No. 887,533. PATENTED MAY 12, 1908.

F. SINDINGCHRISTENSEN.

APPARATUS FOR TELEPHONING.

APPLICATION FILED MAY 17, 1901.

2 SHEETS—SHEET 1.

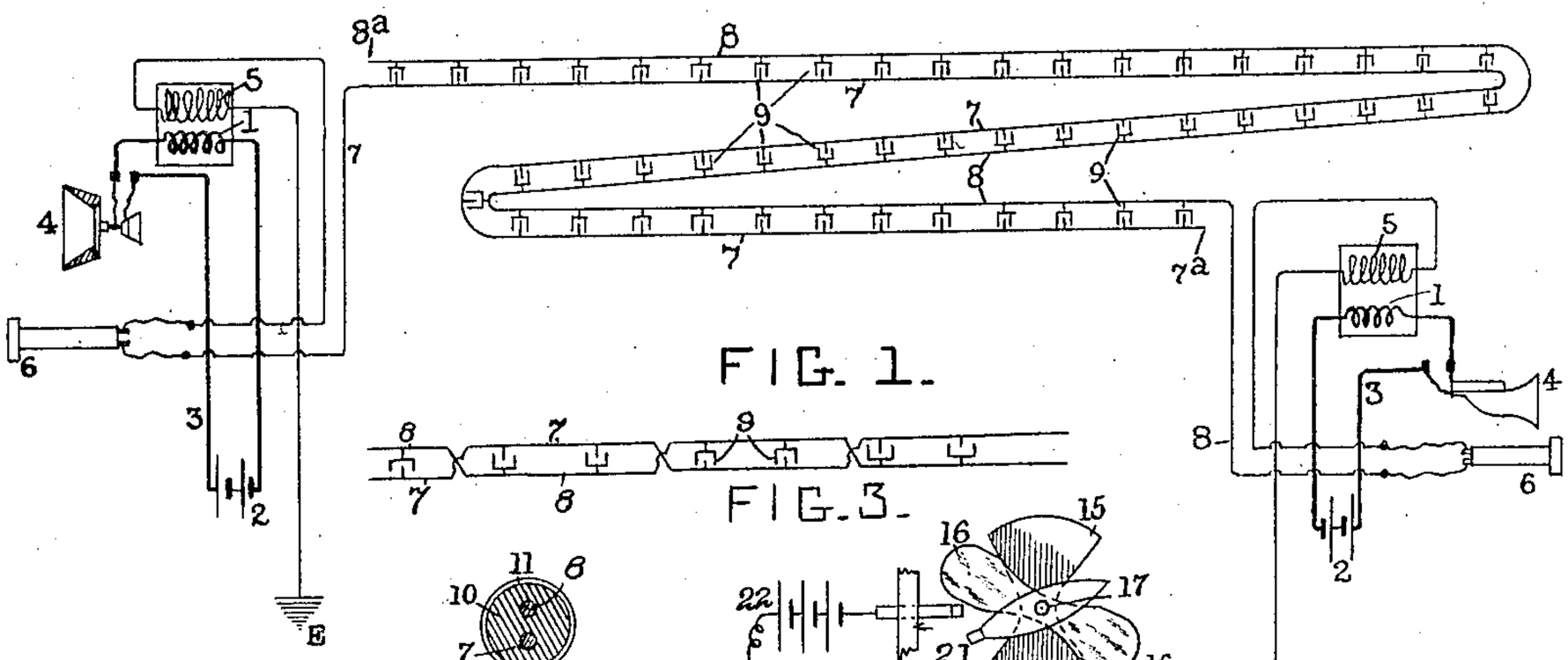

FIG. 1.

FIG. 3.

FIG. 4.

FIG. 5.

