No. 879,438. PATENTED FEB. 18, 1908.

M. BROOKS.

TELEPHONY.

APPLICATION FILED MAY 31, 1906.

2 SHEETS—SHEET 1.

Fig. 1.

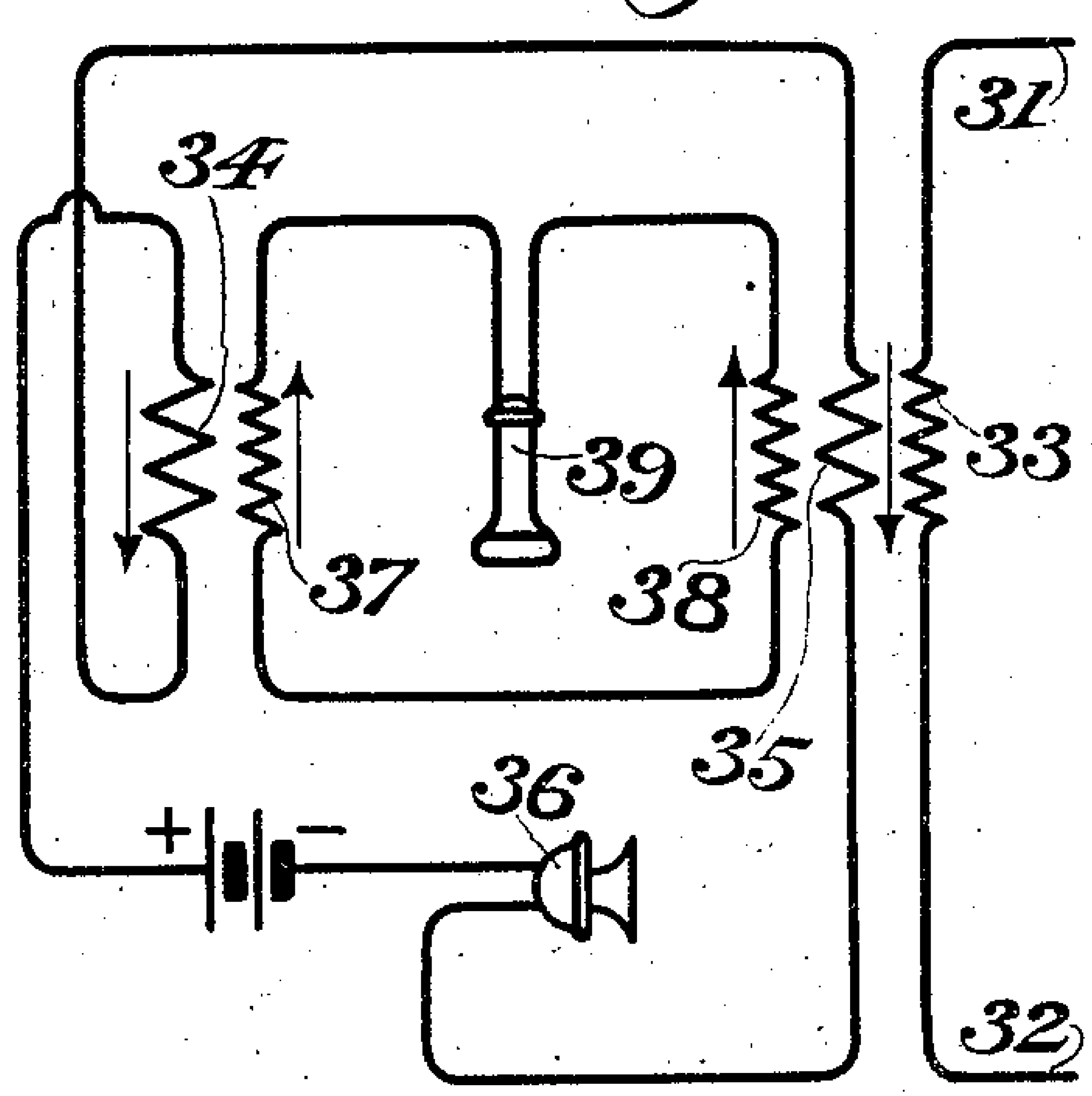


Fig. 2.

