(No Model.) 2 Sheets—Sheet 1.

S. P. THOMPSON.

ELECTRIC CABLE.

No. 571,707. Patented Nov. 17, 1896.

FIG. 1.

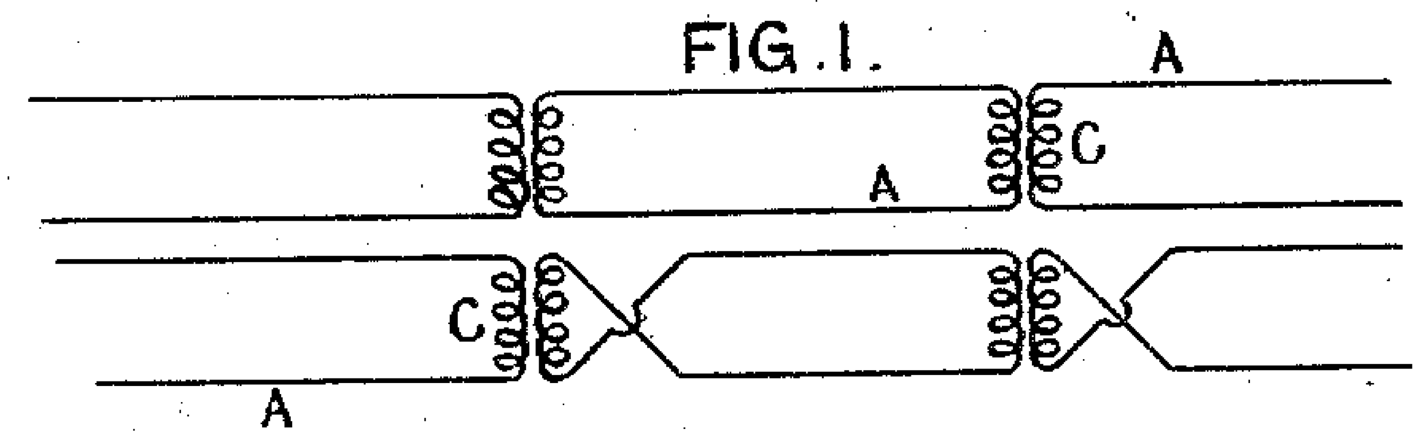


FIG. 2.

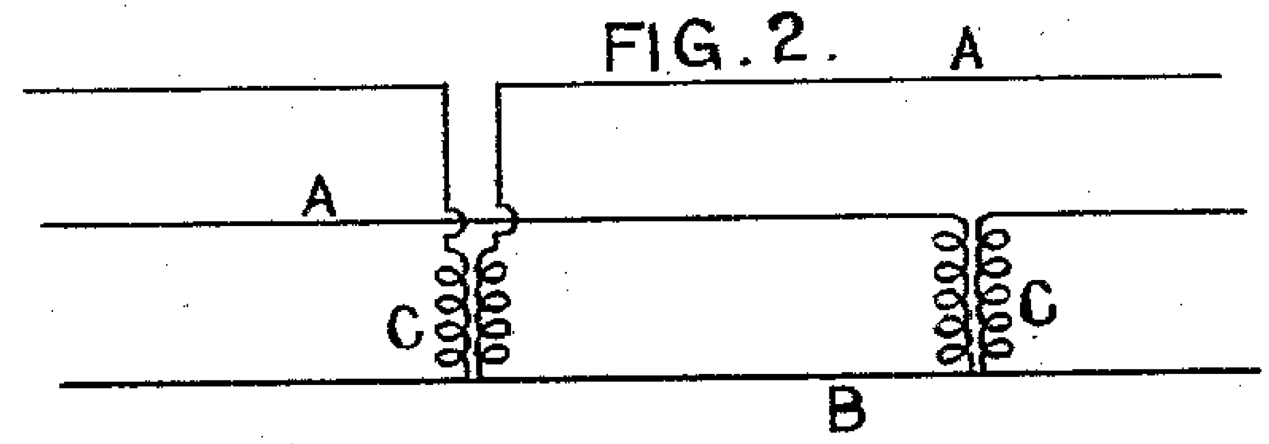


FIG. 3.

