(No Model.)

S. P. THOMPSON.

ELECTRIC CABLE.

No. 571,706. Patented Nov. 17, 1896.

FIG. 1.

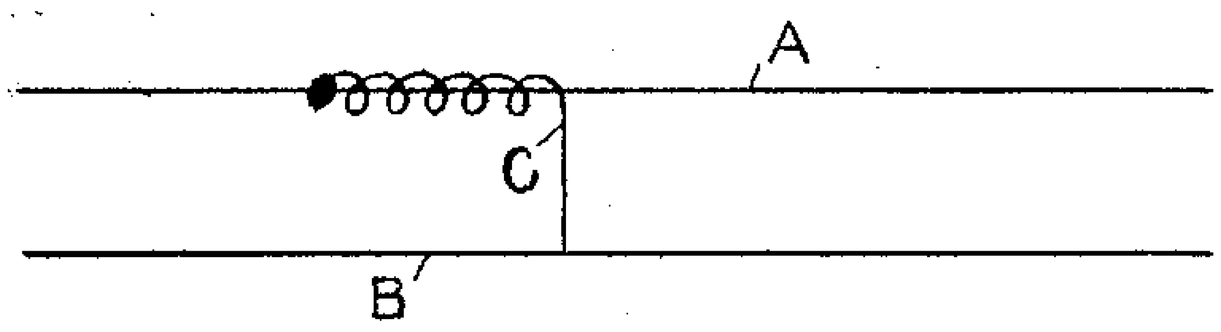


FIG. 2.

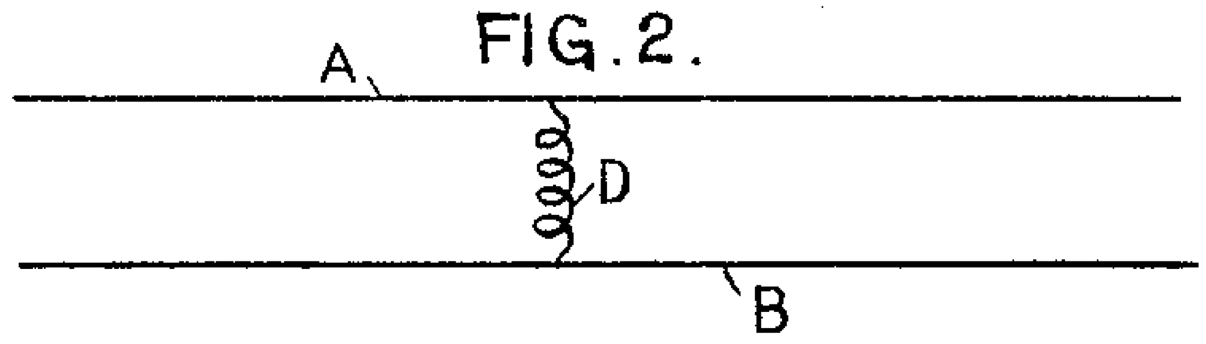


FIG. 3.

