(No Model.)

S. P. THOMPSON.

ELECTRIC CABLE.

No. 568,964. Patented Oct. 6, 1896.

Fig. 1.

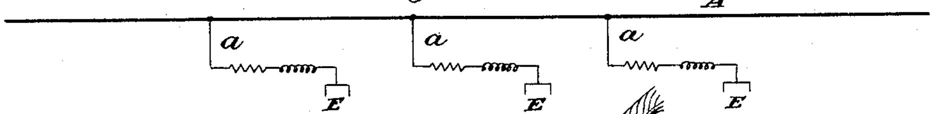


Fig. 2.

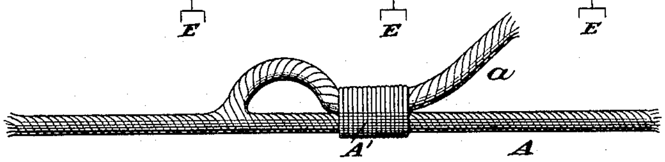


Fig. 3.

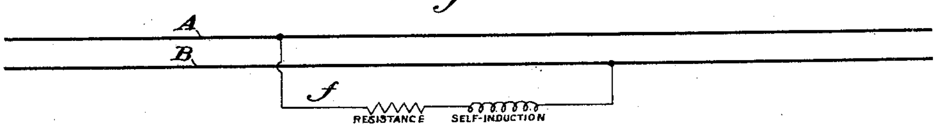


Fig. 3ª.

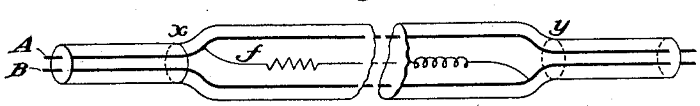


Fig. 4.

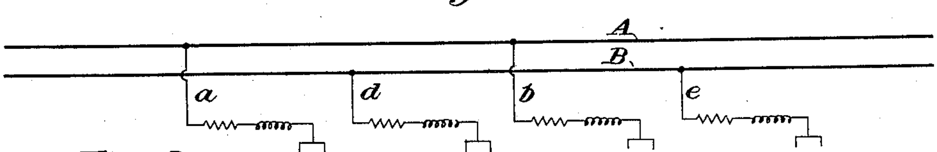


Fig. 5

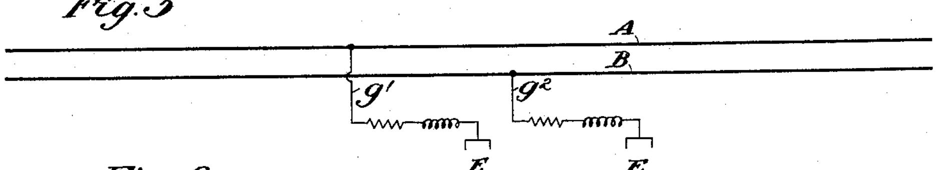


Fig. 6.

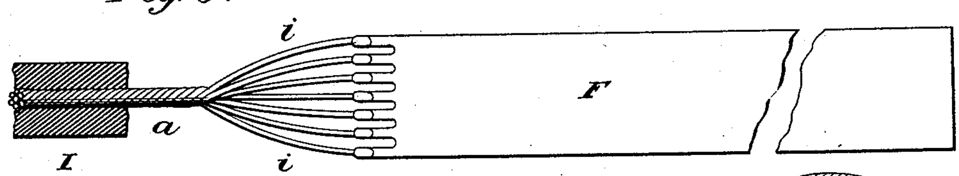
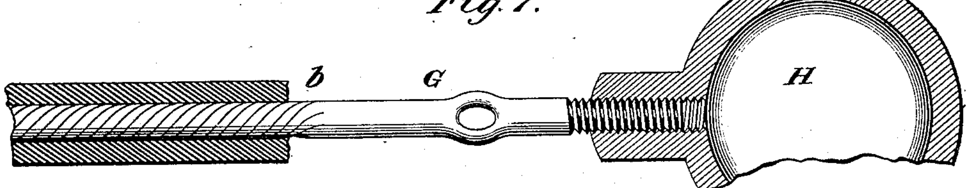


Fig. 7.



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UNITED STATES PATENT OFFICE.

