from the interstices and the filling material then forced into them in any suitable manner. Just prior to the passage of the conductor into the extrusion machine it is passed through a bath of the filling compound and wiped with a wiper of a diameter sufficiently larger than the conductor to leave a layer of filling material .005″ to .010″ thick on the outside of the loading material.

It has previously been proposed to coat a bare conductor with Chatterton's compound before wrapping the iron wire around it, but this simply serves to protect the conductor from the ingress of water and does not serve the purposes of the present invention. Furthermore, this method is not applicable to the conductor loaded with magnetic material of high permeability of the type described, for the reason that this high permeability is best secured by a heat treatment process which is given the loaded conductor after the loading material has been applied. This heat treatment includes passing the loaded conductor through a furnace maintained at a temperature of approximately 900° C. Such a high temperature would destroy any known insulating material which is fluid under the conditions to which the cable is later to be subjected. Hence, the method of applying Chatterton's compound first and the loading material second is not suitable for filling the interstices of the conductor loaded with an alloy of high permeability which is sensitive to mechanical strain.

In the drawings,

Fig. 1 is an elevation, partly in plain and partly in section, showing the loaded conductor in its preferred form, and

Fig. 2 is a cross section of a cable core made in accordance with the present invention.

Referring to the drawing, 1 is the central copper wire of the conductor surrounded by a plurality of helically applied segmental strips 2 which, together with the central wire 1, form the conductor, which is a type commonly employed for long submarine cables. Surrounding the conductor is the loading material 3 which is preferably in the form of a helically applied tape wound closely around the stranded conductor. The filling material 4 fills all the interstices of the conductor and loading material and also forms a layer outside of the loading material, the whole being surrounded by the insulating medium 5 which is usually gutta percha. The layer of filling material outside of the loading material has a thickness of from .005″ to .010″ so that it constitutes a reservoir which serves to supply filling material to fill any voids in or about the conductor and loading material which may not have been filled when the filling material was applied or voids which may develop during the fabrication, storage, laying and use of the cable. This filling material is of such quantity as to effectually "float" the loading tape and prevent its being subjected to strains or deformations either during its manufacture or storage or at temperatures and pressures to which it is subjected in use

The structure illustrated forms the core of the cable which further comprises, in the ordinary case, layers of jute and armoring wires to give mechanical protection. While the application of the invention to a stranded conductor has been specifically illustrated and described, it is to be understood that the invention is not limited to this type of conductor.

A series of tests have been made with a number of different loaded cores treated with the liquid bitumen in the manner described above in detail, the coating having a thickness of from .005″ to .010″ on the outside of the loading material. After the gutta percha covering was applied, the permeability of the loading material in place in the various cores was measured and found to average between 2000 and 3000. After being cooled to temperatures ranging from 1° to 5° centigrade these cores were subjected to hydrostatic pressures of from 5200 to 6000 pounds per square inch. While under these pressures and temperatures the permeability of the loading material of the cores was measured and it was found that in no case had the permeability declined more than 35 per cent. The permeability in the case of some of the cores exhibited no declination after the application of the pressures above referred to, and in those instances in which the permeability declined after the application of these pressures, the permeability recovered while under such pressures to approximately the original value, i. e. 2000 to 3000, in periods of time varying from thirty minutes to two hours.

Loaded cores filled with the liquid bitumen described above and applied in the manner explained were made and stored for two and a half months. Upon subjecting these cores to pressures as high as 6000 pounds per square inch and simultaneously to temperatures of 2° to 5° centigrade it was found that the permeability decreased to some extent, but recovered to the original values while under such pressures in a few hours.

Although several methods have been disclosed for applying the filling material, various other methods may be employed for this purpose without departing from the spirit and scope of the present invention. Furthermore, although a specific description has been given with reference to liquid bitumen which serves as the filling material, it is not intended to limit the scope of the invention to these particular materials, but only in so far as is defined in the appended claims.

What is claimed is:

1. A continuously loaded submarine conductor impregnated with a filling material which is fluid at the temperature and pressure at which the conductor is to be used, and a reservoir of such material surrounding the impregnated conductor.