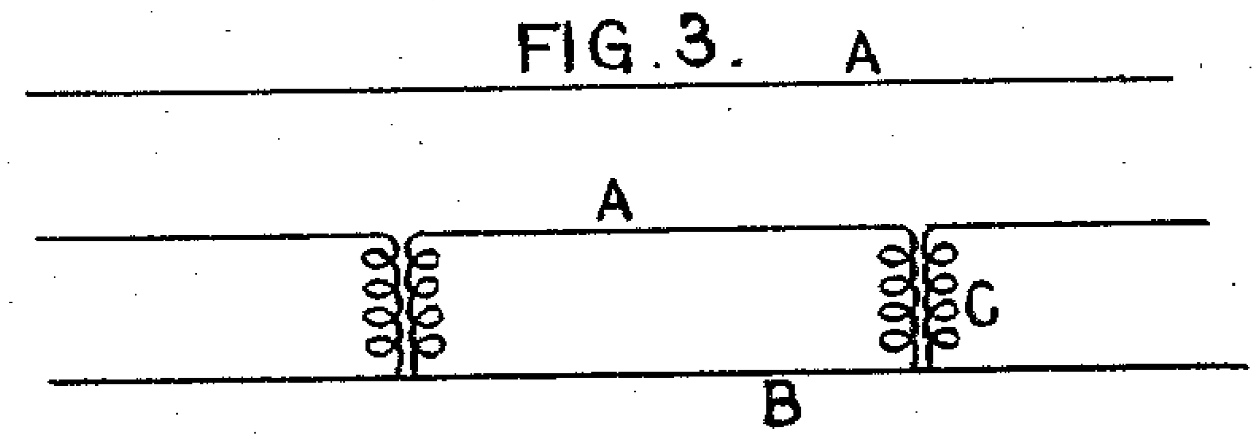


FIG. 4.

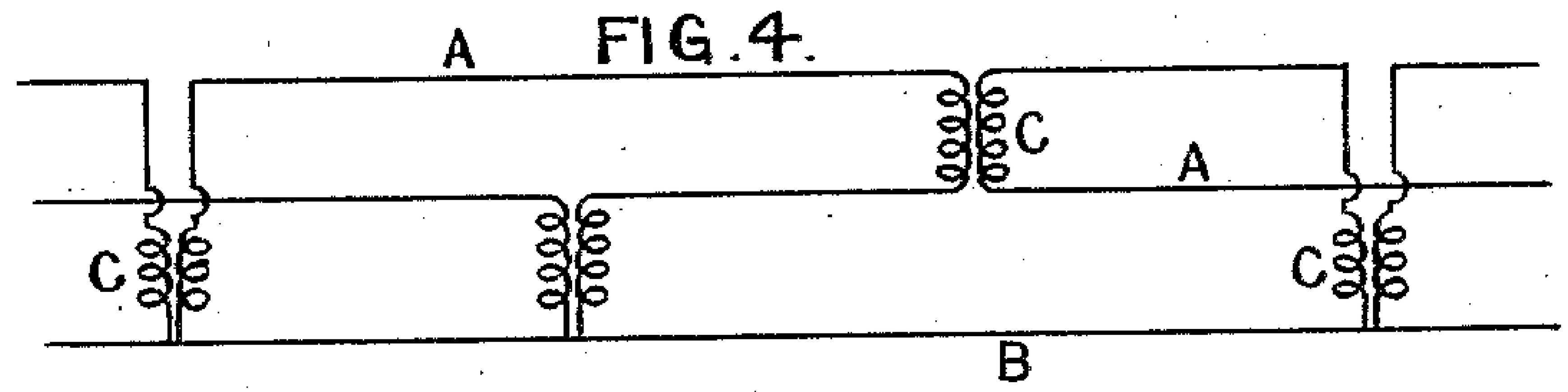


FIG. 5.