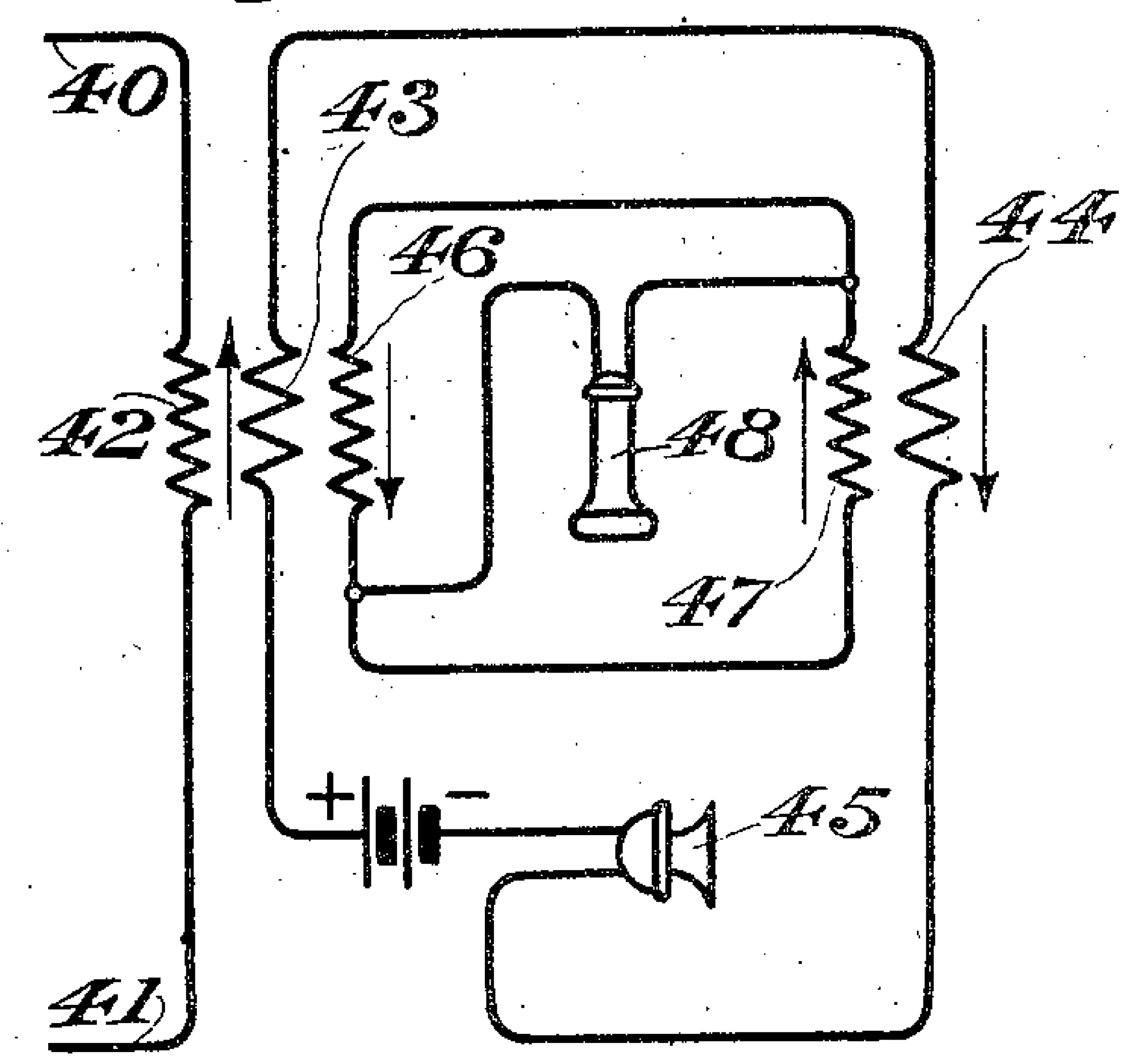


Fig. 3.

