No. 777,324. PATENTED DEC. 13, 1904.

C. ADAMS-RANDALL.

TELEPHONE SYSTEM.

APPLICATION FILED DEC. 22, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.

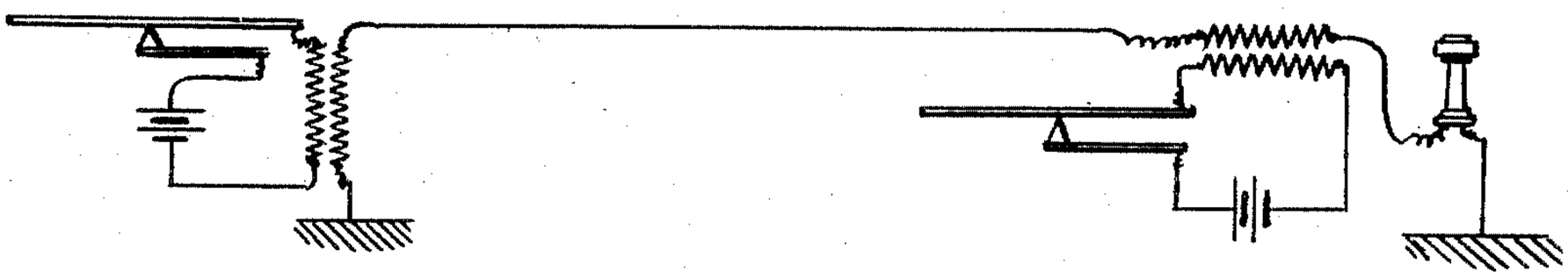


Fig. 2.

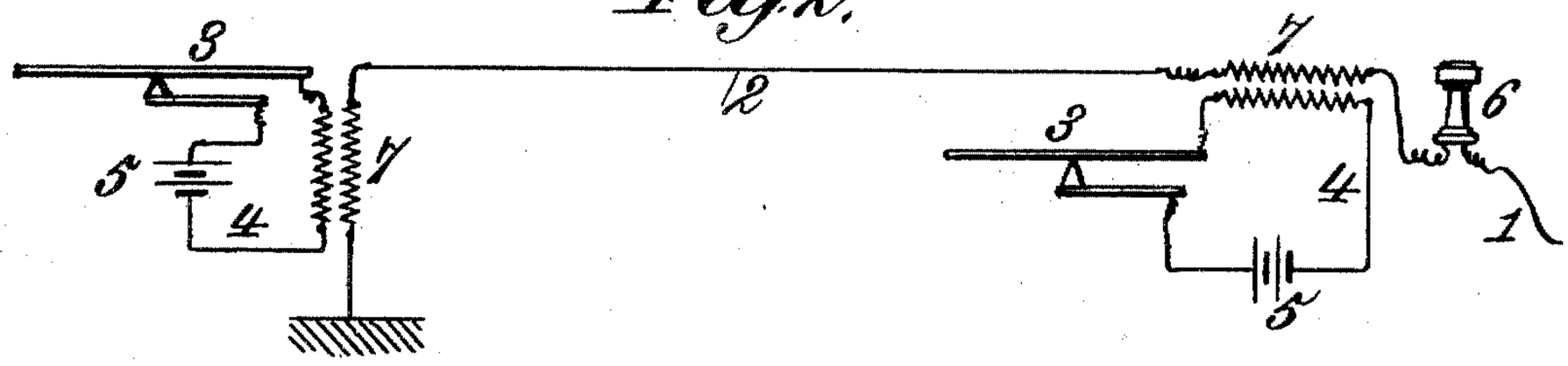


Fig. 3.