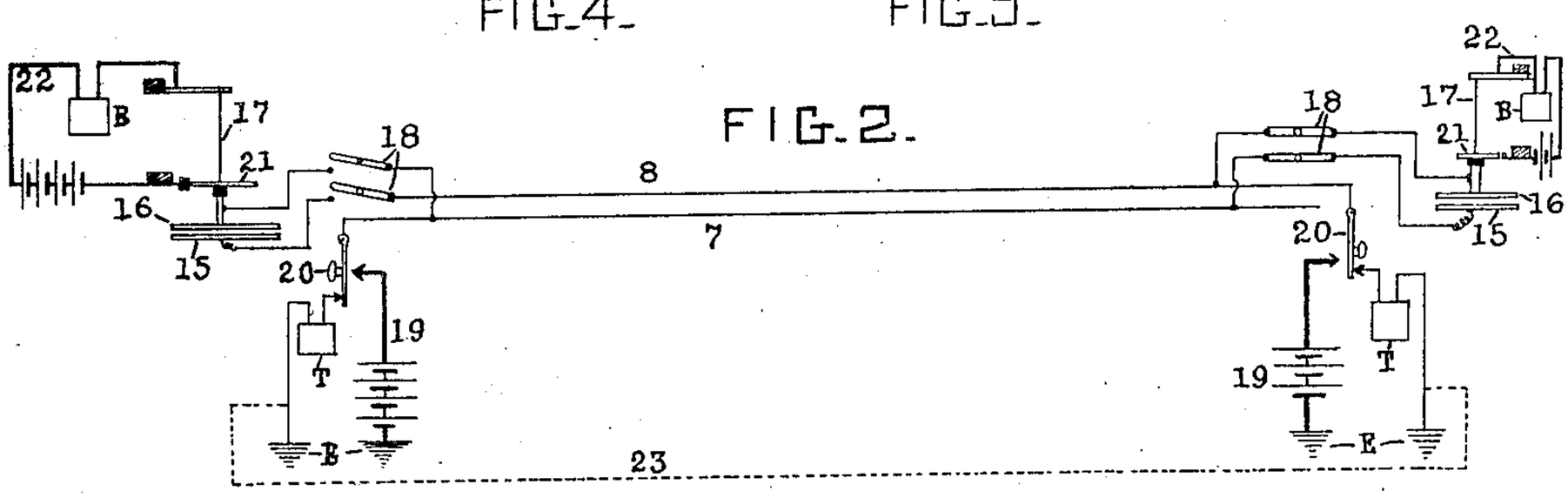

FIG. 2.

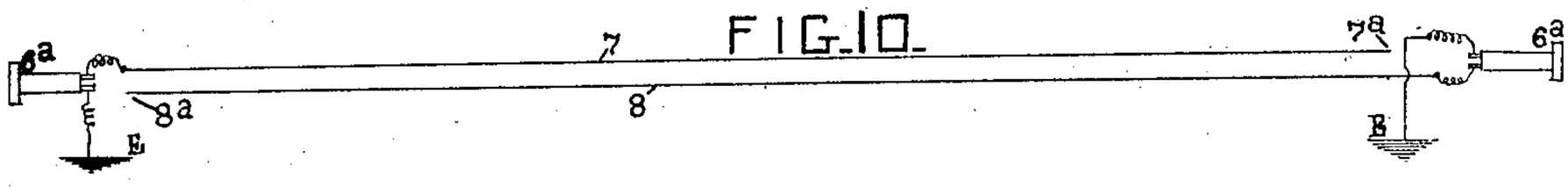

FIG. 10.