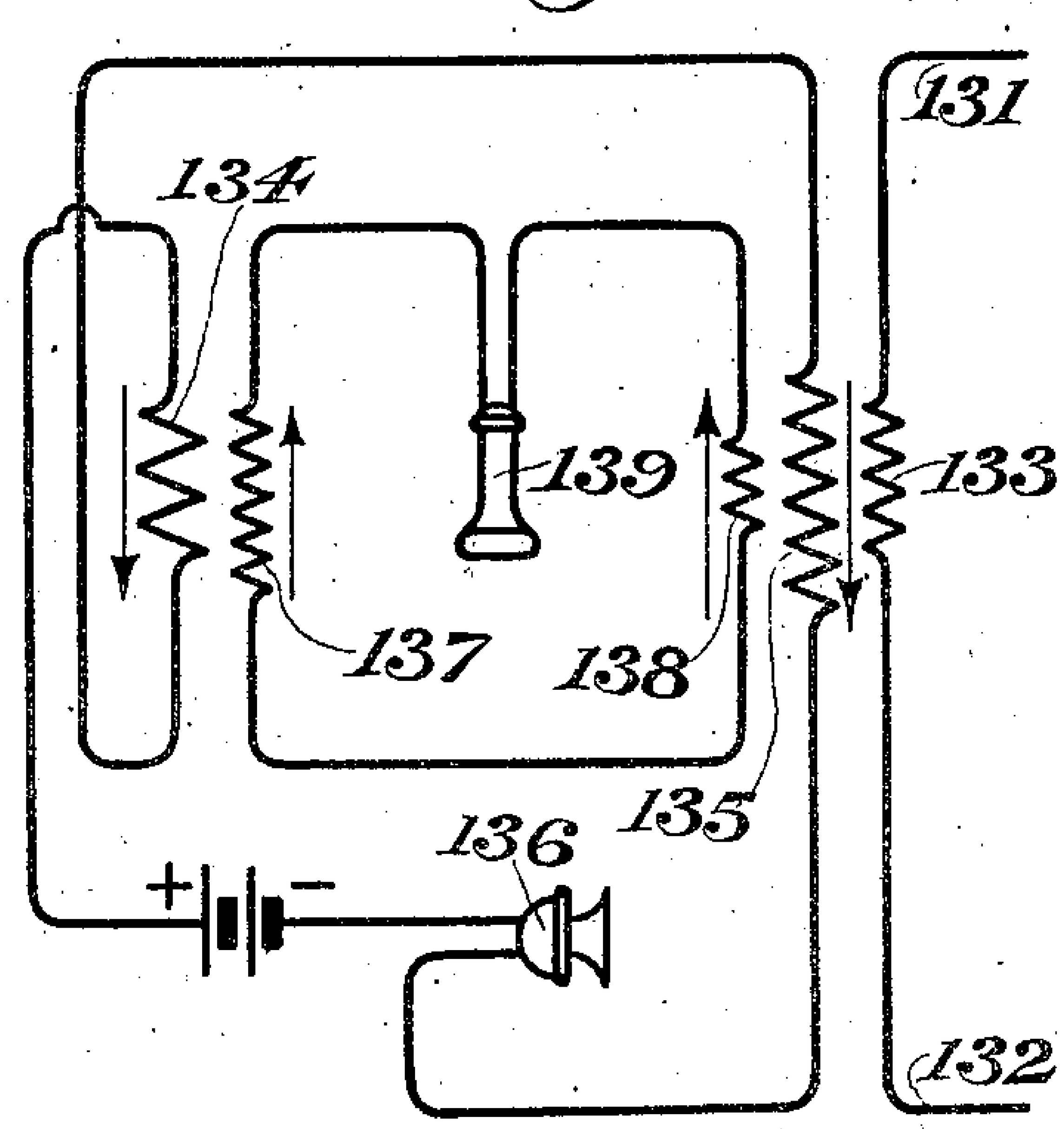