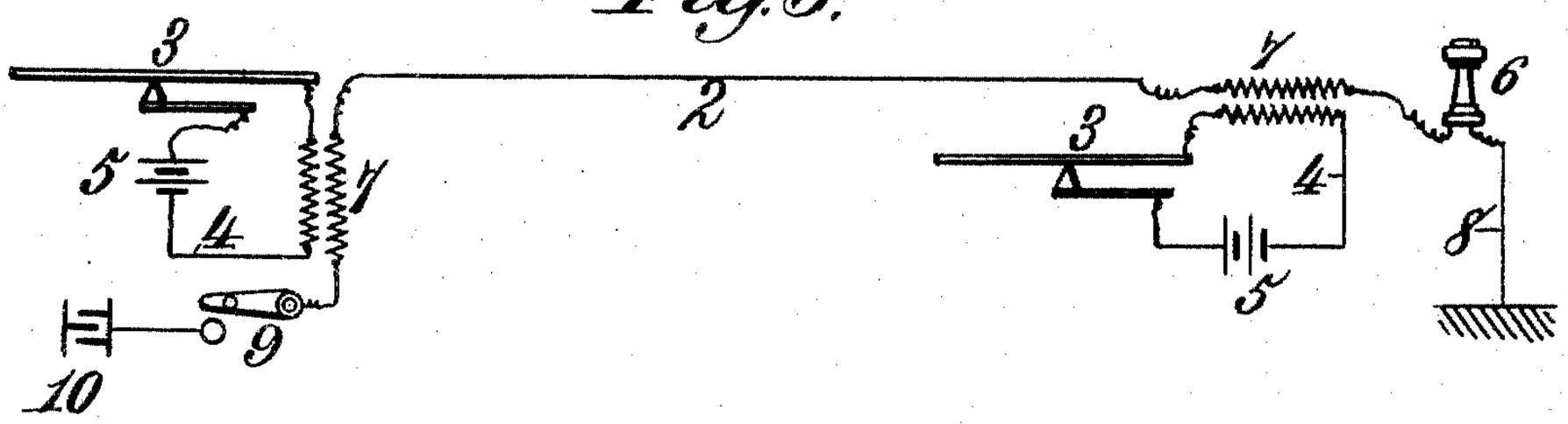
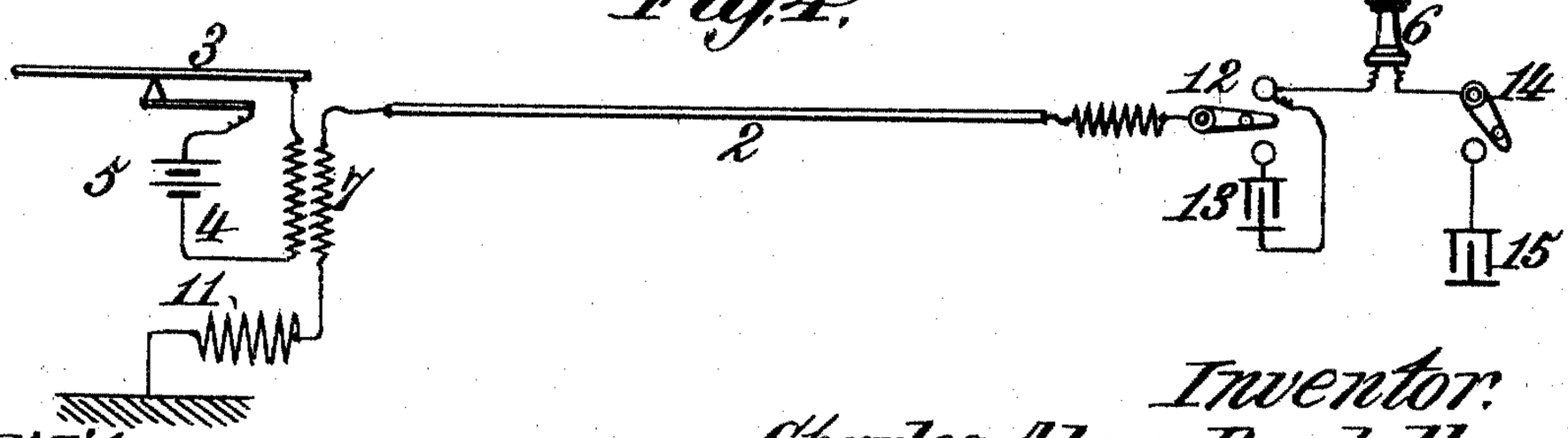


Fig. 4.