WITNESSES

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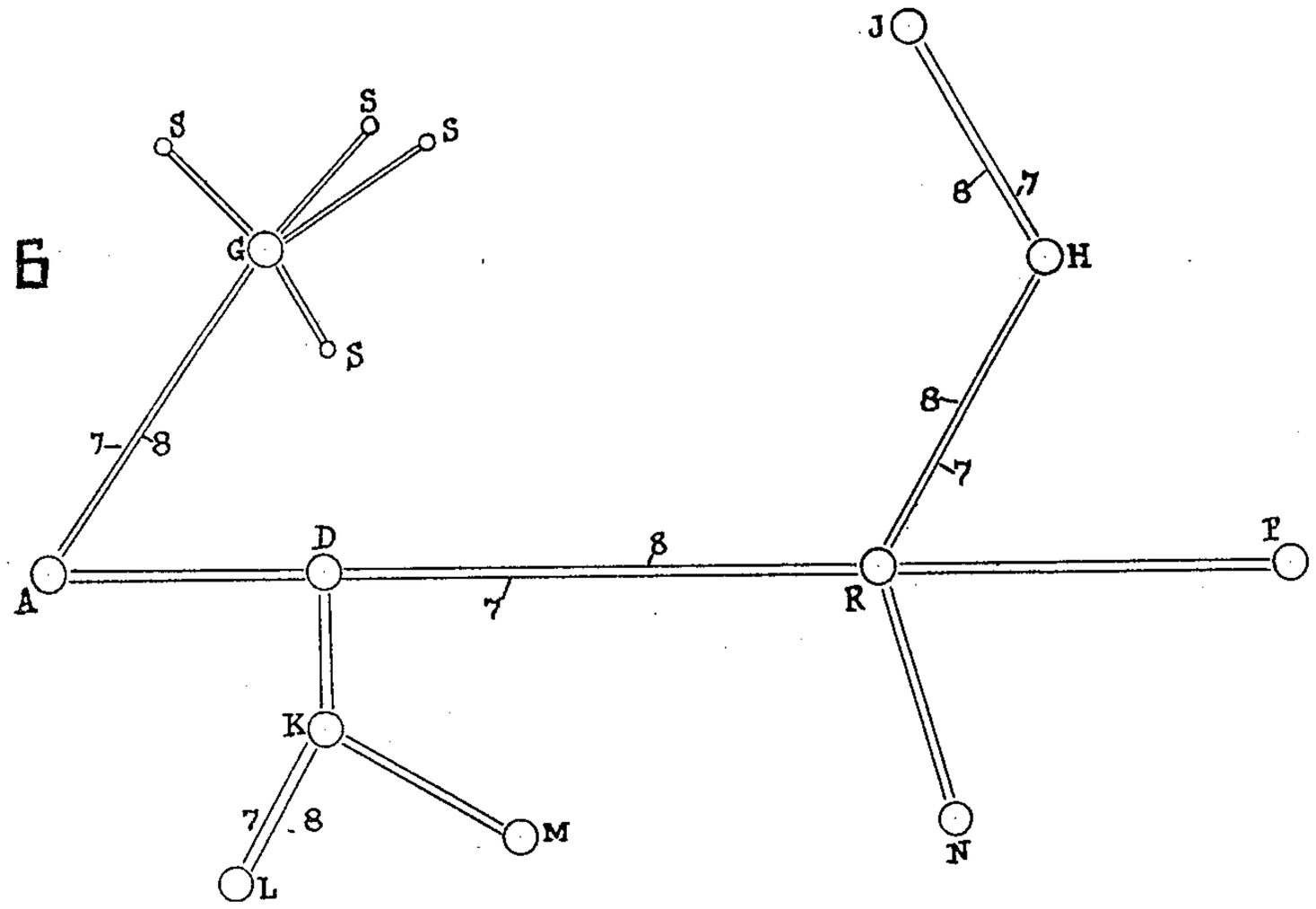
2 SHEETS—SHEET 2.

FIG. 6



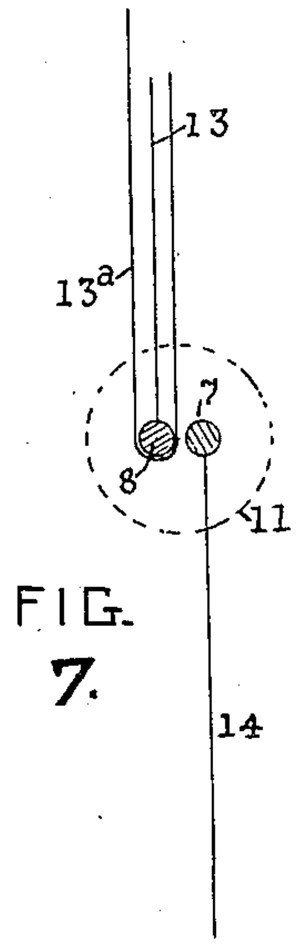


FIG. 7.