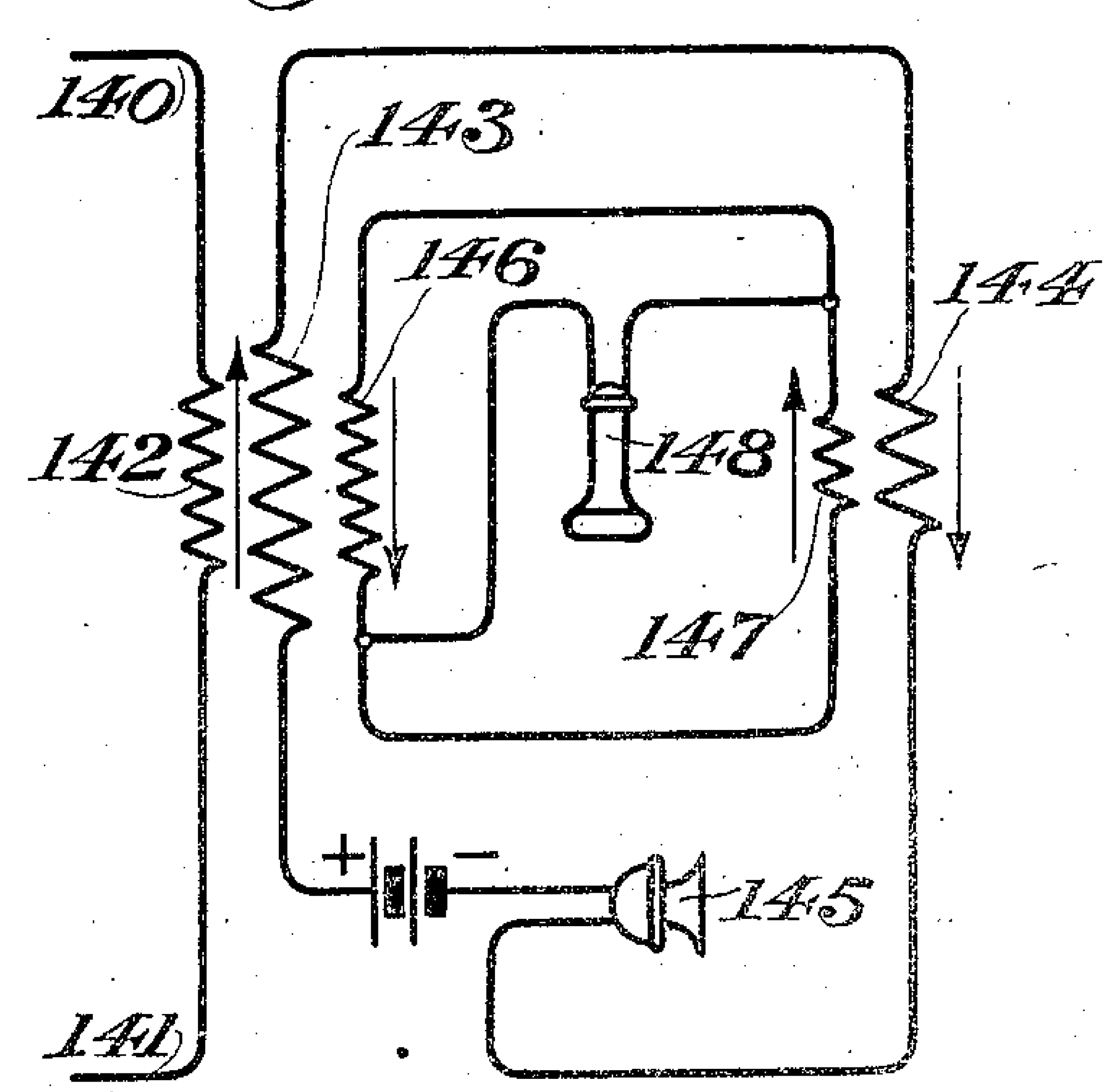


