(No Model.) 3 Sheets—Sheet 1.

J. J. CARTY.

TELEPHONE AND TELEGRAPH CIRCUIT.

No. 348,512. Patented Aug. 31, 1886.

Fig. 1.

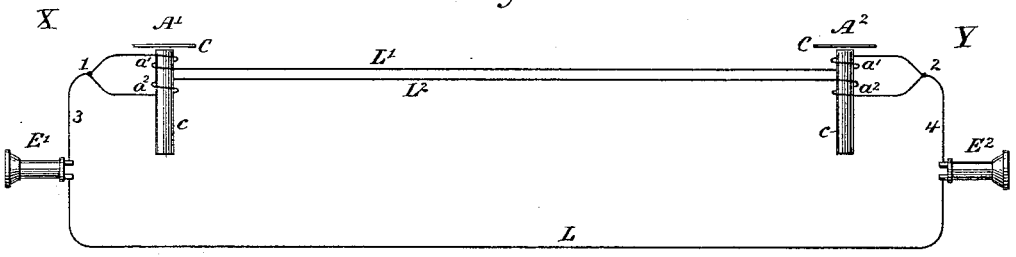


Fig. 2.

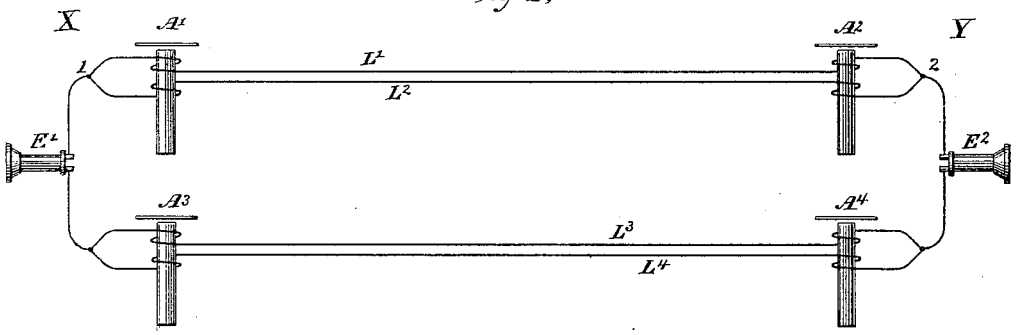
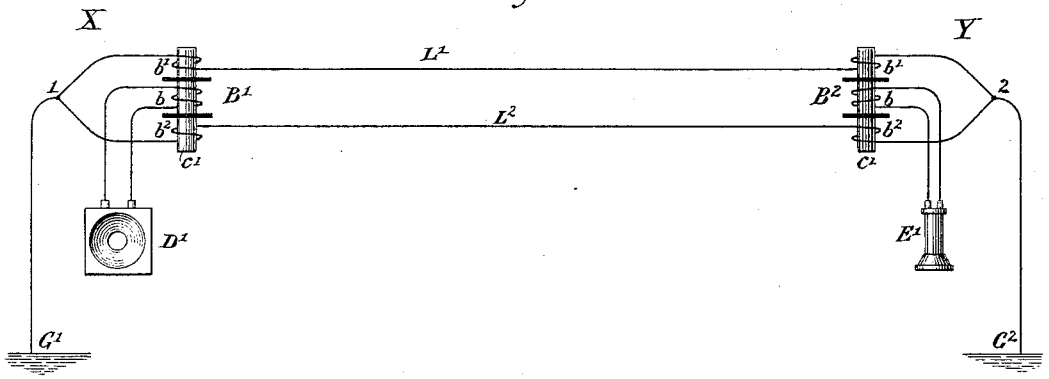


Fig. 3.



Witnesses

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(No Model.) 3 Sheets—Sheet 2.

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TELEPHONE AND TELEGRAPH CIRCUIT.

No. 348,512. Patented Aug. 31, 1886.

Fig. 4.