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TELEPHONE SYSTEM.

APPLICATION FILED DEC. 22, 1903.

NO MODEL. 2 SHEETS—SHEET 2.

Fig. 5.

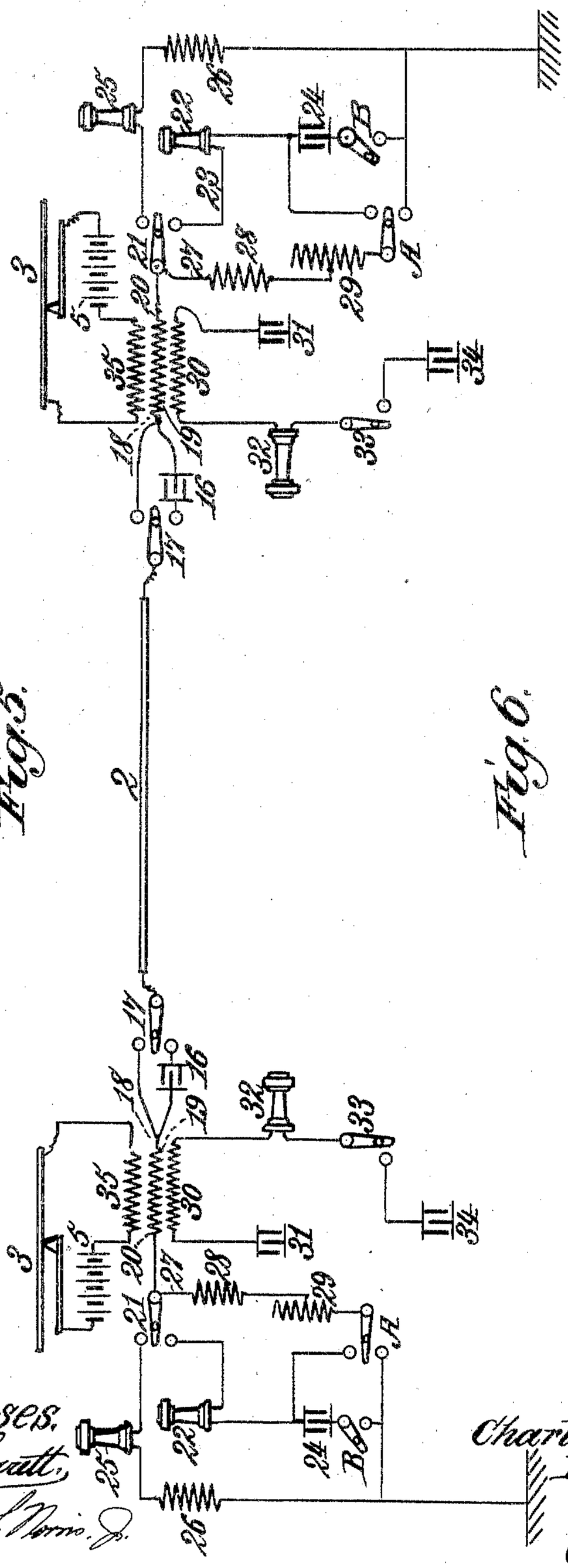
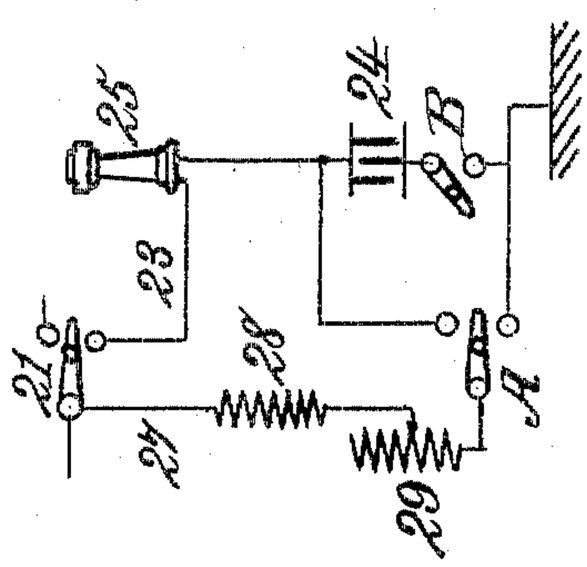