Fig. 4.



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2 SHEETS—SHEET 2.

Fig. 5.

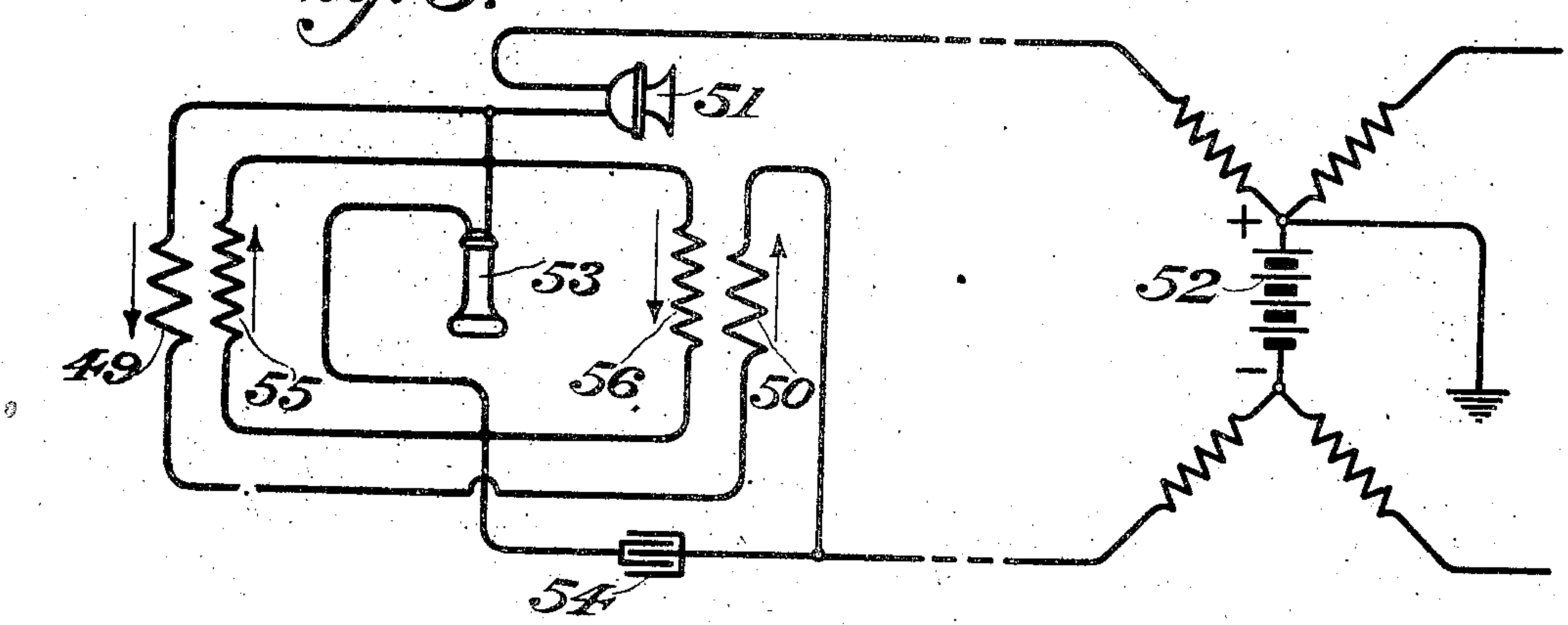


Fig. 6.