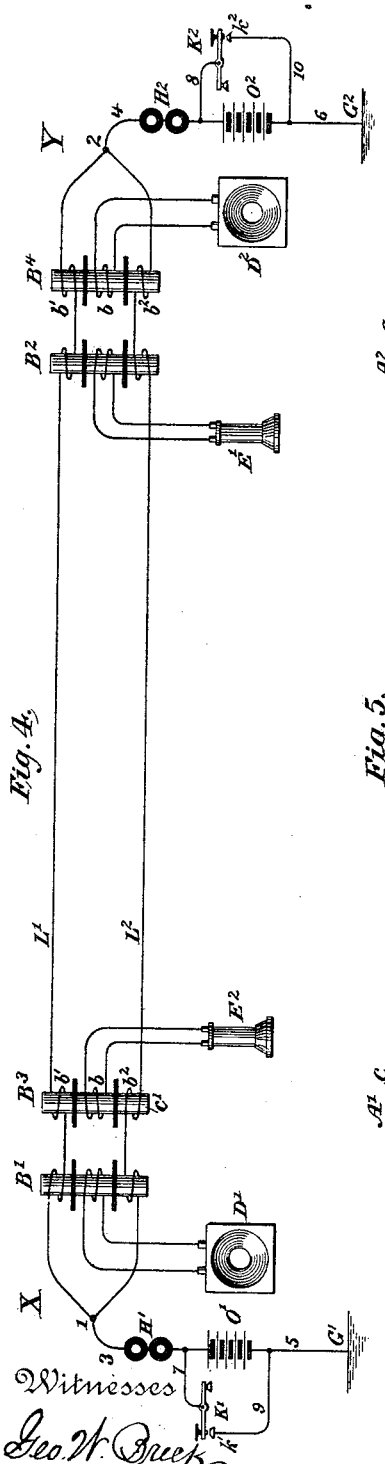
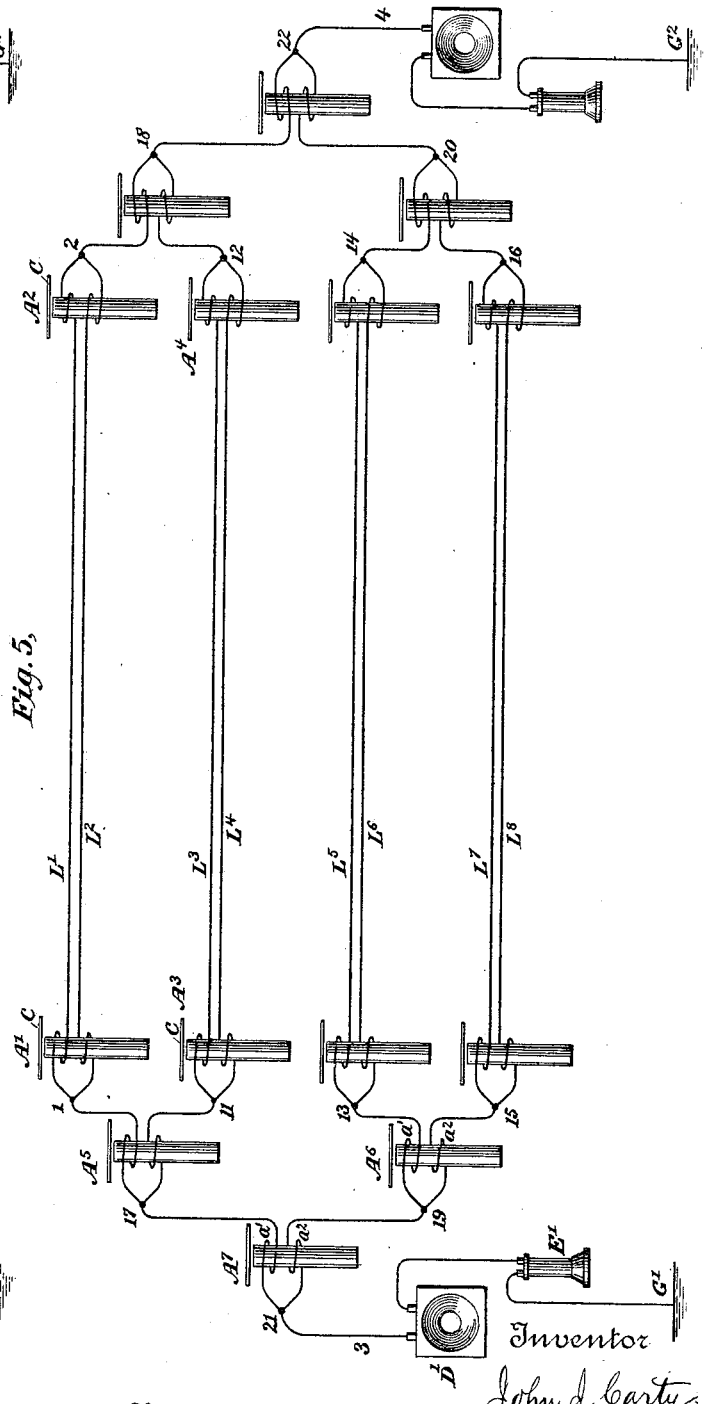