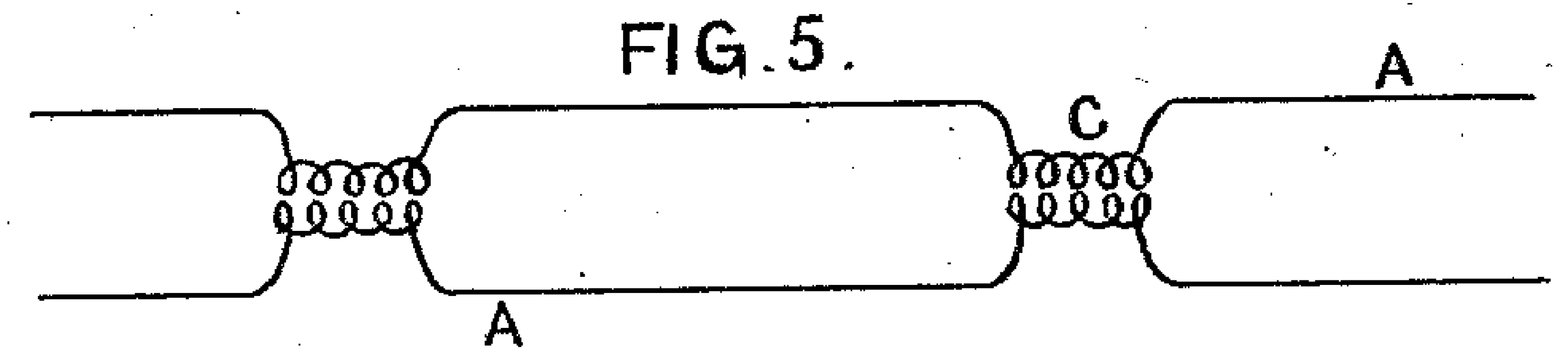


FIG. 6.

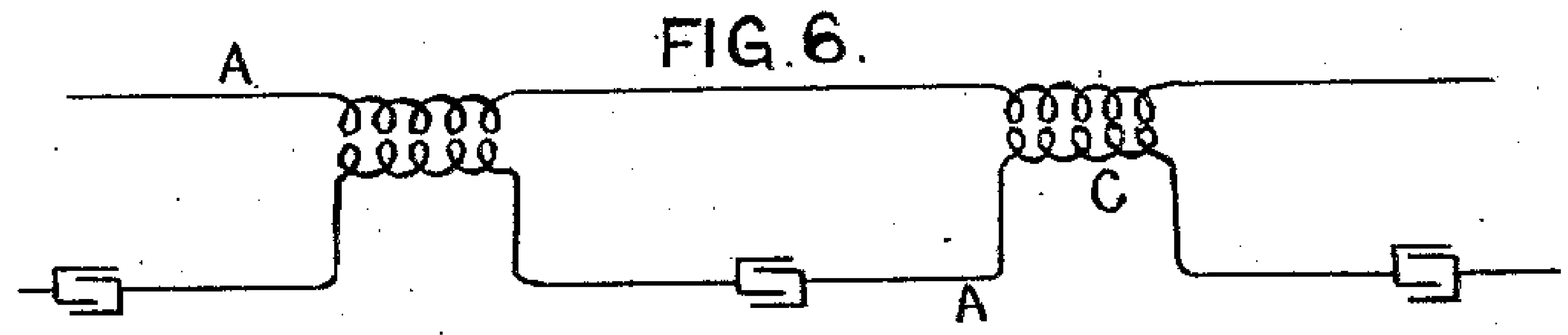
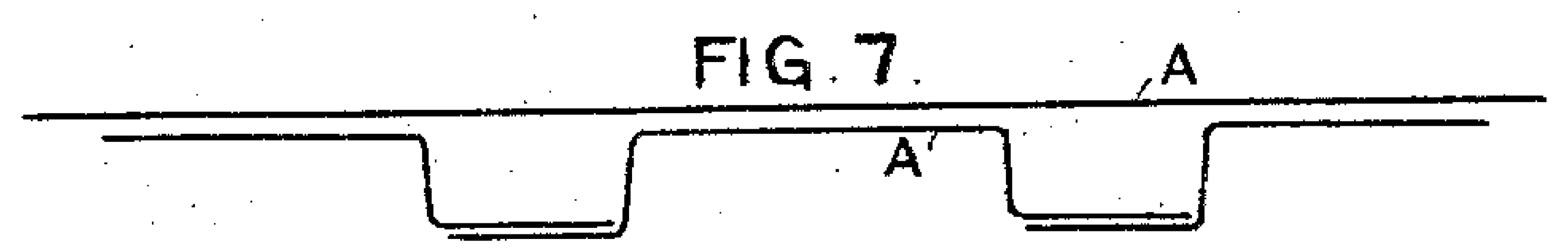


FIG. 7.