SILVANUS PHILLIPS THOMPSON, OF LONDON, ENGLAND.

ELECTRIC CABLE.

SPECIFICATION forming part of Letters Patent No. 568,964, dated October 6, 1896.

Application filed December 19, 1893. Renewed August 11, 1896. Serial No. 602,457. (No model.) Patented in England December 21, 1891, No. 22,304, July 4, 1893, No. 13,064, and December 19, 1893, No. 13,581; in France June 20, 1892, No. 222,460, and December 13, 1893, No. 234,763; in Germany October 23, 1892, No. 86,013; in India April 25, 1893, No. 320, and August 17, 1894, No. 18; in Spain September 4, 1893, No. 13,896, and April 10, 1894, No. 15,306; in Brazil February 7, 1894, No. 1,686; in Ceylon August 22, 1894, No. 443, and in Straits Settlements December 14, 1895.

To all whom it may concern:

Be it known that I, SILVANUS PHILLIPS THOMPSON, a citizen of Great Britain, residing at East Hampstead, London, in the county of London, England, have invented certain new and useful Improvements in Electric Cables, (patented in the United Kingdom, No. 22,304, December 21, 1891, No. 13,064, July 4, 1893, and No. 13,581, July 13, 1894, antedated December 19, 1893; in France, No. 222,460, June 20, 1892, and No. 234,763, December 13, 1893; in Germany, No. 86,013, October 23, 1892; in Spain, No. 13,896, September 4, 1893, and No. 15,306, April 10, 1894; in Brazil, No. 1, 686, February 7, 1894; in India, No. 320, April 25, 1893, and No. 18, August 17, 1894; in Ceylon, No. 443, August 22, 1894, and in Straits Settlements December 14, 1895,) of which the following is a description, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

My invention relates to improvements in submarine electric cables, and more particularly to means for overcoming the retardation of signals therein.

In my applications for Letters Patent, Serial Nos. 440,672 and 440,673, filed July 20, 1892, I have shown, described, and claimed methods and apparatus having this end in view. The present application, however, differs therefrom in certain important particulars, as will more fully hereinafter appear.

The present application discloses means for adapting my generic invention to existing types of submarine electric cables, whether the same contain one or two continuous conductors, and by said means I am enabled to increase their speed of signaling and also to adapt them for use as telephone-circuits.

In the case of a single-wire cable I join onto the conductors at intervals compensating branches of the hereinafter-described kind, which for telegraphic purposes may be as much as two hundred or even five hundred miles apart and for telephonic purposes as near together as twenty or forty miles, according to the nature and total length of the cable. Each compensating branch consists of a short conductor in metallic connection with the conductor within the cable and thoroughly insulated with the usual coatings and sheathings, so as to prevent the admission of water to the main cable and to the insulated part of the branch, the branch being provided at its extremity with an exposed metallic terminal, which, being in contact with the water, forms an "earth-plate," or in lieu thereof being connected to the iron sheathing of the cable, so that the same may act as earth or earth-plate. The branch possesses resistance and self-induction and is so proportioned that it forms a leak on the cable of a definite and determined kind, that is to say, it constitutes a leak differing from an accidental leak in that it possesses a definite resistance and a definite self-induction, both of which qualities remain practically constant and are not liable to change by corrosion, as accidental leaks will do.

In the drawings, Figure 1 is a diagrammatic view of a single-wire cable and branches. Fig. 2 is an enlarged detail showing a method of securing the branches to the cable. Fig. 3 shows diagrammatically a two-wire cable with branches extending across. Fig. 3[a] shows diagrammatically a two-wire cable with a piece of special cable joined in. Fig. 4 shows diagrammatically a two-wire cable with alternately-arranged compensating branches. Fig. 5 shows a two-wire cable, each conductor provided with a branch. Fig. 6 is an enlarged detail of one form of exposed terminal. Fig. 7 is an enlarged detail of another form of exposed terminal.

If the compensating branch possesses a high resistance, for example, from ten thousand to one hundred thousand or more ohms, even without any appreciable self-induction, it will accelerate the speed of signaling; but if it also possesses a coefficient of self-induction, say from as little as one millihenry to as much as one hundred henries, it will act better as a compensator, because such self-induction will not only increase its apparent resistance, but will also actually in some measure operate favorably as a negative capacity to counteract the capacity of the cable in the parts within some miles on both sides of the point where it is attached.