Fig. 5.



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J. J. CARTY.

TELEPHONE AND TELEGRAPH CIRCUIT.

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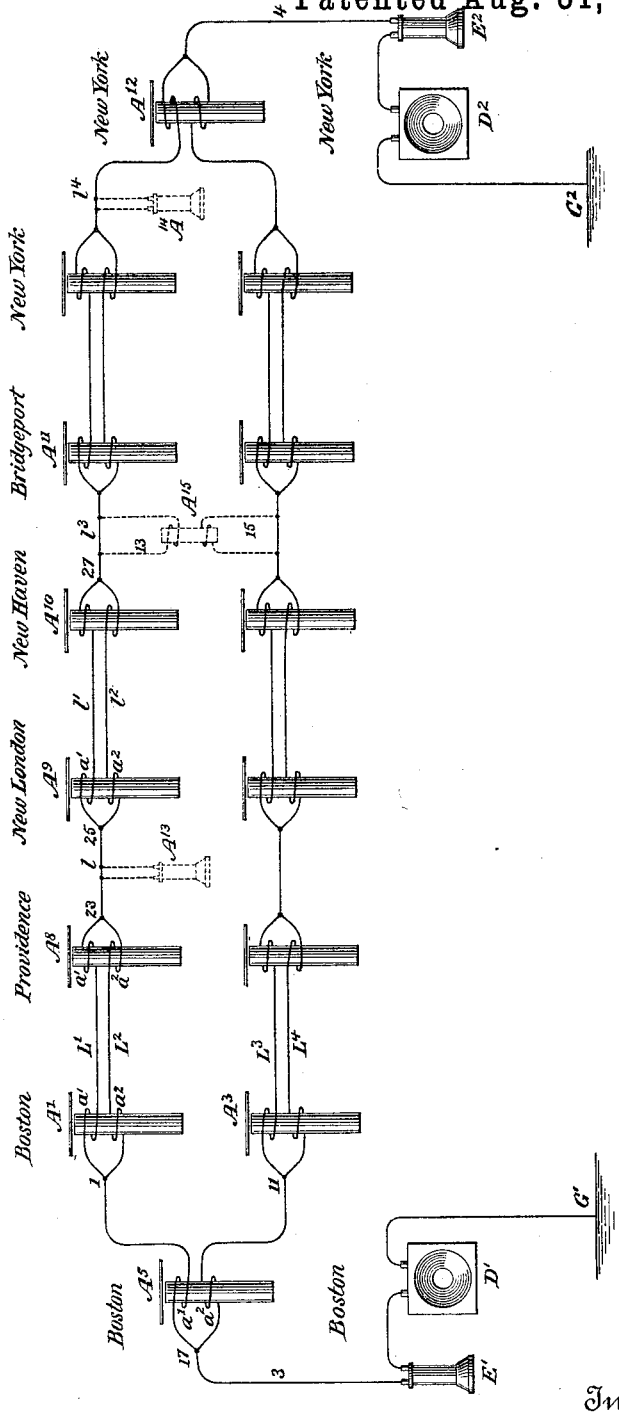

Fig. 6.

Witnesses

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UNITED STATES PATENT OFFICE

JOHN J. CARTY, OF CAMBRIDGE, ASSIGNOR TO THE NEW ENGLAND TELEPHONE AND TELEGRAPH COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONE AND TELEGRAPH CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 348,512, dated August 31, 1886.