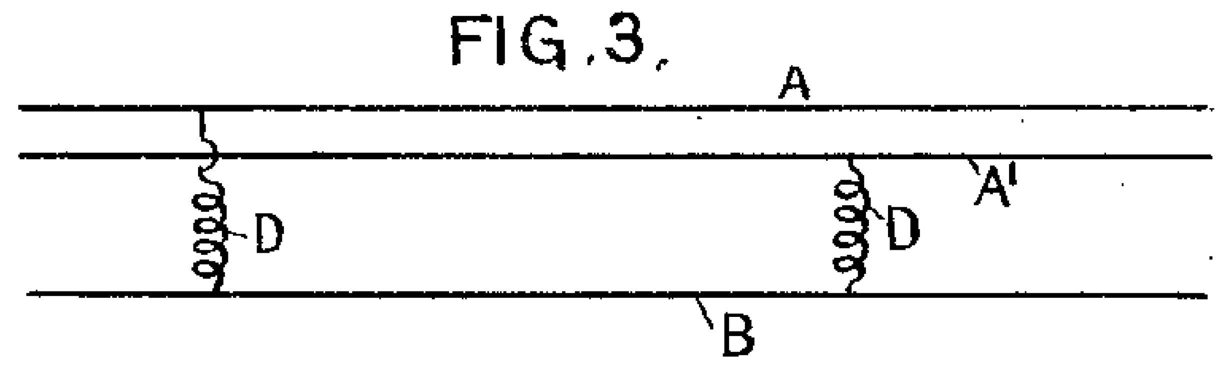


FIG. 4

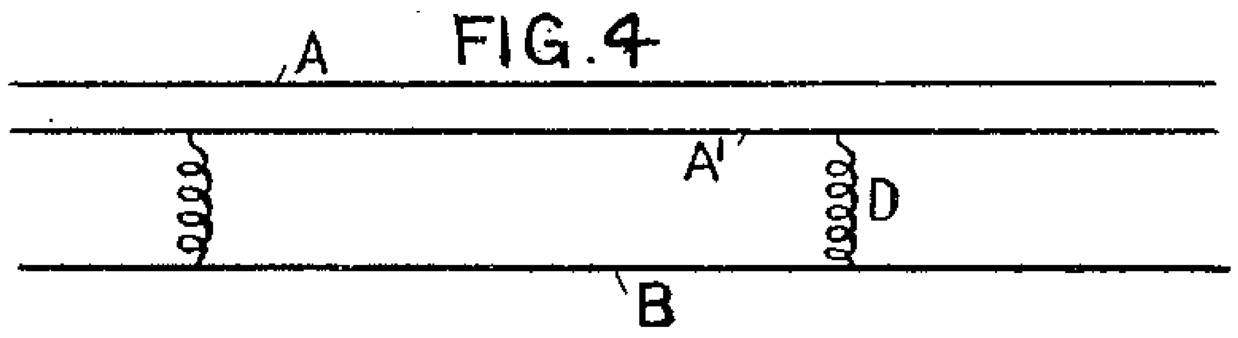


FIG. 5.

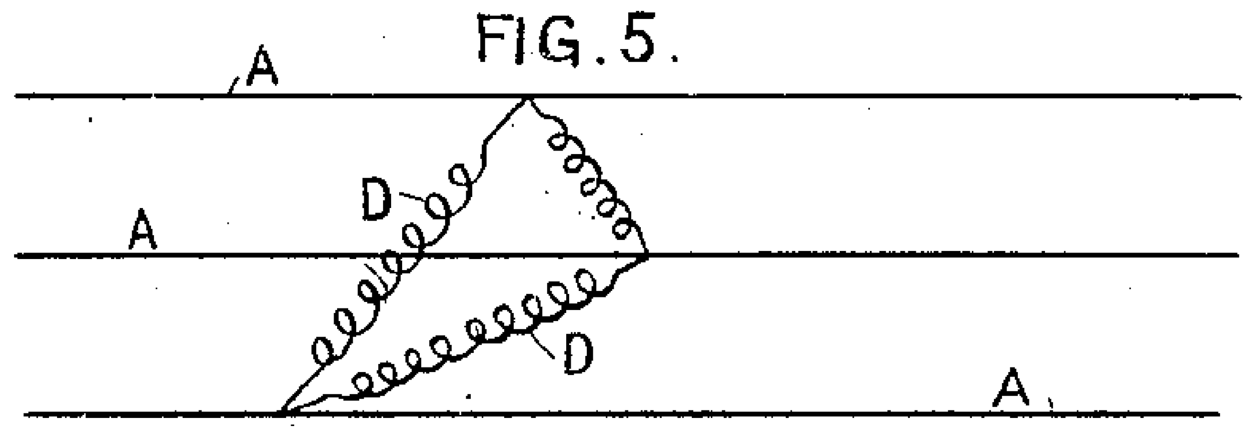


FIG. 6.