Compensating branches having the desired property will resemble outwardly portions of ordinary submarine cable, but inwardly differ somewhat. If an iron wire is employed in place of the ordinary copper wire, it will have both a higher resistance and a higher self-induction. If a german-silver wire is used, it will have higher resistance, but it will not have a higher self-induction unless it is either coiled around an insulated iron core (which may itself be a stranded bundle of iron wire insulated) or is itself rewound with iron outside to increase its self-induction. A compensating branch five miles long, if made of a straight insulated iron wire one twenty-fifth of an inch in diameter, insulated and overwound with five layers of iron wire each about a fortieth of an inch in diameter, will have approximately a resistance of eight hundred ohms and a self-induction of three hundred to four hundred millihenries. For rapid signaling it will have a virtual resistance many times greater than its actual resistance. If the iron wire, instead of being straight, is lightly insulated and coiled in a spiral around a well-insulated stranded iron wire as core, and the whole is then well insulated externally and inclosed in a proper sheath, it will serve as a compensating branch of higher resistance.

One end of each such compensating branch will be jointed into the cable, Fig. 2, the insulating material around it being carefully jointed with that surrounding the cable and must be continuous with it. The other end will be connected to a suitable earth-plate or similar organ suitable to be immersed in the sea or to the iron sheathing of the cable. If an iron wire is used as a conductor in the compensating branch, it may be joined at the end where it is to unite with the earth-plate to a stouter-stranded iron wire, and this again to a still stouter-stranded iron cable, a portion of which may be submerged exposed or it may terminate in the iron sheathing of the cable; or an iron plate or ball or shell, Figs. 6 and 7, may be employed, the same being several feet in diameter, giving also a large surface and of considerable thickness, so that the corrosion may be spread over many years, but in all cases avoiding any exposure to the sea of any two metals which would set up galvanic corrosion mutually by contact. All such joints near the sea end should be preferably made by electric welding. If the last few feet of the conductor in the compensting branch be constituted of a stranded platinum wire jointed onto the iron or german-silver or other wire used in the branch, the end of the stranded platinum wire may be brought out and welded to a platinum plate, Fig. 6, to serve as an earth-plate. In all cases the insulating covering must be waterproof and be carried right down to the mass of metal which serves as earth-plate.

In the cases where the compensating branches are to be applied to an existing cable containing two insulated conductors, they will be jointed in at one end to a point on one of the two conductors, and at the other end they will be jointed onto the other conductor, Fig. 3, thereby constituting a bridge across from one to the other conductor. If the two points chosen on the respective conductors are near together, the compensating branch or bridge must have both high resistance and high self-induction; but if the two points chosen on the respective conductors are far apart, then the compensating branch or bridge need not be either of such high resistance or self-induction.

For example, if the two conductors of the cable are stranded copper wires, each consisting of seven wires, each being one-fortieth of an inch in diameter, and the compensating branch used as a bridge be ten miles long, consisting of an iron stranded wire made up of three wires, each one-fortieth of an inch in diameter, such compensating branch or bridge should be joined at its ends to the two conductors, respectively, at points ten miles apart. In the case of cables containing two insulated conductors it is also possible to use compensating branches not as bridges from wire to wire, but as branches from the cable to the sea, with earth-plates, as previously described, for single-wire cables, but in such case the compensating branches should be connected to the two conductors alternately: namely, first, from one conductor of the cable to the sea; then at an interval of ten or twenty or more miles from the other conductor of the cable to the sea; then at another similar interval from the first conductor to the sea, &c.; and in such case also there is no need for the compensating branches so used to have either a very high resistance or a very high self-induction. For instance, a branch one mile long, consisting of a stranded iron wire made up of three wires each one twenty-fifth of an inch in diameter, suitably insulated and connected to a suitable earth-plate, may be jointed in alternately, as described above, at intervals of ten, twenty, or fifty miles, or more; or two such may be inserted at fifty or one hundred miles apart near the middle of a long cable to increase its speed of signaling; or, again, at the middle of a long two-wire cable a single bridge f, Fig. 3, may be inserted from wire to wire, its ends being, for example, inserted at two points twenty miles apart; or a special piece of cable of much smaller length, containing both the bridge-wire f and the two parallel conductors from x to y, may be inserted in the middle of the two-wire cable.