Application filed February 2, 1886. Serial No. 190,585. (No model.)

To all whom it may concern:

Be it known that I, JOHN J. CARTY, a citizen of the United States, residing in Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Telephone and Telegraph Circuits, of which the following is a specification.

The invention relates to certain improvements in the organization of electric circuits for telegraphic and telephonic communication; and its object is to diminish the detrimental effects due to induction in long lines, to decrease the resistance of long circuits, and to increase the available capacity of the lines for transmitting and receiving.

While the invention is especially of use in telephony, it is also applicable to telegraphic and other electric systems. It is well known that long lines are influenced by currents traversing neighboring conductors, by atmospheric electricity, and earth-currents, and that these frequently produce in telephone-circuits such extra currents as to render the operation of long lines impracticable. Underground and submarine circuits are also difficult to operate because of the currents induced by currents traversing neighboring conductors, and because of the static capacity of the lines. For this reason it has become customary, in operating systems in which it is necessary to avoid induced currents, to employ metallic circuits. Whatever currents are then induced upon the outgoing conductors are practically neutralized, because of the equal and opposing currents induced in the return-conductors. Such construction, however, is expensive, in that it requires two conductors in place of the single conductor usually employed.

The present invention consists, principally, in employing two conductors in place of a single main line, and transmitting currents over both lines for operating the apparatus, and usually a third conductor or set of conductors, or the earth is employed as a return-conductor. Like currents induced upon these two lines have equal and opposite effects upon the receiving apparatus, for each wire includes in its circuit a coil of the receiving-instrument, and these two coils oppose each other. The lines, after traversing the receiving-instrument at each terminal station, are connected with each other and then with the return-conductor or with the earth. Other telegraphic or telephonic instruments may then be included in the conductors leading from the united lines to this return-conductor or to the earth. The organization at each of the respective ends or terminals of the lines is essentially the same. It is evident that whatever currents are established in the main lines by outside causes will oppose each other in the receiving-instruments, and therefore produce no effect. Any current, however, which is caused by the transmitter to pass over one line will be of a given character, and that simultaneously transmitted upon the other line will be of the opposite character. These currents will assist each other in operating the receiving-instrument at the distant station. The operation of the instruments included in the earth or return conductors will have no effect upon the instruments in the double lines, for the reason that whatever currents pass to the lines from either or both conductors will divide between the two lines and neutralize each the effect of the other. The conductors thus formed into pairs may be still further coupled with other pairs to any desired extent, and instruments may be included in the conductors leading from two pairs before they are united with each other, and these conductors being united are either led directly to the earth or through one coil of a receiving-instrument, the other coil of which is included in a line derived in the same manner from two other pairs. This system may be extended to any desired extent. The united conductors, instead of being led directly to the earth, may lead to more or less distant stations, and there again connected with branch conductors leading to another station.

I am aware that it has been proposed to employ outgoing and return wires twisted about each other for conducting currents from opposing batteries to a receiving-instrument wound with opposing coils, which coils are respectively included in the two wires.

In the accompanying drawings, Figure 1 is a diagram illustrating the general principles upon which the invention is based. Fig. 2 illustrates a method of employing two pairs of lines in combination. Figs. 3 and 4 show the application of telegraphic apparatus in

connection with a telephonic system, and also the application of repeating-coils. Fig. 5 is a diagram illustrating the extension of the system, and Fig. 6 is a diagram illustrating the method of connecting different points with alternate single and double conductors.

Referring to the figures, L′ and L² represent two main lines extending between two stations, X and Y. At the station X the line L′ leads from a point, 1, through the coil *a′* of a suitable instrument, A′, in this instance a magneto-telephone wound with two opposing coils. The main line L² leads from the point 1 through the second and opposing coil, *a²*, of the instrument A′. The core *c*, upon which the coils *a′* and *a²* are mounted, is a permanent magnet, and a diaphragm, C, is placed near one end in the usual manner.