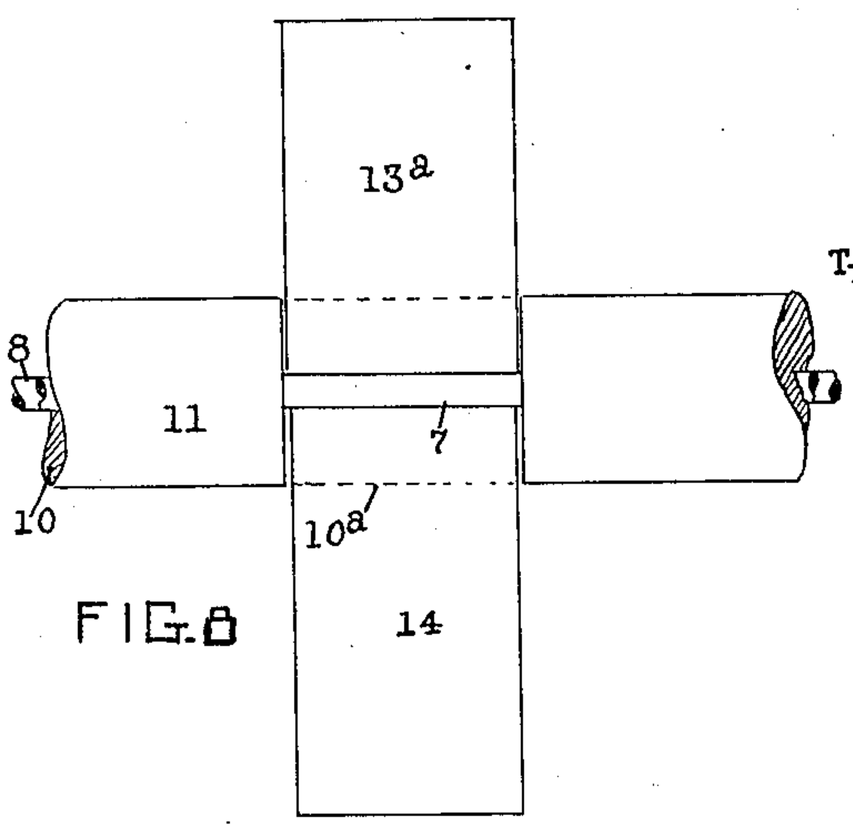


FIG. 8

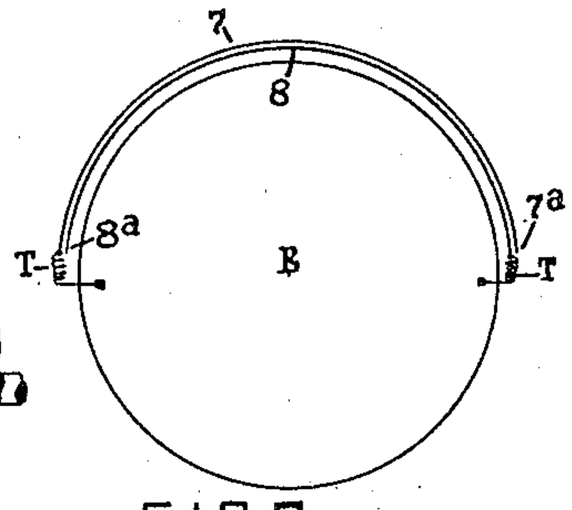


FIG. 9.

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APPARATUS FOR TELEPHONING.

No. 887,533. Specification of Letters Patent. Patented May 12, 1908.

Application filed May 17, 1901. Serial No. 60,687.

To all whom it may concern:

Be it known that I, FREDERIK SINDINGCHRISTENSEN, a subject of the King of Denmark, and resident of the borough of Manhattan, city of New York, and State of New York, have invented certain new and useful Improvements in and Apparatus for Telephoning, of which the following is a specification.

This application relates specifically to telephony.

The specific object of the invention is to increase the range of telephony, or to enable the telephone to carry farther than has heretofore been found practicable, as well as to increase its effectiveness for shorter lines, more particularly such as have heretofore overtaxed the capacity of the telephone.