Fig. 6.



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No. 777,324. Patented December 13, 1904.

UNITED STATES PATENT OFFICE.

CHARLES ADAMS-RANDALL, OF BOSTON, MASSACHUSETTS.

TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 777,324, dated December 13, 1904.

Application filed December 22, 1903. Serial No. 186,198. (No model.)

To all whom it may concern:

Be it known that I, CHARLES ADAMS-RANDALL, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented new and useful Improvements in Telephone Systems, of which the following is a specification.

This invention relates to electric telephony, and has for its object to telephonically transmit articulate speech over underground and submarine cable circuits and land-lines, being especially applicable to circuits having what is known in the art as "high static capacity."

In telegraphy the static capacity of a submarine or underground cable has been found to affect the transmission of electric impulses thereover, limiting the distances that messages can be sent reliably and also the speed of transmission. This has also been held to apply to telephoning, and the limiting distance of transmission of speech by telephony has been mathematically formulated under what is known as the "K. R. law," which (it has been calculated) gives the limiting distance or K. R. at which the transmission of speech is good or satisfactory, as follows: for overhead copper wire, ten thousand K. R.; for cables and underground circuits, eight thousand K. R.; for overhead iron wires, five thousand K. R. This law has been generally accepted and applied (with some modifications) by electrical engineers in the construction of telephone-circuits. By means of my present invention, however, I have transmitted articulate speech over iron-wire circuits having a K. R. many times greater than the above-calculated K. R. and over artificial cables of high capacity and resistance up to a K. R. of five million nine hundred and eighty-five thousand. To enable me to accomplish such a result, I have made important discoveries and improvements, which constitute the subject-matter of the present invention herein described.

An important feature of my invention consists in leaving the line-circuit open at one end, which may be either the transmitting or the receiving end, in combination with other features hereinafter described, and particularly pointed out in the claims following the description. I have also discovered that both ends of the circuit may be left open and the speech telephonically transmitted in a thoroughly practical manner over long distances, such circuit having normally or provided artificially with the proper resistance and capacity, and especially if a suitable impedance is inserted in the circuit between the transmitter and the usual ground terminal disconnected from the ground. By such arrangement a return-wire or an earth-return is not used or required.

In carrying my invention into practice in such manner as to obtain the best results the main features to be observed and the apparatus to be used in combination with the above-described arrangement of circuits consist, first, of a telephonic transmitter capable of carrying and varying an electric current expressed in watts or mille-watts sufficient for or corresponding to the work to be done in the line-circuit; second, the provision of one or more induction-coils having the primary or primaries constructed and adapted to the current to be used in the local circuit with the transmitter, the secondary coil or coils being wound to give the desired electromotive force in the line or cable; third, in the provision of a compound-wound coil or helix having three or more independent coils, the line coil or coils being arranged either for receiving or for transmitting; fourth, the use of a shunt or derived circuit around the receiver or connected directly to ground and having included therein an impedance and resistance, or either of them.

The distinctive features of my invention will be fully set forth in the following description and illustrated in the accompanying drawings, wherein—

Figure 1 is a diagrammatic view illustrating a grounded telephone-circuit well known to those skilled in the art and in common use. Fig. 2 is a similar view of such a circuit arranged according to my invention and ungrounded or open at the receiving end only.