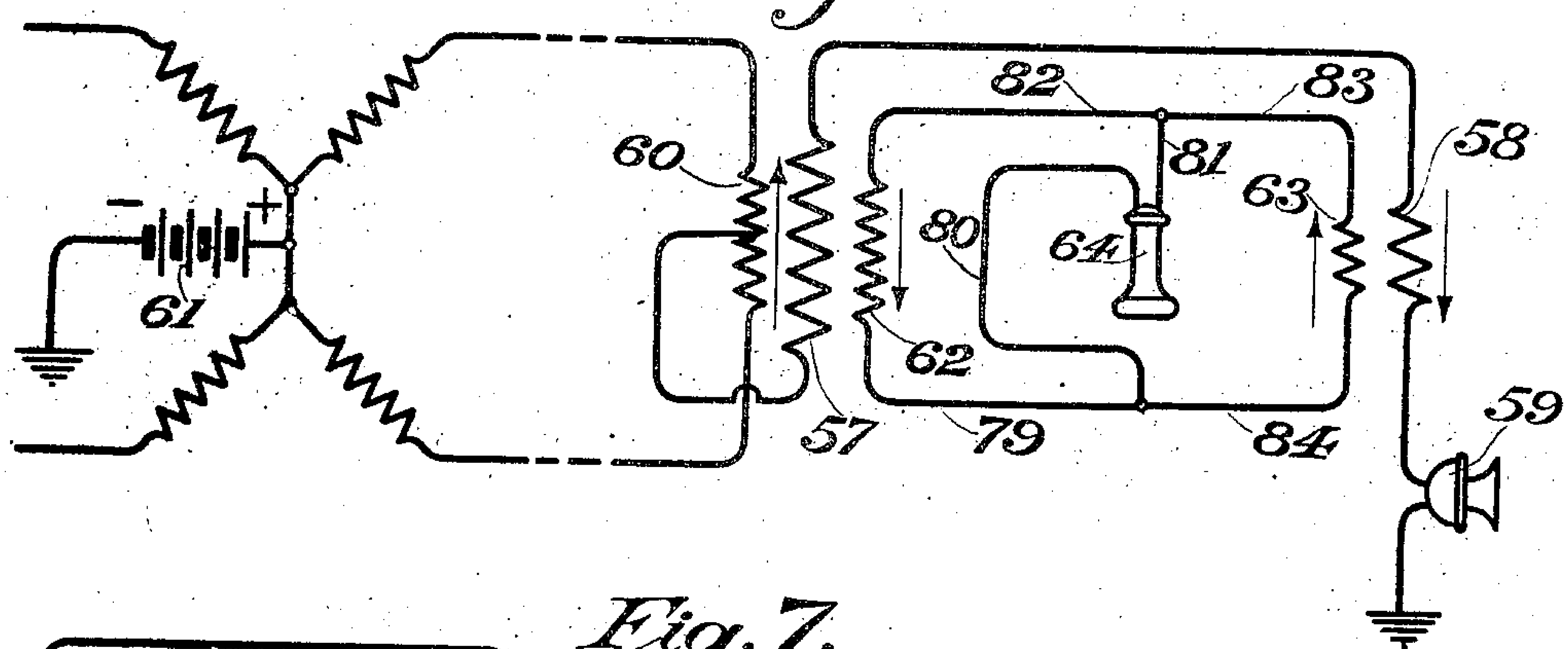
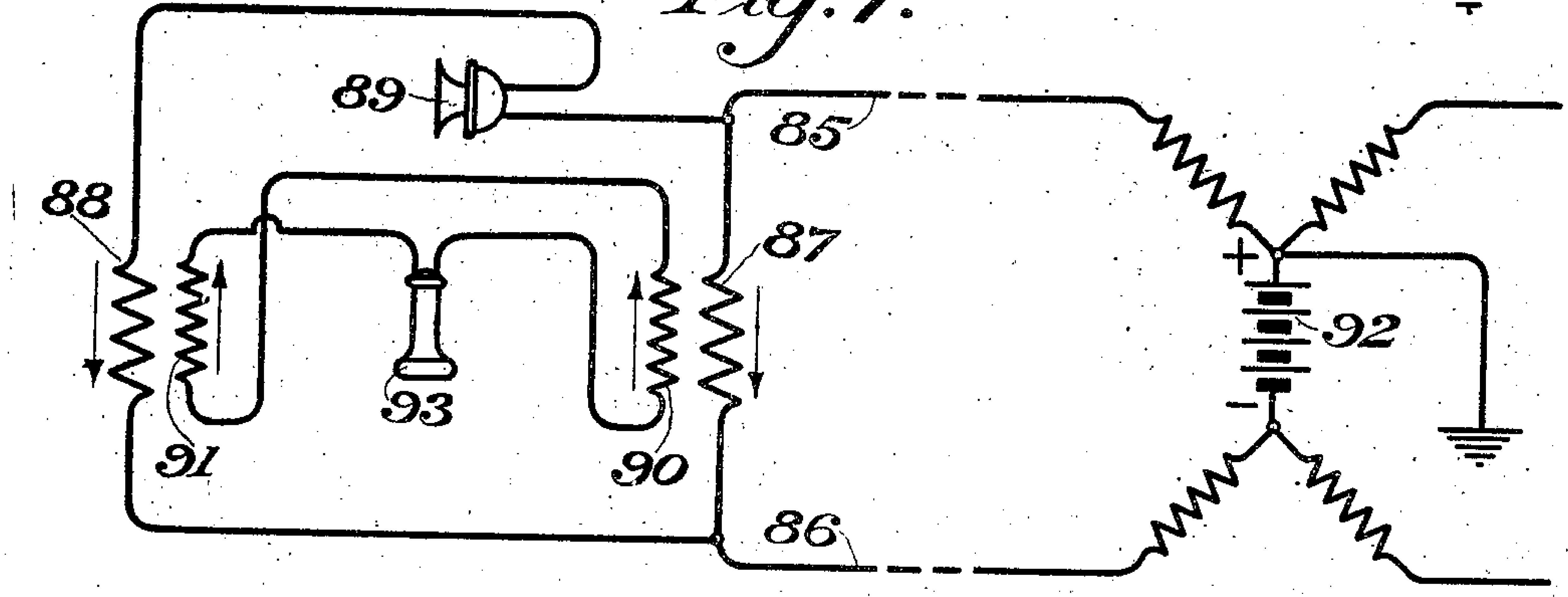


Fig. 7.