By my invention not only is interference from other circuits minimized or practically obviated, but the electrical capacity of the line, instead of looming up as an obstacle, as heretofore, is turned to advantage, so that a line of great capacity may transmit better than a line of very small capacity. The line wire may hence be of considerable thickness, if desired.

In telephoning, one end of an induction coil is joined or electrically connected to the transmitting line-conductor, and the other end of said coil is grounded. A receiver is connected to the far end of the other line-conductor, that is to say, the coil usually forming part of the receiver is so connected, while the other end of said receiver coil is grounded. Thus a broken circuit is formed, beginning say at the dead end of the receiving line-conductor, and extending thence to the receiving station, thence through the earth back to the transmitting station, and thence to the dead end of the transmitting line-conductor. The sound-generated or produced electricity present in the induction coil flows or spreads through the transmitting line-conductor toward the far station, and throughout its flow induces correlative or opposite-sign electrification of the receiving line-conductor, so that the appliances connected to the far end of the latter are affected accordingly, causing the reproduction of the original sound.

In the accompanying drawings, Figure 1 is a diagram indicative of the general arrangement of the form of telephonic apparatus preferred for a private line, including transmitters, receivers, and a main line (the latter consisting of parallel conductors) extending between stations. In order to indicate great length, the line is represented in this figure as extending in a zigzag direction. Fig. 2 is a diagram illustrative of a method of signaling from either station to the other. Fig. 3 is a diagram of a portion of a main line, illustrating a method of crossing or twisting exposed overland line-conductors, so as to reduce interference from other lines or from earth currents. Fig. 4 is a cross section of a land cable containing inductively coöperating conductors separated by a dielectric. Fig. 5 is a plan, upon an enlarged scale, of the apparatus employed at each end of the main line at Fig. 2, for both making a visual signal to the receiving operator, and also closing a local bell circuit at the receiving end of the line, thereby giving in addition an audible signal. Fig. 6 is a diagram illustrating a telephone trunk line with its branches. Fig. 7 represents, upon an enlarged scale, a cross-section of a land cable taken through a condenser, and giving an edge view of the condenser armatures and a dielectric sheet, spread open. Fig. 8 is a side view of the devices illustrated at Fig. 7, and shows how the cable may at intervals be stripped of its insulation, thus laying the conductors bare, so that condensers may be applied thereto. Fig. 9 is a diagram illustrative of a broken induction circuit, of which the earth forms the return member. Fig. 10 is a diagram of a simplified telephonic apparatus.

In the several views, similar parts are designated by similar numerals of reference.

At Fig. 1 the terminal apparatus is substantially duplicated at the stations, so that conversation may be conducted over the line. 1 designates a primary coil and 2 a battery, both included in a transmitter circuit 3, a transmitter of the usual type being depicted at 4. At 5 is represented an induction coil, one end whereof is grounded at E, and the other end whereof is connected, (through the usual coil of a telephone receiver 6) to a line-conductor. Twin line-conductors are indicated, one thereof, marked 7, being connected at one end to the induction coil 5 at the left of said figure, and being insulated or hanging dead at its remote end at 7^a; while the other line-conductor is connected at one

end to the induction coil 5 at the right of said figure, and is also insulated at its inactive terminal 8^a.

As the effectiveness of the apparatus depends in a large measure upon the mutual electrical capacity or upon the degree of the mutual inductive action of the line-conductors, I recommend that such capacity or inductive power be augmented by means of a number of condensers 9, joined in parallel by the line-conductors and arranged at intervals of one to ten miles or more, the frequency of the condensers depending upon their individual capacities, the proximity and hence the mutual capacity of the line-conductors themselves, the liability of interference from other circuits or from earth currents, etc. Where the line is short, or where other causes make it necessary, the condensers may be applied at less than mile intervals, in order to secure the required capacity. When the line-conductors run closely side by side, one may more readily induce electrification of the other, and hence there is less need for the application of condensers at frequent intervals, and in some cases the condensers may even be omitted; but where the conductors are widely separated and can directly affect each other little or perhaps not at all, it becomes necessary to provide them with one or more condensers between stations, in order to enable the line-conductors to coöperate.