The instrument is in all respects the same in construction as a magneto-telephone, with the exception that is is provided with two coils instead of one, and these are designed to be connected in two circuits and oppose each other. Whatever variations in the magnetism of the core *c* are produced, will, it is evident, establish currents opposite in character in the lines L′ and L², since the coils *a′* and *a²* are wound in opposite directions. The line L′ leads to a station, Y, through the coil *a′* of an instrument, A², similar to the instrument A′. From the coil *a′* the conductor L′ leads to a point, 2. The line L² leads through the opposing coil *a²*, surrounding the core *c* of the instrument A², and thence to the point 2, where it unites with the main line L′. It will be apparent that whatever current traverses the coil *a′* from the main line L′ will tend to induce a certain polarity in the core *c*, and an opposing current upon the line L² will tend to produce the same polarity in that core. Thus the currents sent upon the two lines by the instrument A′ will assist each other in operating the instrument A², while the currents established upon the lines from other causes will neutralize each other. The points 1 and 2 are respectively connected by conductors 3 and 4 with a conductor, L. A current traversing either line L′ or L² will, it is evident, have a return path either through the conductor L² or L′ or through this conductor L. The earth may be substituted for the conductor L, as shown in Fig. 3, and usually this is preferred, as it offers practically no resistance. The current upon either line may be considered as passing to earth, and as encountering only the resistance of the single line L′ or L². From this it will be apparent that not only are all the advantages due to the employment of a metallic circuit obtained when the earth is employed as a return, but the resistance of the circuit is reduced one-half, for the reason that the currents are compelled to traverse only one-half the length of conductor, and, moreover, the currents upon the two lines assist each other, and a stronger action of the receiving-instrument is secured.

In Fig. 1 a magneto-telephonic apparatus is represented at the station X and Y. It will be understood, however, that the invention is not in any manner limited to the method shown of connecting or employing telephonic apparatus, nor to telephonic apparatus itself, but that this general organization may be employed in various different manners to develop opposing currents in the two lines and transmit them to a distant point, where they may be employed in developing magnetism, which may be utilized in any well-known manner for operating various electrical apparatus. Additional apparatus may be placed in the conductors 3 and 4, as shown at E′ and E². In this instance the usual forms of magneto-telephones are represented. It is evident that whatever current passes to the point 1 from the instrument E′ will divide between the lines L′ and L², and produce no effect upon the instruments A′ and A², but, uniting again at the point 2, they operate the instrument E².

In Fig. 2 there is shown in place of the return-conductor L a second pair of lines, L³ and L⁴. Additional instruments, A³ and A⁴, similar to the instruments A′ and A², are included in these lines. In this manner three sets of instruments are employed in connection with four line-wires.

It is not intended herein to claim, broadly, the precise organization of apparatus illustrated in Figs. 1 and 2, but only as involved in the claims, as hereinafter pointed out. A description of this system of apparatus, however, is of assistance in understanding the other features of the invention.

In Fig. 3, in place of the magneto-telephones shown in Figs. 1 and 2, there is shown at station X an induction-coil or repeating apparatus, B′. This consists in this instance of a soft-iron core carrying the opposing coils *b′* and *b²* and a third coil, *b*. A suitable transmitter, D′, of any desired character is represented as being connected with conductors including this third coil, *b*. The coil *b* may in this instance be considered as a primary coil and the coils *b′* and *b²* as secondary coils.

At station Y a repeating-coil, B², is shown. The opposing coils *b′* and *b²*, surrounding the soft-iron core *c′* of this instrument, are connected in the lines L′ and L², respectively, in the same manner as the coils *a′* and *a²* in Fig. 1. The third coil, *b*, of this instrument is connected through a suitable receiver, E′. The method of operating this organization will be evident. The points 1 and 2 are respectively connected with the earth at G′ and G². Should, therefore, either of the lines L′ or L² become broken or otherwise inoperative, the remaining wire may still be employed in connection with the earth-conductors and thus communication might be continued while the first wire was being repaired.

It will be understood that other forms of repeating apparatus may be employed than that shown. It is not always necessary that

a soft-iron core be employed, and in some instances the direct inductive action of the currents may be employed.