Fig. 3 is a similar view of such a circuit ungrounded at the transmitting end only. Fig. 4 is a view of such circuit grounded at the transmitting end through an impedance interposed between the line-coil and the ground, the receiving end being open or connected to a condenser. Fig. 5 is a view illustrating a line or cable connected at each end to a tertiary coil and means for connecting and disconnecting either or both ends from the ground separately or conjointly, as may be desired; and Fig. 6 is a detail view illustrating the shunt or derived circuit and connection at the receiving end.

The usual normal connections of a grounded telephone-circuit are shown in Fig. 1 of the drawings and are well understood by those skilled in the art and need not, therefore, be herein described in detail. I have discovered that if such a circuit or cable has normally or has artificially imparted thereto the proper electrostatic condition the connection between the receiver and earth may be broken or disconnected and the wire left open at that end, as indicated at 1 in Fig. 2 of the drawings, under which conditions the receiver will reproduce the transmitted speech with a greater volume of tone and will also work on longer circuits than would be possible in the arrangement shown in Fig. 1. In said Fig. 2 the numeral 2 indicates the line-wire; 3, transmitters arranged in local circuits 4, which also include batteries 5; 6, the receiver, and 7 the induction-coils, the primaries of which latter are included in the local circuits and the secondaries in the line. It will be obvious that any variations set up in the local circuit by the transmitter will be transmitted by the primary of one induction-coil to the secondary thereof and transmitted over the line to the receiver 6.

In Fig 3 of the drawings the receiver 6 is connected to ground by a conductor 8 and the ground connection from the induction-coil 7 at the transmitter is left open by means of a switch 9 or is connected to a condenser 10 by means of said switch. In such an arrangement results corresponding to those obtained with the arrangement illustrated in Fig. 2 are obtained.

In the arrangement shown in Fig. 4 an impedance 11 (a coil or the like) is interposed between the induction-coil 7 and the ground at the transmitting end. At the receiving end the receiver 6 has one terminal connected directly to the cable-wire through a switch 12 or is connected thereto through a condenser 13 by means of said switch 12, the other terminal of the receiver being connected to a switch 14, which may be either left open, held in the hand of the operator, or connected to a suitable condenser 15. In such an arrangement the impedance seemingly acts as a dam or obstruction and forces the induced currents over the circuit to the receiver, as the loudness and clearness of the sounds reproduced by the receiver is greatly increased over that obtained in the arrangement shown in Figs. 2 and 3 of the drawings.

In Fig. 5 I have shown another arrangement of the receiver and transmitter circuits in combination with other features forming a part of my invention. In such arrangement the cable 2 is connected either directly or through a condenser 16 by any suitable means—such, for example, as a two-way switch 17—to one end, 18, of one of the coils 19 of a compound coil having three or more independent helices, the other end, 20, of said coil being connected to a suitable switch 21, and therefrom the current passes to a receiver 22 by wire 23, the other end of the terminal of the receiver being preferably connected to a condenser 24, which may, if desired, be connected to ground by means of a switch B, or the switch 21 may be turned to connect the cable to one terminal of a receiver 25, the other terminal of which is connected through an impedance 26 with earth. The cable is also connected around the receiver 22 or to the ground by means of a two-way switch A by a shunt-circuit wire 27, connected to the switch 21, the shunt-circuit having included therein an impedance 28 or a resistance 29, or both the resistance and the impedance. The second coil 30 of the tertiary coil is connected at one end to a condenser 31, the other end being connected to one terminal of a receiver 32, the other terminal of said receiver being left open or connected by means of a switch 33 to a condenser 34. It will be apparent that by the use of a second local circuit the receiver 32 is removed from the direct main-line circuit or cable and is ungrounded, whereby it is less affected by the earth-currents upon or discharging from the line or cable. The third coil 35 should be of low resistance and is located in the local circuit which includes the transmitter 3 and battery 5. The circuit used and connections shown in Fig. 5 of the drawings are normally the same or duplicates of one another at each end of the line circuit or cable.