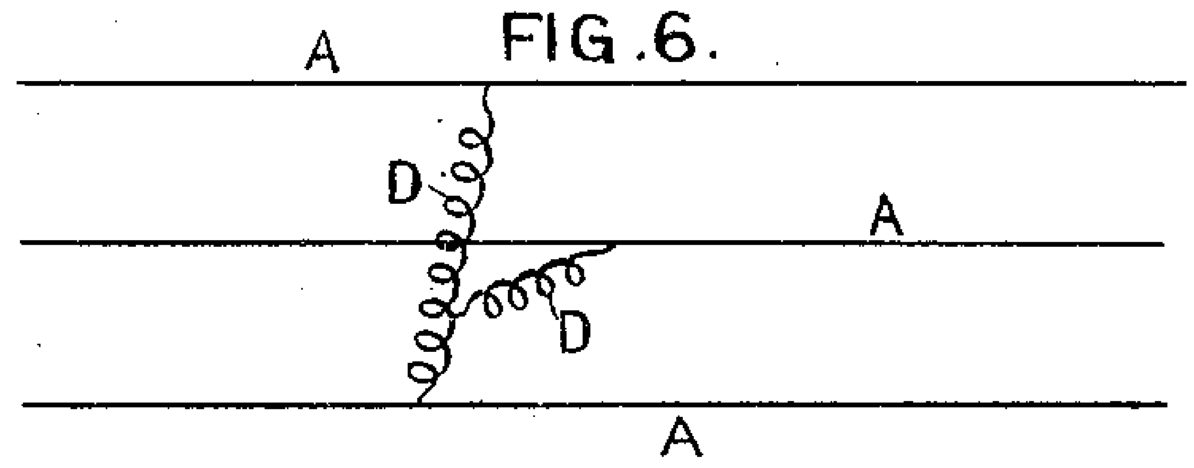
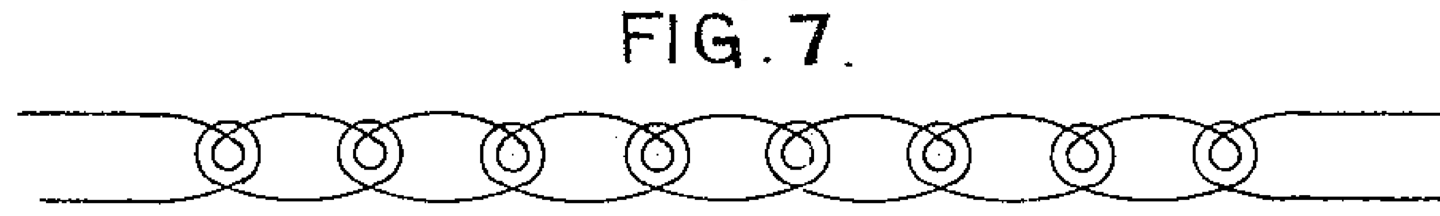


FIG. 7.



WITNESSES

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UNITED STATES PATENT OFFICE.

SILVANUS PHILLIPS THOMPSON, OF LONDON, ENGLAND.

ELECTRIC CABLE.

SPECIFICATION forming part of Letters Patent No. 571,706, dated November 17, 1896.

Application filed July 20, 1892. Serial No. 440,672. (No model.) Patented in England December 21, 1891, No. 22,304, and July 4, 1893, No. 13,064; 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, doctor of science, a subject of the Queen of Great Britain, residing at Morland, Chislett Road, West Hampstead, London, in the county of Middlesex, England, have invented certain new and useful Improvements in Electric Cables, (for which I have obtained patents in Great Britain, No. 22,304, dated December 21, 1891, and No. 13,064, dated July 4, 1893; in France, No. 222,460, dated June 20, 1892, and No. 234,763, dated December 13, 1893; in Germany, No. 86,013, dated October 23, 1892; in Spain, No. 13,896, dated September 4, 1893, and No. 15,306, dated April 10, 1894; in India, No. 320, dated April 25, 1893, and No. 18, dated August 17, 1894; in Brazil, No. 1,686, dated February 7, 1894; in Ceylon, No. 443, dated August 22, 1894, and in Straits Settlements, dated December 14, 1895,) of which the following is a specification.

This invention is applied for under the Convention for the Protection of Industrial Property, my English application for the same invention, No. 22,304, being dated the 21st day of December, 1891.

My invention pertains to electric signaling for telegraphic, telephonic, or other purposes through long lines or cables, and has for its chief objects to extend the distance to which such signaling can be carried on and to increase the rapidity and facility of signaling.

By "signaling" I mean the communicating of any sort of signals, whether spoken words, as in telephonic signaling, or humming sounds, as in harmonic telegraphs, or rapidly-reversed impulses, like those used in rapid automatic telegraphy, or dot-and-dash signals due to interruptions or reversals of current, or deflections of a needle to right and left, or motions of a siphon-recorder or of the tongue of a relay.