When sound enters the transmitter, say at the left of Fig. 1, undulations are set up in the transmitter circuit 3, as usual in telephony; or in other words, rapid fluctuations occur in the quantity of electricity flowing in the circuit, and by an inductive process the coil 5 is affected accordingly. A sudden increase in the strength or voltage in the primary current and hence in the flow of electricity through the primary coil 1 induces a negative electrification of the induction coil 5, while a sudden decrease in the primary current induces a positive electrification of the induction coil. Such changes follow one another with great rapidity in the primary coil and in the surrounding induction coil, and since the latter may be wound with finer wire and may have more turns than the former, the fluctuations produced in the induction coil 5 may be made sharper, and of more widely varying potential.

For convenience, the mutating electrical conditions of the coil 5 may be regarded as electrostatic, or as charges rather than currents. When a negative charge is induced in said coil 5 by the primary coil, a positive charge is repelled to earth at E, while said negative charge is distributed both along the condenser armatures which are joined to said conductor, thereby inducing a positive charge both in the other line-conductor 8 and in the condenser armatures which are joined to the latter, and hence repelling a negative charge to earth through the coil mounted in the receiver 6 joined to the receiving line-conductor 8 at the station upon the right of Fig. 1, whereby the bar magnet in said receiver is affected, and causes the diaphragm usually arranged therein to generate or rather reproduce sound.

It will be understood that the negative charge repelled to earth through the receiver at the right-hand station substantially balances the positive charge repelled to earth from the induction coil 5 at the left-hand station, and hence that the earth serves as a "return." The line circuit may therefore be regarded as beginning at 8^a, and extending thence along the conductor 8 and through the receiver coil joined thereto into earth, thence back through the earth to the induction coil 5 at the left-hand station, and thence along the line-conductor 7 to its termination at 7^a, as illustrated at Figs. 1 and 9. By means of the ground connection, the instruments at the respective stations are electrically connected independently of the line-conductors. Although the line circuit is broken, so that a continuous current may not flow around the same, still it will be understood that in a broad sense the circuit forms a complete operative device, and that the mutual inductivity of the parallel line-conductors may be regarded as a substitute for the expedient heretofore practiced of sending a current directly around a closed circuit from one station to another and back to the starting point.

Thus it will be perceived that the varying electrical impulses occasioned by the entrance of sound into the transmitter are caused to flow towards the receiving station, and to induce correlative impulses in a line-conductor which extends from the far station towards the transmitting station, such induction preferably taking place throughout the entire flow or spread of the charges or impulses along the transmitting line-conductor; or in other words, the electrification of the receiving line-conductor is effected at successive points throughout the flow of the transmitting charges towards the receiving station, that is, said transmitting charges perform their function *en route*. The receiving line-conductor may thus be directly affected by the transmitting line-conductor right up to the receiving station, so that the distance over which either wire 7 or 8 acts merely as a solitary line for the conveyance of electrical impulses may be reduced to *nil*. Hence in one view of the invention, the telephone line heretofore employed may be regarded as being eliminated, even though the stations may be separated by many leagues; and the earth-connected line-conductors, taken together, may be regarded simply as constituting an instrument extending from one station to the other, its internal opera-

tions being performed with practically uniform power and effectiveness throughout its length, and the impulses delivered at one end thereof comparing quite favorably in point of strength and sharpness with the impulses sent into the other end thereof. In this connection it will be perceived that by correlating the conductors 7 and 8, so that the momentary charges in each may be "bound" by the charges in the other, interference from other circuits or from earth currents may be practically eliminated. The more intimately the conductors are associated, or the greater their mutual capacity, the less will their work suffer by reason of outside interference. Moreover, the solitary line over which the impulses must pass before the correlative action begins or after it ends may be eliminated, or at least so shortened as not to impair the efficiency of the apparatus.