In Fig. 4 there is illustrated an organization in which, in addition to the apparatus shown in Fig. 3 there is represented at station X a receiver, E^2, connected through the coils b of a repeating-coil, B^3. This has opposing coils b' and b^2 surrounding its core c' and respectively connected with the conductors L' and L^2. In like manner a second induction-coil, B^4, at the station Y is provided with a primary coil, b, included in the circuit of a transmitter, D^2, and opposing coils b' and b^2 are respectively included in the main lines L' and L^2. The operation of this portion of the apparatus has already been sufficiently explained. The conductor 3 leads from the point 1 at station X through a Morse receiving-instrument, H', to one pole—say the positive—of a battery, O'. The negative pole of this battery is connected with the earth at G' by a conductor, 5. A conductor, 7, leads from the positive pole of the battery O' to a key, K'. The front contact, k', of this key is connected by a conductor, 9, with the negative pole of the battery. When the key is closed, the battery O' is shunted. At station Y a conductor, 4, leads through a similar receiving-instrument, H^2, to the positive pole of a battery, O^2. The negative pole of this battery is connected by a conductor, 6, with the earth at G^2. A conductor, 8, leads from the positive pole of this battery to a key, K^2, the front contact-point, k^2, of which is connected by a conductor, 10, with the negative pole of the battery. The two batteries O' and O^2 therefore oppose each other, and no current traverses the line so long as both keys remain open. By closing the key K' the battery O' will be shunted and the instrument H^2 at the distant station will respond, as also in this instance the instrument H', to the unopposed currents from the battery O^2. In like manner the instrument H' may be operated by the key K^2. The currents thus transmitted from the batteries O' and O^2 will, it is evident, traverse both main lines L' and L^2; but as they traverse the opposing coils of the instruments B', B^2, B^3, and B^4, they will produce no effect upon these instruments, it being understood that the resistance of the two lines is equal. At the same time this advantage is gained, that the resistance which is encountered between the points 1 and 2 is only half as great as if the currents were compelled to traverse only one line, L' or L^2. Two sets of apparatus are therefore operated over the two main lines, with the advantage already named.

In Fig. 5 a method of extending the system is illustrated. In this figure there are represented, instead of only two lines, L' and L^2, connected in the manner already illustrated in Figs. 1 and 2, three other pairs of lines, L^3 and L^4, L^5 and L^6, and L^7 and L^8. Each pair of conductors is connected in the manner described with reference to Figs. 1 and 2, and provided with the requisite transmitting and receiving apparatus, as illustrated at A', A^2, A^3, and A^4, &c. The lines L' and L^2 are connected at the points 1 and 2, as before. In like manner the lines L^3 and L^4 are connected with the points 11 and 12, the lines L^5 and L^6 at the points 13 and 14, and the lines L^7 and L^8 at the points 15 and 16. A conductor leads from the point 1 through one coil of an instrument, A^5, and a conductor leads from the point 11 through the opposing coil of this instrument, and these two conductors are united at a point, 17. In like manner conductors leading from points 13 and 15 include opposing coils a' and a^2 of an instrument, A^6, and are connected at a point, 19. Conductors lead from the points 17 and 19, respectively, through opposing coils a' and a^2, applied to a receiving-instrument, A^7. These conductors unite at a point, 21, and are connected with the earth at G' by the conductor 3, including suitable transmitting and receiving instruments, D' and E'. The organization at the other terminal station of the line is precisely similar, and a detailed description will not be necessary.

It is evident that the instruments A', A^2, A^3, and A^4 will be operated in precisely the manner already described with reference to Figs. 1 and 2, likewise the instruments in each of these pairs of main lines; but the currents passing through the opposing coils a' and a^2 of this instrument A^5 will pass to the distant station through the four wires L', L^2, L^3, and L^4, and the resistance encountered will be correspondingly diminished. The instrument A^6 will operate in a similar manner. The instrument A^7 will operate in the same manner, the currents through the opposing coils passing to the distant station through the eight lines, and therefore encountering a correspondingly small resistance. In this figure there are represented telephonic transmitters and receivers of the magneto type, each being wound with two opposing coils, a' and a^2, and each provided with a diaphragm, C. This form of illustration is employed for convenience; but it is evident that the invention is in no manner restricted to this organization.