WITNESSES
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(No Model.)

2 Sheets—Sheet 2.

S. P. THOMPSON.

ELECTRIC CABLE.

No. 571,707. Patented Nov. 17, 1896.

FIG. 8.

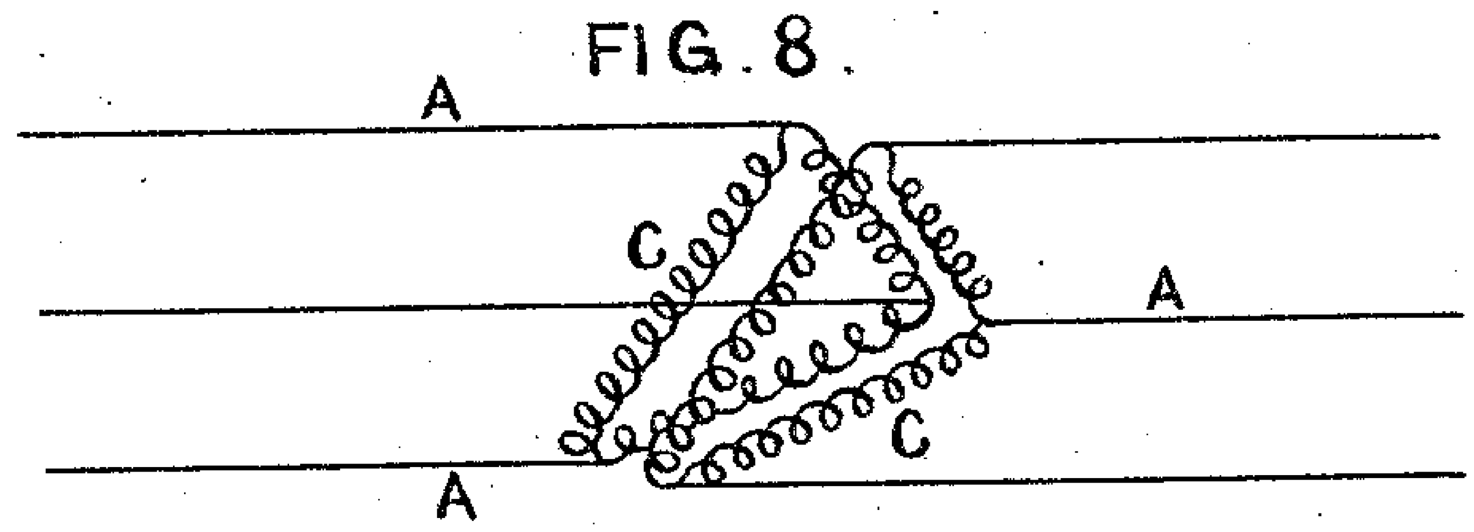


FIG. 9.