In the arrangement last described, the circuit being ungrounded at one end, and preferably at the receiving end, I have transmitted and reproduced articulate speech practically and satisfactorily over circuits having very high static capacity when using proper current energy at the transmitter.

In the application of the telephone to actual use upon submarine and underground cables I have found that under some conditions of such circuits the receiver is detrimentally affected by what is termed in the art "earth-currents," an electric condition of the cable resulting seemingly from contact with the earth even though insulated therefrom. To

overcome and prevent this detrimental effect or action of the earth-currents upon the receiver, I place a shunt or derived circuit around the receiver, as before described, and, as most clearly shown in Fig. 6 of the drawings, such circuit including an impedance 28 and an adjustable or variable resistance 29. This arrangement constitutes an important improvement, as the earth-currents are thereby shunted from the receiver-coil and telephone currents or a large percentage thereof are prevented from passing over the shunt-circuit because of the impedance therein, which impedance being of low resistance does not stop or impede the discharge of the accumulated earth-currents to ground, whereby the detrimental effects of the earth-currents are prevented and the quick natural action of the receiver is obtained.

Whatever may be the scientific explanation of the various phenomena that I have observed in the practical use of the novel arrangement of circuits herein described and forming a part of this invention, the receiving apparatus does in practice faithfully reproduce both in quality and characteristics the electric vibrations generated in the transmitter-circuit, and these electrical vibrations may be transmitted over lines of great length. The vibrations are seemingly transmitted with an intensity and volume dependent only upon the potential or current energy employed at the transmitting end of the line and without any of the evil effects of retardation due to static capacity experienced in telegraphy.

Having described my invention, what I claim is—

1. In telephony, a main line, a telephone-transmitter arranged in a local circuit at one end of said line, a battery included in said local circuit, an induction-coil having the primary thereof forming a part of the said local circuit and the secondary forming a part of the main line, an impedance arranged in the line-circuit, a receiver in the line-circuit, and a condenser between the receiver and earth.

2. In telephony, a main line or cable, a suitable transmitter and receiving apparatus, in combination with a condenser coöperating with said apparatus, a coil connecting the receiving end of the main line to the receiver, a conductor leading from the receiver, and an ungrounded condenser connected to said conductor.

3. In telephony, a main line or cable, a suitable transmitting and receiving apparatus, in combination with a condenser and coil, a receiver, and an impedance connecting the receiving end of the main line with ground in the order named.

4. In telephony, a main line or cable, in combination with suitable transmitting and receiving apparatus, the receiving end of the main line being connected to earth through a condenser, a coil and a split circuit, one branch of said split circuit including a receiver and a condenser, and the other branch being connected to ground through an impedance.

5. In telephony, a main line or cable, in combination with suitable transmitting and receiving apparatus, a split circuit connecting the receiving end of the main line with ground, a receiver and a condenser included in one branch of the split circuit and an impedance included in the other branch of said circuit, and a condenser arranged between the receiving end of the main line and the split circuit, substantially as and for the purpose specified.

6. In telephony, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at one end of the main line having three independent helices one of which is included in the main line-circuit and the other two helices being connected up in local circuits and suitable line and local connections, substantially as and for the purpose specified.

7. In telephony, a main line or cable, in combination with suitable transmitting and receiving apparatus, and a shunt-circuit around the receiving apparatus and connectible either to the latter and the main line or to the receiving apparatus and earth, substantially as and for the purposes specified.

8. In telephony, the combination with a main line or cable and suitable transmitting and receiving apparatus, said main line being ungrounded at the receiving end through the receiver, and an impedance interposed in the transmitting end of the main line between the latter and earth, substantially as and for the purpose specified.