In Fig. 6 the invention is illustrated in its application to double and single circuits alternately connected. In this figure there are represented terminal stations at Boston and New York, and intervening stations at Providence, New London, New Haven, and Bridgeport. At the Boston terminal the transmitting-instrument D' and receiver E' are represented as included in the conductor 3, leading to the earth at G'. At the point 17 the circuit divides between the opposing coils a' and a^2 of the instrument A^5. The currents traversing the coil a' of the instrument A^5 pass to the point 1 and there divide, passing through the opposing coils a' and a^2 of the instrument A'. The currents traversing the coils a^2 of the instrument A^5 pass to the point 11 and there divide through the opposing coils a' and a^2 of the instrument A^3, included in the circuit of

the lines L^3 and L^4. The lines L' and L^2 are connected at the Providence station through the opposing coils a' and a^2 of the instrument A^8, and then united at a point, 23, in a line, l, which leads to the New London station. At this station the lines again divide at the point 25, and pass through the opposing coils a' and a^2 of the instrument A^9. As these last-mentioned coils oppose each other, the current from the section of line l will produce no effect upon the instrument A^9, and the currents will pass from the coils to the next station through the two lines l' and l^2, which connect the New London with the New Haven station. These sections of line are in turn connected at a point, 27, at New Haven, in precisely the same manner. The instrument A^{10} at New Haven is included in circuit in precisely the same manner as represented at A^8 at Providence. It will be unnecessary to continue the description of this circuit to the stations at Bridgeport and New York, as the organization will be evident from the preceding description. The other branch of the conductor, 3, at Boston passes from the point 11 through another system of main conductors precisely similar to that described. It will be evident that the instrument E^2, included in the conductor 4 at New York, will respond to the currents transmitted from the instrument D' at Boston, and likewise the instrument E' at Boston will respond to the instrument D^2 at New York, and the currents from these instruments will pass through the entire system of main lines without affecting any of the intermediate instruments. In like manner, when the instrument A^5 is used as a transmitter the instrument A^{12} will respond, and vice versa. The instruments A' and A^8 may be employed, each for operating the other, without affecting the other instruments of the system. Likewise the instruments A^9 and A^{10}, and so on throughout the system.

It may be desirable, in some instances, to include in one of the single lines—l, for instance—an instrument designed to operate or respond to an instrument included at some other point where the lines are united—thus, for instance, an instrument, A^{13}, (indicated in dotted lines,) may be included, as shown in the conductor 1, and switched in and out of circuit as desired. This instrument will operate in connection with a similar instrument, A^{14}, included in the conductor l^4, leading through the single coil a' of the instrument A^{12} at New York. In like manner an instrument, A^{15}, indicated in dotted lines, may have its opposing coils included in the respective conductors 13 and 15, which unite New Haven and Bridgeport, or any similar stations, and this instrument will respond either to the instrument A^5 at Boston or A^{12} at New York.

It is evident that the general plan of the invention may be still further extended, and various modifications in the organization are obvious, but these do not here require specific description.

I claim as my invention—

1. The combination of two main lines, a transmitting device connected with both main lines and consisting of an inductorium for establishing electrical impulses upon said main lines, a receiving-instrument having coils included in both said main lines, and a conductor or conductors uniting said main lines with the earth or a return-conductor.

2. The combination, as hereinbefore set forth, of a transmitter and a receiving instrument, coils in each of said instruments, two main lines, each including one of the coils in each instrument, conductors uniting said main lines with the earth or with each other, a third coil in one of said instruments, and means for establishing currents therein, substantially as described.

3. The combination, substantially as hereinbefore set forth, of two cores, opposing coils upon each of said cores, two main lines, each including one of the coils upon each core, conductors uniting said main lines with the earth or with each other, a third coil upon one of said cores, and means for establishing currents therein, substantially as described.

4. The combination, substantially as hereinbefore set forth, of two pairs of coils, two main lines, each including one of the coils of each pair, substantially as described, two inductoriums having primary and secondary coils, the secondary coils being respectively included in said main lines, conductors uniting said main lines with a common return-conductor or the earth and telegraphic or telephonic instruments included in the first-named conductors.