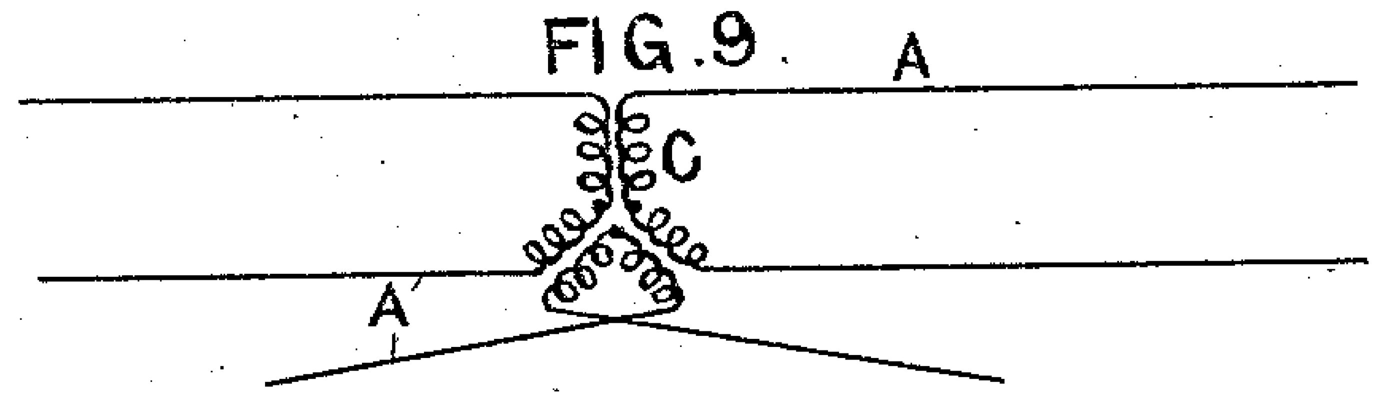
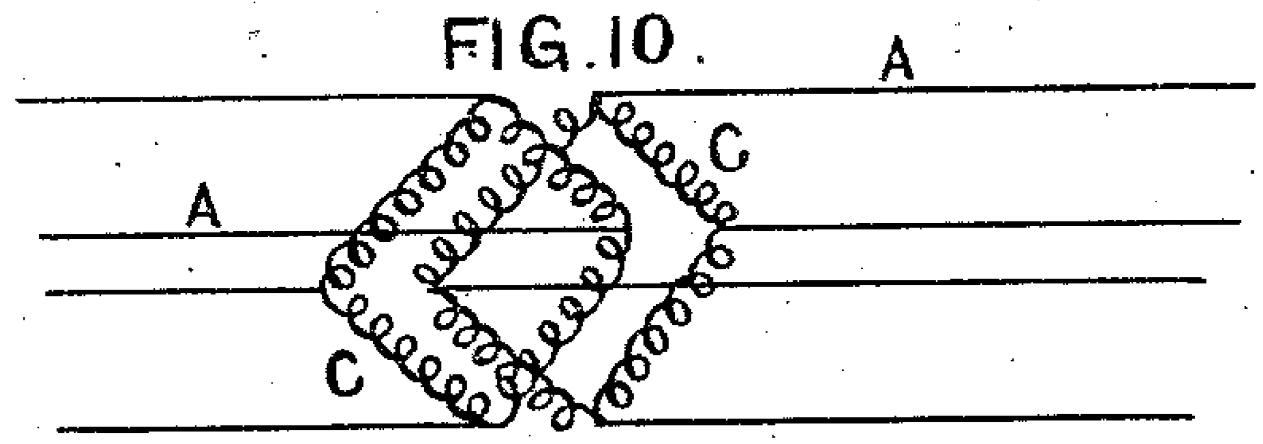


FIG. 10.



WITNESSES

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UNITED STATES PATENT OFFICE.

SILVANUS PHILLIPS THOMPSON, OF LONDON, ENGLAND.

ELECTRIC CABLE.

SPECIFICATION forming part of Letters Patent No. 571,707, dated November 17, 1896.

Application filed July 20, 1892. Serial No. 440,673. (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.

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 sent 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 elecromotive 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.

Now my present invention consists in dividing or virtually dividing the entire distance through which the signals have to be sent into a series of shorter circuits connected with each other by the aid of double induction-coils or other devices for producing mutual induction between the parts, so that each circuit in turn induces a current in the next. The essence of the sectioning of the cable is that, since retardation results from there being a capacity distributed along a great length, one should so modify the system that movements of electricity to effect the charges and discharges of the accumulations in the cable can take place over short lengths of circuit instead of having to flow in and out from the ends up to the places where the charge has accumulated.

In those cases where coils are employed, if iron cores be used for the coils, they must be small in quantity and well laminated. In cases where these coils are connected across the two lines of the conductors within the cable they shall preferably have a relatively high resistance and a high time constant. 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 much less than and shall be preferably greater than one one-hundredth second, while the resistance of the said coil shall be at least as great as or greater than that of the ten or twenty mile section of the cable, and shall, indeed, in the case of long cables, be with advantage as great as or greater than the resistance of the entire length of the conductor. I may produce a distributive mutual induction between the separate sections of a cable in various other ways.