9. In telephony, the combination with a main line or cable and suitable transmitting and receiving apparatus, said main line at the receiving end being ungrounded and connected to a condenser, and an impedance interposed in the transmitting end of the main line between the latter and earth, substantially as and for the purpose specified.

10. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line or cable having three independent helices, one helix of each induction-coil being connected to the line or cable and to ground through a receiver and impedance, the other helices being connected up in independent local circuits, substantially as and for the purpose specified.

11. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at one end of the line having three independent helices, one helix being connected to the line through a condenser and to ground through a receiver and impedance, the other helices being connected up in independent lo-

cal circuits, substantially as and for the purpose specified.

12. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at one end of the main line having three independent helices, one helix of each induction being connected at one end to said line and at its other end connected to a condenser through a receiver, the other helices of each induction-coil being connected up in independent local circuits, substantially as and for the purpose specified.

13. In a telephone system, the combination with a main line or cable, and suitable transmitting and receiving apparatus, of an induction-coil at each end of the main line having three independent helices, one helix of each induction-coil being connected at one end to said line through an intervening condenser, and at its other end connected to a condenser through a receiver, the other helices of each induction-coil being connected up in independent local circuits, substantially as described and for the purpose specified.

14. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line having one of its helices connected at one end to the line, the other end of the said helix being connected to a condenser through a receiver and to ground through an impedance, one helix of each induction-coil being connected up in a local circuit with a transmitter and battery, substantially as and for the purpose specified.

15. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction at each end of the line having one of its helices connected at one end to the line through an intervening condenser, the other end of the said helix being connected to a condenser through a receiver and to ground through an impedance, one helix of each induction-coil being connected up in a local circuit with a transmitter and a battery, substantially as and for the purpose specified.

16. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line or cable having one end of one of its helices connected to the line, the other end of said helix being connected to ground through a split circuit, a receiver and condenser being included in one branch of said circuit and an impedance in the other branch of said circuit, one helix of each of the induction-coils being connected up in local circuit with a transmitter and battery, substantially as and for the purpose specified.

17. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line having one end of one of its helices connected to the line, a condenser interposed between the induction-coil and the line, the other end of said helix being connected to ground through a split circuit, a receiver and condenser included in one branch of said circuit and an impedance included in the other branch of said circuit, one helix of each of the induction-coils being connected up in local circuit with the transmitter and battery, substantially as and for the purpose specified.

18. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line having three helices, one helix of said coil being connected at one end to the line and at the other end connected to ground through a receiver and impedance, a second helix of said induction-coil being connected up in local circuit with a battery and transmitter, and a third helix of the induction-coil being arranged in a second local circuit including therein a receiver, substantially as and for the purpose specified.

19. In a telephone system, the combination with a main line or cable, and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line having three helices, one helix of said coil being connected at one end to the line through an intervening impedance, and at the other end connected to ground through a receiver and impedance, a second helix of said induction-coil being connected up in a local circuit with a battery and transmitter, and a third helix of the induction-coil being arranged in a second local circuit including therein a receiver, substantially as and for the purpose specified.

20. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil, at each end of the line having three helices, one helix of said induction-coil being connected at one end to the line, the other end of said helix being connected to a condenser through a receiver, a second helix of the induction-coil being connected up in a local circuit in a battery and transmitter, and a third helix of said induction-coil being arranged in a second local circuit in which is included a receiver, substantially as and for the purpose specified.

21. In a telephone system, the combination with a main line or cable and suitable transmitting and receiving apparatus, of an induction-coil at each end of the line having three helices, one helix of the induction-coil being connected at one end of the line, the other end of said helix being connected to ground through a split circuit one branch whereof includes a receiver and condenser and the other branch an impedance, a second helix of the

induction-coil being connected up in local circuit with a battery and transmitter, and a third helix of the induction-coil being arranged in a second local circuit in which is included a receiver, substantially as and for the purpose specified.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

CHARLES ADAMS-RANDALL.

Witnesses:
V. BIGELOW,
GUARD C. R. MARSHALL.