As lines and cables are now constructed there is a practical limit to the distance to which signaling is possible with existing instruments. My invention will increase this distance. There is also for a line or cable of given length, as at present constructed, a limit to the rapidity at which signals can be transmitted by instruments of a given type. My invention will increase this rapidity of signaling. There is, moreover, for a line or cable of given length, as at present constructed, a limit to the kind of instrument that can be used to signal, high-speed instruments, harmonic telegraphs, and telephones not being capable of being used on long cables or on very long lines. My invention will extend the facility of signaling by rendering lines and cables available for instruments for which they are not now available. It will also increase the facility of signaling through cables by enabling signaling to be carried on without such expensive arrangements for securing balance, known as "artificial cables," as at present used at the shore ends.

It is known that the presence in cables and lines of electrostatic capacity limits the rate of signaling and the distance of signaling, as well as limits the kinds of signals that can be sent to a given distance. For example, the capacity of an Atlantic cable, which is about one-third microfarad per nautical mile, retards telegraphic signals so much that only a few words per minute can be transmitted. The distance to which rapid automatic signals can be sent through cables of this type is but a few score miles. Through very long cables of existing types telephones, harmonic telegraphs, and rapid automatic instruments cannot be used at all.

It is known that the cause of the limitations mentioned above, as found with cables and long lines of existing type, is the presence of electrostatic capacity. Such electrostatic capacity is in general not located at any one point, but is distributed more or less uniformly along the line or circuit. Now by my invention I counterbalance the effects of this distributed capacity by applying distributed electromagnetic induction. Electromagnetic induction is the action which the rise or fall of the current in any part of the circuit produces on the same or any other part of the circuit by virtue of the fact that every varying current produces around it a varying magnetic field. When the current is varying in a wire or coil, the varying magnetic field around it induces electromotive forces in neighboring conductors or coils or in other convolutions of the same wire or coil. By proper dispositions, as hereinafter further described, such electromagnetic induction, if suitably distributed along the cable or line, may be utilized to diminish, or even to neutralize for all effective purposes, the retarding and limiting effects of electrostatic capacity. Under the most favorable dispositions the whole of the electrostatic capacity is counterbalanced, and then the retarding and limiting effects will be neutralized. Where the conditions or arrangements are less favorable, a part only of the electrostatic capacity will be counterbalanced, and in such cases the retarding and limiting effects, though not entirely neutralized, will be diminished. When the arrangements are such as to thus balance the distributed capacity and neutralize the retarding effects, then the system will conduct, like any ordinary plain conductor, the current shunted off through the compensators following the ordinary laws of current flow.

The present invention consists in introducing into the electric circuit at intervals what I may term "compensators" possessing electromagnetic induction sufficient, more or less, completely to balance the distributed capacity, bearing in mind the average frequency of the electric impulses, whether telegraphic, telephonic, or other, which are to be transmitted. The electrostatic capacity distributed along the cable or line is thus balanced, as it were, in sections, each organ so introduced into the line or cable exerting a neutralizing effect on the capacity of the cable in the adjacent parts. Thus, for example, if a self-induction coil, inserted as hereinafter described, is of sufficient size and power to approximately neutralize the effects of electrostatic capacity of any cable for a distance of five miles on either side from the point where it is inserted it will be expedient to treat that cable in sections each of ten miles length, similar self-induction coils being inserted every ten miles along the cable. It is an important point that these coils should be all alike for any given sample of cable and at approximately equal distances apart. Self-induction coils for use as compensators should also have not only a high-time constant, but a high resistance relatively to that of the section of cable which they are to compensate. In cases where it is important to avoid a material weakening of the transmitted currents from flow through the compensators it is preferable that the resistance of the compensators should be greater than that of the entire cable. These coils should have each such dimensions and be made with such a number of turns of wire of such a gage (wound around a well-laminated iron core of such shape and length) that the time constant (or interval of time that is needful for the current in the said coil to rise to 0.634 of its final value) shall be not less than, and shall be preferably greater than, one one-hundredth of a second, while the resistance of the said coil shall be much greater than that of the ten-mile or twenty-mile section of the cable, and shall, indeed, in the cases just previously mentioned, be with advantage as great as or greater than the resistance of the entire length of the conductor. In electric cables they must be further arranged so as not to form unwieldy enlargements of the cable. Ordinary electromagnets with ordinary iron cores will not do. Iron cores, when they are employed, must be made of a relatively small amount of very well laminated iron.