In the foregoing description it has been assumed that sound is originated at the left-hand station at Fig. 1 and emitted or reproduced at the right-hand station; but it will be observed that the appliances at each station are substantially duplicate, so that sound spoken into the transmitter at the right-hand station may be reproduced at the left-hand station. In this case the wire 8, which is joined to the secondary 5 of the transmitting apparatus at the right-hand station, acts as the transmitting line-conductor, and induces impulses in the wire 7, which in this case acts as receiving line-conductor, whence the impulses flow through the coil in the receiver 6 at the left-hand station and into earth. Thus it will be seen that the impulses generated at either station flow out therefrom over the same route that is followed by impulses coming in from the direction of the other station. Although either of the line-conductors may thus be caused to serve as either transmitting or receiving line-conductors, still for convenience the line-conductor which is grounded at a station may be regarded as the transmitting line-conductor for that station.

As it is desirable for the line-conductors to have considerable mutual capacity, I prefer to employ frequent condensers 9, which are joined in parallel by the line-conductors so as to increase the total capacity of the line. One advantage of large capacity in my system arises from the increased or more powerful charge of electricity that is caused to flow from the secondary coil into the line-conductor, so that a greater amount of electricity is repelled oppositely from said coil to earth; and correlatively a greater charge is induced in the receiving line-conductor and a greater amount of electricity is repelled to earth through its receiver coil, which correspondingly affects the receiver diaphragm, so that the latter is more powerfully actuated.

Although by the enlargement of the area or capacity of the transmitting conductor the potential thereof at all points is correspondingly reduced, nevertheless the extension of the induction surface secured by introducing the condensers enables a larger aggregate charge to be induced in the receiving line-conductor, and the inductive action is hastened, so that the receiver diaphragm is given a quick and powerful vibration. A further advantage of enlarged capacity resides in the fact that the opposite electrifications simultaneously permeating the line are more closely bound together, and hence less liable to be affected by the earth "return" or by any outside influences. The more frequent and capacious the condensers 9, the less the liability of interference, and the more faithfully are the original impulses reproduced at the receiving station; and it is obvious that by employing suitable frequency and capacity of condensers, interference may be practically eliminated.

Each of the conductors may consist of either a single coarse wire or of a strand of wires, or any other form of conductor may be employed. By placing the conductors close alongside of each other, their mutual capacity is increased, with corresponding benefit, although they should not be placed so closely together that disruptive discharges will be liable to occur between them. By making the conductors of suitable size and length, and associating them closely together, so much capacity may be secured, that the condensers may be omitted.

In an overland cable (Fig. 4), the twin conductors may be made of thick wire and lie closely side by side, forming a double core, each conductor being embedded in a sheath 10 of rubber or other dielectric, the latter being provided with one or more fibrous or other coverings 11.

It is not essential that the terminal apparatus should be arranged precisely as indicated at Fig. 1, or operate in precisely the manner described.

The invention is not limited to the methods of electrifying the transmitting line-conductor detailed herein. In adapting the general features of invention to other specific uses, other means may of course be employed for electrifying one of the conductors comprised in the line, and the electrification induced in the other of said conductors, or discharging into "return" therefrom, may be utilized by other terminal appliances.

At Figs. 2 and 5 is illustrated a form of electroscope which may be employed in calling or sending signals of any sort from one station to the other. A set of fixed quadrants 15 is connected at each station to the insulated end (7^a or 8^a) of the receiving line-conductor. Just over the quadrants a flat light needle 16 is suspended by means of a thin

torsion wire 17, and the transmitting line-conductor is connected thereto. Switches 18 may be interposed between the electroscope and the line-conductors, whereby the former may be cut out when the telephone is in active use. When the switches are closed, charges of opposite sign present in the line-conductors may flow or distribute into the quadrants and needle respectively, and in consequence the vanes of the needle will be attracted by the quadrants, and hence rotate from their normal positions above the gaps, and take positions directly over the quadrants, the suspending wire 17 being of course the axis of rotation. The quadrants may be made of brass or copper, and the needle may consist of foil spread upon the under side of a suitably shaped card. At each station is provided a battery 19, which the operator may control by a switch or key 20, which is preferably arranged between the transmitting line-conductor and the telephone T, thus one operation cutting out the telephone and causing a charge to flow from the battery into said line-conductor (an opposite charge being repelled to earth), whereby the quadrant at the far end of the line is electrified, and whereby also a charge of opposite sign is induced in the receiving line-conductor (from whose remote end an equal charge is repelled to earth), so that the far needle 16 becomes likewise charged and is caused to vibrate, thus visually notifying the far operator that his station is being called.