5. The combination, substantially as hereinbefore set forth, of two pairs of opposing coils, two main lines, each including one of the coils of each pair, substantially as described, two differentially-wound inductoriums, the opposing coils of each of which are respectively included in said main lines, a transmitter for establishing impulses in the primary coils, conductors uniting said main lines with a common return-conductor or the earth and telegraphic or telephonic instruments included in the first-named conductors.

6. The combination, substantially as hereinbefore set forth, with two main lines, of a magnetizable core at one station, opposing coils upon said core and respectively included in said main lines, a third coil upon said core, a circuit including said third coil, means for establishing a variable current in said third coil and thereby varying the magnetization of said core, a conductor uniting both said main lines with the earth, a second core located at a distant station, opposing coils upon said core respectively included in the main lines, and a conductor uniting both of said lines with the earth or return conductor at the distant station.

7. The combination, substantially as hereinbefore set forth, of a transmitting-instrument, a soft-iron core, a coil upon said core

connected in circuit with said transmitting-instrument, two coils wound in opposite directions, also mounted upon said core, two main lines respectively including the last-named coils, a conductor connecting the two lines with the earth, and a receiving-instrument responding to currents simultaneously transmitted in opposite directions upon said lines, but silent to currents in the same direction.

8. The combination of two main lines, a transmitting device consisting of a differentially-wound inductorium for sending currents of opposite character upon said lines, a receiving-instrument included in said main lines and responding only to currents transmitted in opposite directions upon said main lines, and conductors leading from said main lines at points respectively beyond said transmitting-instrument and said receiving-instrument, and connecting with apparatus designed to be operated by currents transmitted in the same direction through said main lines.

9. The combination of two main lines, a transmitting device consisting of a differentially-wound inductorium for sending currents of opposite character upon said lines, a receiving-instrument responding only to currents of opposite character upon said lines, a transmitting device for sending currents of the same character upon said lines, and a receiving-instrument responding only to currents of the same character upon said lines.

10. The combination, substantially as hereinbefore set forth, of two main lines, a transmitting device for sending currents of opposite character upon said lines simultaneously, a receiving-instrument included in said main lines and responding only to currents transmitted in opposite directions upon said main lines, conductors leading from said main lines at points respectively beyond said transmitting-instrument and said receiving-instruments to the earth, a battery, and a receiving-instrument included in each of the last-named conductors, said batteries opposing each other, and two keys respectively serving, when operated, to cut said batteries out of circuit.

11. The combination, substantially as hereinbefore set forth, of two or more pairs of main lines, electrical instruments included in said main lines for sending and responding to opposing currents upon each pair of main lines, conductors uniting the respective pairs of main lines with each other, and an instrument having opposing coils respectively included in the last-named conductors, substantially as described.

12. The combination, substantially as hereinbefore set forth, of a main line divided at intervals into two branch lines, a transmitting and receiving instrument for respectively transmitting and responding to opposing currents upon said branch lines, and transmitting and receiving instruments respectively included in the main line.

13. The combination, substantially as hereinbefore set forth, of two main-line conductors divided at intervals into branch conductors, and again uniting into a single conductor, instruments included in each of the loops or branches thus formed for transmitting and responding to opposing currents upon the branches, and conductors uniting the two first-named conductors with each other at their respective terminals, instruments included in the last-named conductors having opposing coils, and conductors uniting these conductors with the earth, substantially as described.

14. The combination, in a telephonic instrument, of two opposing coils respectively included in different main lines, a transmitter and a circuit therefor extending into inductive proximity to said opposing coils, and acting inductively upon the same when traversed by currents.

15. In a telephonic system, opposing coils, a core carrying the same, a transmitter, a circuit for the same, and coils included in said circuit and mounted upon said core.

16. The combination of two main lines, coils included in said main lines respectively, a transmitting device, a circuit for the same, and coils included in said circuit and located in inductive proximity to the first-named coils, whereby opposing currents are established in the two lines through the instrumentality of the first-named coils by variations in the current caused by the transmitter.

In testimony whereof I have hereunto subscribed my name this 27th day of January, A. D. 1886.

JOHN J. CARTY.

Witnesses:
EDWARD F. BACKUS,
CHARLES H. HERZIG.