Referring to the drawings, Figure 1 shows the simplest form of compensator diagrammatically. Fig. 2 is a single line with a compensator connecting it with return; Fig. 3, two wires with separate compensators connecting them with return; Fig. 4, an inner and outer conductor, the outer only provided with compensators; Fig. 5, three lines joined by compensators; Fig. 6, where two lines are joined by compensators and a third is connected to the centers of these compensators by coils of half the length of the other compensators. In this way a star of compensators could be formed, uniting several wires with coils of equal length to one point or wire. Fig. 7 shows two wires in the same cable at intervals coiled in opposite directions around each other or around a common core.

In Fig. 1, A is the conductor; B, the sheath; C, a shunt from the conductor to the sheath coiled around the conductor, which at this point is preferably composed of numerous fine wires insulated by rust or otherwise from each other, so as to form a laminated core. The coil is of course, as well as the core, covered with insulating material. The choking or self-inducting action of this coil, if of sufficient number of turns near together, causes sufficient resistance (which, as before stated, must be greater than the entire circuit) through the conductor to prevent all but an insignificant quantity of the working charge to short circuit.

It is obvious that instead of B in the drawing being the sheath it would act just as well if it were the return-wire. In this latter case it would be desirable for each alternate coil to be around the return, the remainder being around the lead. Such an arrangement is shown in Fig. 7. In said Fig. 7, however, no coils are shown, the lead and return conductors which are alternately coiled one about the other acting by mutual induction.

In Fig. 2, A is the lead-conductor, B the return, and D a self-induction coil connecting A and B.

In Figs. 3 and 4, A is the main conductor, B the return or the sheath acting as a return, and A' is an outer conductor surrounding the inner one A.

In Figs. 5 and 6, A A A are conductors, and D self-induction coils. The self-induction coils D have each a thin core of fine wires in a parallel laminated bundle.

In Fig. 7 is seen an arrangement in which the conductor and return-wires are coiled about each other alternately.

The various arrangements shown will be used according to circumstances, and it will also be apparent to the skilled electrician that in practice other modifications may suggest themselves in view of the disclosed invention and without departure therefrom.

I declare that what I claim is—

1. In an electric cable having continuously-insulated metallic conductors from end to end, the combination with the said conductors of a series of compensators or devices possessing both resistance and self-induction, systematically distributed at intervals along the entire length of the cable, so proportioned and arranged that their electromagnetic induction shall counterbalance from point to point the effect of the distributed electrostatic capacity of the gutta-percha surrounding the said conductors.

2. A cable divided into sections, in each of which is an electromagnetic induction device connecting the conductors, and forming a structural and integral part within the outer sheathing of the cable, each said electromagnetic induction device being so proportioned as to counterbalance the electrostatic capacity of the particular section to which it is applied, whereby the capacity of the section is counterbalanced.

3. The combination of two or more conductors in a cable with short-circuiting induction-coils placed between the conductors having each a resistance at least as great as that of the portion of the conductor between each such coil and the next, whereby the statical charges otherwise accumulating along its entire length, are drawn off at intervals along the length.

4. In a cable, the combination with the conductors thereof, one of which is formed at intervals as a laminated core, of a shunt extending from the other conductor and coiled around a laminated core in a coil of greater resistance than that of the entire circuit.

5. A cable having its conductors united at periodic intervals by shunts which are coiled around cores, and which have each a greater resistance than the combined resistance of the conductors between any such shunt-coil and the next such shunt-coil.

6. In an electric cable having continuously-insulated conductors running therethrough side by side, the combination within said cable of a conductor and a return-wire with induction-coils having their axes approximately parallel with the axes of the conductors.

7. The combination of two conductors which would if uncompensated exercise electrostatic retarding effects on one another by mutual capacity, with a self-induction coil or coils connecting them, of greater resistance than their circuit or circuits, such coil or coils possessing a high time constant and having a small and highly laminated core.

8. In an electric cable having two continuous insulated conductors, the combination of the said conductors with a self-induction coil or device which is connected across as an oblique bridge from one conductor to the other, one end of the said device or bridge being joined to one of the conductors at a point farther along the cable than that at which the other end of the said device or bridge is connected to the other conductor.

9. A cable comprising two or more insulated conductors running therethrough side by side and provided at intervals with compensating devices for diminishing the electrostatic capacity.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

SILVANUS PHILLIPS THOMPSON.

Witnesses:
WALTER P. RERTEN,
T. F. BARNES.