An audible signal may be produced by rigidly mounting an aluminium or other circuit-closer 21 upon the needle, whereby a local bell-circuit 22 may be completed, causing a bell to ring at B, thus indicating to both the eye and ear of the operator that the other operator is calling. Of course neither line-conductor should be so powerfully electrified as to cause a disruptive discharge to occur at any point, particularly in the condensers, when these are employed. Other methods of signaling may be resorted to.

Instead of grounding the telephone coils to which the active ends of the line-conductors are joined, said coils may be connected by a return wire 23, as indicated by a dotted line at Fig. 2, which may be of considerable thickness, and should be as widely separated as practicable from the line-conductors 7 and 8 included in the same broken circuit therewith, so as to avoid disturbance of the charges in said conductors, which might otherwise occur because of the mutual attraction between the return and the conductors.

At Fig. 3 is illustrated a method of crossing exposed line-conductors at intervals, whereby liability of interference either from other currents or from "return" may be reduced.

At Fig. 6 line-conductors are indicated as extending in pairs between central stations or telephone exchanges, the latter being marked at A, D, F, G, H, J, L, M, and R. If a subscriber S, connected say to central office G, desires to converse with a subscriber whose lines run to any other central office, as at J, one of the usual twin local lines going from G to S is grounded at G, and the other thereof is connected with the line-conductor 7; and at each of the intervening central stations A, D, R, and H appropriate connections are made, so that the line-conductors 7 and 8 may extend unbrokenly from G to J. At the latter station the end of line-conductor 8 is connected to one of the twin local lines going to the subscriber, while the other of said local lines is grounded by the central operator. When these connections have been made, the operation of telephoning between the subscribers proceeds in the manner already narrated in connection with Fig. 1. The local lines may be many miles in length, so that by the use of a few trunk lines and ramifying local lines, telephoning may be conducted among points distributed over wide territory, any subscriber being able to converse with any other subscriber throughout the system.

What I claim as new, and desire to secure by Letters Patent, is as follows:

1. A telephonic apparatus comprising line-conductors, condensers arranged at intervals therealong and joined in parallel thereby, a grounded induction coil joined to one end of one of said line-conductors, a transmitter circuit for affecting said induction coil, and a grounded receiver connected to the remote end of the other line-conductor.

2. A telephonic apparatus comprising line-conductors, condensers arranged at intervals therealong and joined in parallel thereby, an induction coil joined to one end of one of said line-conductors and forming part of a transmitting appliance, a receiver joined to said coil, a like induction coil and a receiver both joined to the remote end of the other line-conductor, and means for electrically connecting said induction coils and receivers independently of said line-conductors.

3. A telephonic apparatus comprising line-conductors running closely side by side, each having one end free, condensers arranged at intervals therealong and joined in parallel thereby, grounded transmitting and receiving devices connected to one end of one of said line-conductors, and grounded transmitting and receiving devices connected to the remote end of the other of said line-conductors.

4. A telephonic apparatus comprising a transmitter circuit including a primary coil, a grounded induction coil joined to one end of a line-conductor, a grounded receiver also connected to said end of said line-conductor, a second line-conductor, condensers arranged at intervals along said line-conductors and

joined in parallel thereby, a grounded induction coil joined to the remote end of said second line-conductor, a transmitter circuit including a primary coil for affecting the last mentioned induction coil, and a grounded receiver also joined to said remote end of said second line-conductor.

5. An apparatus for the transmission of intelligence, comprising line-conductors, condensers arranged at intervals therealong and joined in parallel thereby, means for sending varying impulses into one end of one of said line-conductors, means connected to the remote end of the other line-conductor for rendering intelligible impulses induced therein by the transmitting line-conductor, and means for electrically connecting said sending means with said receiving means independently of said line-conductors.

Signed at Elizabeth, State of New Jersey, this 15th day of May, 1901.

FREDERIK SINDINGCHRISTENSEN.

Witnesses:
B. C. STICKNEY,
BENJAMIN M. OGDEN.