Referring to the drawings, Fig. 1 represents the conductor of a single-wire cable, to which are electrically connected branch wires a b c, connected with earth-plates E. The branch wires and conductor A are thoroughly insulated, the earth-plates E alone being exposed.

The insulation is in this instance omitted for convenience.

A, in Fig. 2, is an enlarged detail illustrating means for lashing the branch wires to the main cable at a point beyond its junction with said cable in order to relieve the strain and possible leakage at the joint. *a* is the branch, and A' is a suitable lashing uniting the main cable and the branch.

Fig. 4 shows diagrammatically a two-wire cable containing conductors A and B, separately insulated and contained within a single external sheath. In this instance branch wires *a b* extend from the cable A, while similar branches *d e* extend from the cable B. The branch conductors are the same in structure in this instance as in Fig. 1, but where the cable contains two wires the branches are taken alternately from opposite conductors, and although said branches are shown in close proximity it must be understood that they are to be placed more or fewer miles apart, according to circumstances.

Fig. 3 shows a two-wire cable A B, joined by a compensating branch *f*, extending from one conductor to another, said branch extending over a considerable distance and so proportioned as to equalize the electrostatic conditions of the conductors.

Fig. 3^a shows in detail and conventionally a piece of special cable from x to y, joined into the main cable and provided with bridge-conductor *f*, which possesses both high resistance and self-induction.

Fig. 5 illustrates, diagrammatically, the application of a single pair of compensating branches g' g^2 near the middle of a long cable.

Fig. 6 shows one form of plate in which the cable *a*, forming the branch, is spread at its end and each strand *i* thereof soldered or otherwise metallically connected with an extended exposed plate F of the same metal as the end of the branch cable, which is preferably of platinum, for durability. The extremities, at least, of the strands of the branch conductor should also be of platinum, care being taken that the joint between the platinum extremities of the branch conductor and the remainder thereof, especially if of different material, be securely inclosed within waterproof insulating material I.

A convenient and durable form of terminal for the branch conductors is shown in Fig. 7, in which the extremity of the branch conductor *b* is secured to a stem G, provided with an opening to facilitate handling the same, said exposed stem being connected with a ball H of the same metal as the stem.

In view of the foregoing description it will be apparent that the form and nature of the earth-plate or exposed terminal of the branch conductors may be made in various forms and of various materials. I therefore do not limit myself to any specific detail in this connection. It is also obvious that the branch conductors may be arranged in various different ways consistent with the description thereof.

Having described my invention, what I claim is—

1. An electric cable for submarine use consisting of a main copper conductor continuous from end to end, surrounded by an insulating-sheathing and furnished at regular intervals along its length with branch conductors all of equal high resistance and equal self-induction, each such branch conductor consisting of a metallic core jointed into the main conductor and of an insulating-sheath extending all along its length and continuous with the insulating-sheath of the main conductor, the outer end of each such branch being earthed.

2. The combination with a single-conductor electric cable for submarine use of one or more compensating branches, each such branch consisting of an insulated conductor having both a higher resistance and a higher self-induction than the entire length of the main conductor jointed into the cable at some intermediate point and constituting an integral part of the cable.

3. The combination with an electric cable for submarine use having two insulated conductors, of one or more compensating branches, each such branch being jointed in as a bridge across from one conductor to the other conductor, such branch being surrounded throughout its entire length with insulating material which is jointed into and continuous with that of the cable.

4. The combination with an electric cable having two insulated conductors, of an intermediate piece of special cable containing also a bridge-wire possessing both self-induction and high resistance, the insulating material surrounding said bridge-wire being continuous with the insulation surrounding the two insulated conductors.

5. The combination with an electric cable having two separately-insulated conductors running therethrough side by side of one or more compensating branches, each such branch being of higher resistance and self-induction and jointed on as a leak from one of the conductors to the sea, said branches being taken at regular intervals and alternately from the two conductors.

In testimony whereof I hereto affix my signature in presence of two witnesses.

SILVANUS PHILLIPS THOMPSON.

Witnesses:

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SYDENHAM KEEN.