In cases where double induction-coils are arranged in the two lines or conductors, (instead of across them,) as in Figure 5, hereinafter described, the coils, though they should in general have time constants and cores, as before, must be of resistance lower than that of the rest of the circuit, and their windings may with advantage be interwound, that is to say, not separated into two coils, primary and secondary, each apart from the other, one inside, the other outside, or one at one end of the core, the other at the other, but are wound between one another, so as to lie as nearly as possible geometrically in identical relations to their core.

In some cases where cables with two conductors are used the actual mutual induction between adjacent parallel portions of the two conductors or lines (going and return wires) within the cable may be sufficiently utilized without inserting specific double induction-coils, for it is well known that there is mutual induction of the electromagnetic kind even between two parallel straight conductors lying near to one another. This mutual induction can be increased by adding outside a wrapping of laminated iron wires wound over the insulating sheathing of gutta-percha or similar material. It may also be increased by constructing the cable so that the two wires or conductors spiral round one another, either continuously or at intervals, a distributed mutual induction being thereby attained, but in all cases there should be in the designing of a cable for any given service such proportioning of mutual induction to capacity and resistance as to fulfil for the case arising the conditions of approximate balance of effects.

Referring to the drawings, in Fig. 1 a series of circuits are connected by double induction coils or transformers C. In Fig. 2 each wire is connected to the sheath or earth by double induction-coils and the two wires can be used independently. In Fig. 3 an inner and outer conductor are employed and the outer connected by double induction-coils with the sheath or earth. In Fig. 4 the inner and outer conductors are connected with each other and also with the earth by double induction-coils; Fig. 5, two lines wound round each other or a core at intervals to form double induction-coils; Fig. 6, two lines forming double induction-coils at intervals and one of them cut into sections joined by condensers; Fig. 7, two conductors, one of them continuous, the other cut into sections, the ends of which overlap sufficiently to produce an induced current. Fig. 8 is a cable where three conductors are connected by double induction-coils; Fig. 9, where two lines are joined by double induction-coils, and a third line is coiled in double induction manner round cores placed in each circuit; Fig. 10, where four lines are connected in similar manner to plans already described in the case of three wires.

In the drawings, A A are conductors; B, sheath or earth; C, double induction-coils.

I declare that what I claim is—

1. The herein-described method of counterbalancing the effect of distributed electrostatic capacity in long lines of metallic return-circuits in which the conductors are separately insulated throughout, which consists in dividing the circuit into a series of suc-

cessive separately-insulated metallic return-circuits in each of which a movement of electricity takes place and connecting these circuits by mutual induction.

2. A cable comprising a metallic return-line formed into a series of comparatively short independent and completely-insulated circuits each of substantially the same length or capacity and connected by mutual induction coils, or devices, the whole being inclosed within a common sheath, substantially as described.

3. The combination in a submarine electric cable of one or more short sections intermediate its ends, said section or sections each consisting of two conductors both separately insulated and inclosed within one common sheath, the said intermediate section or sections being connected by means of mutual induction devices with the portions of cable lying beyond in both directions.

4. An electric cable consisting of two insulated conductors inclosed side by side within a common external sheath, one of the said conductors being continuous from end to end, and the other being actually divided, the two divided parts being arranged in inductive relation and their ends connected to the undivided conductor.

5. A cable consisting of two or more internal conductors, each of which is divided into sections constituting thereby a large number of successive circuits arranged in inductive relation each to the next and each inducing into the next in succession, the lines of conductors being connected across to a continuous conductor by double induction-coils, each having a high time constant, and having small well-laminated iron cores.

6. A cable consisting of two internal conductors separately insulated and inclosed within a common external sheath acting with a distributive mutual induction between their own parallel portions, either of the said internal conductors being divided, actually or virtually, into sections in each of which a motion of electricity is possible.

7. In a cable consisting of two continuous metallic conductors, means for virtually dividing said conductors into connected sections, said means comprising induction devices applied distributively to said conductors at intervals.

8. A twin-wire cable comprising an outgoing and a return line, both separately insulated and inclosed within one common sheath, the said cable being formed into a series of comparatively short independent completely-insulated circuits each of substantially the same length or capacity, and connected by mutual induction coils or devices, substantially as described.

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

SILVANUS PHILLIPS THOMPSON.

Witnesses:
T. F. BARNES,
WALTER J. SKERTEN.