2. A continuously loaded submarine cable having substantially all the interstices of the conductor and loading material filled with a material adapted to equalize pressure upon the loading material when hydrostatic pressure is applied to the cable and the loading material being surrounded by an excess of said material for filling interstices which may develop subsequently to its application.

3. A continuously loaded submarine conductor containing a filling material which is fluid at 2° centigrade, the loading material being an alloy capable of having high permeability under favorable conditions, but having materially reduced permeability when strained, and said filling material surrounding said loading material in a layer of sufficient thickness to effectively prevent unequal pressures from being transmitted to said loading material.

4. A continuously loaded submarine conductor having the loading material completely surrounded by a layer of pressure equalizing material, said material being fluid at 2° centigrade, and having insulating properties approximating those of gutta percha, and the loading material of said loaded conductor having a magnetic property which is highly sensitive to applied strains.

5. A continuously loaded submarine cable having a conducting core, a layer of magnetic material disposed about said core, a layer of heavy insulating material disposed about said loading material, and a pressure equalizing material completely surrounding said magnetic material to relieve it of strains, said equalizing material being fluid at sea bottom conditions, and being of such character that it does not deleteriously affect said insulating material and having insulating properties approximating those of said insulating material.

6. A continuously loaded submarine cable having a conducting core, a layer of magnetic material disposed about said core, said magnetic material having a magnetic property which is deleteriously affected by strains applied to said material, a layer of heavy insulating material disposed about said loading material, and a pressure equalizing material completely surrounding said magnetic material to relieve it of strains, said equalizing material having a penetration of not less than 25 units at 0° centigrade as measured by a standard penetrometer using a 100 gram load acting upon a standard needle and having insulating properties approximating those of said insulating material.

7. A continuously loaded submarine conductor having an equalizing material having a penetration of not less than 25 units at 0° centigrade as measured by a standard penetrometer using a 100-gram load acting for five seconds on a standard needle, said material being positioned about the loaded conductor to prevent the loading material from being subjected to undue strain.

8. A continuously loaded submarine conductor, the loading material consisting of an alloy the permeability of which varies materially when the alloy is strained, and a filling of liquid bitumen completely surrounding said loading material to prevent strain thereof.

9. A continuously loaded submarine conductor, the loading material consisting of an alloy the permeability of which varies materially when the alloy is strained, and a filling of liquid bitumen consisting largely of malthenes completely surrounding said loading material to prevent strain thereof.

10. A continuously loaded submarine conductor, the loading material consisting of an alloy the permeability of which varies materially when the alloy is strained, and a filling of liquid bitumen consisting largely of malthenes, which is so refined as to be free from

appreciable matter volatile below 200° centigrade surrounding said loading material to prevent undue stresses being exerted thereon.

11. A continuously loaded submarine conductor, the loading material consisting of a magnetic material the permeability of which varies materially when the material is strained, and a filling of liquid bitumen substantially soluble in petroleum ether filling the interstices between the conductor and loading material and present in such an amount to form a reservoir of filling material completely surrounding the loaded conductor.

12. A continuously loaded submarine conductor having a layer of magnetic material and a layer of filling material over the magnetic material, the loading material consisting of an alloy capable of having high permeability under favorable conditions and having materially reduced permeability when strained, and the layer of filling material being not less than five-thousandths of an inch in thickness.

13. A continuously loaded submarine cable comprising a conductor, a layer of magnetic material disposed thereabout, and a filling of liquid bitumen of not less than five thousandths of an inch thickness over the magnetic material.

14. A continuously loaded submarine cable comprising a copper conductor and a layer of magnetic material disposed thereabout and gutta percha insulation, said magnetic material being surrounded by a layer at least five thousandths of an inch in thickness of filling material which is fluid under sea bottom conditions and which is not deleterious to the copper conductor, the magnetic material, or to the gutta percha.

In witness whereof, I hereunto subscribe my name this 5th day of Feb., A. D. 1923.

ARCHIE R. KEMP.