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UNITED STATES PATENT OFFICE.

MORGAN BROOKS, OF URBANA, ILLINOIS.

TELEPHONY.

No. 879,438. Specification of Letters Patent. Patented Feb. 18, 1908.

Application filed May 31, 1906. Serial No. 319,440.

To all whom it may concern:

Be it known that I, MORGAN BROOKS, a citizen of the United States of America, and a resident of Urbana, county of Champaign, and State of Illinois, have invented a new and useful Improvement in Telephony, of which the following is a specification.

My invention concerns the substation circuits of a telephone plant, and has for its object the reduction or elimination of "side tone", or that speech or noise heard in a telephone receiver resulting upon the operation of the transmitter pertaining to that receiver's substation equipment.

Side tone, always useless, becomes objectionable when loud enough to interfere with the proper function of the receiver, the reproduction of sounds produced at a distant point. Upon short lines the disadvantages of side tone are usually not serious, but when a telephone set is in a noisy position, as in a factory, the side tone due either to mechanical vibration of the transmitter, or to sounds not intended to affect the telephone, is often so serious as to prevent conversation over the telephone except in a carefully built sound-proof booth. My invention will prevent all such sounds from interfering with the proper receipt of words from the distant end of the line. Upon long distance connections, where the transmission of speech approaches the limitations of the transmitting and receiving apparatus, the side tone manifests itself to disadvantage in three ways: First, the loudness of the tone received by his own ear from his own transmitter may be painful to the speaker when speaking loudly into the transmitter, and thus he may be inclined not to speak into the transmitter with requisite loudness to secure the maximum efficiency of transmission of the transmitter and of the line conductors; second, the ear adapts itself to the volume of the side tone and thus is disabled from hearing at once the fainter volume of received speech; and, third, the incoming transmitted speech from the distant station may be so very feeble as compared with the volume of side tone that when both parties speak at once, as when one wishes to interrupt the other, the side tone of each quite obliterates the feeble transmitted speech of the other, neither knows that the other is speaking, time is lost and confusion and even misunderstanding may result.

The means here disclosed for the reduction or elimination of side tone do not involve any weakening of the sounds received from the distant end of the line. The speaker may speak more loudly into his transmitter; his ear retains involuntarily sensitiveness for weak sounds from the distant end of the line, it being unnecessary to remove the receiver from the ear in speaking, and he is immediately aware of any attempt at interruption by the distant speaker, thus avoiding the possibility of misunderstanding from simultaneous conversation by both parties, hitherto a frequent source of trouble.

Seven figures accompany this specification, in which,

Figure 1 shows a circuit with balancing induction coils of equal turns, the receiver-circuit windings of the induction coils being in series; Fig. 2 shows a circuit with balancing induction coils of equal turns, the receiver-circuit windings of the induction coils being in multiple with each other; Fig. 3 shows the circuit of Fig. 1 with modified coils in which proportional windings are adapted to balance the receiver circuit; Fig. 4 shows the circuits of Fig. 2 with modified coils in which proportional windings are adapted to balance the receiver circuit; Fig. 5 shows a circuit for common battery or central energy transmission where the transmitter current is received from the central office over one of the line wires and returns to the central office over the remaining line wire; Fig. 6 shows a circuit for common battery or central energy transmission where the transmitter current is received from the central office over both of the line wires in multiple, and returns to the central office over an earth circuit or over a common return conductor; Fig. 7 shows a common battery substation circuit in which the balanced receiver is inductively associated with the line conductors, direct connection with the line conductors being avoided.

In each of these circuit diagrams, it will be noted that the receiver has associated with it two inductive windings, these windings being associated in each instance with independent cores.

My method of accomplishing the reduction or elimination of side tone consists in thus providing the receiver with two or more associated inductive windings, and then of so associating those windings with the transmission circuits, and of so balancing those windings against each other, or in coöperation with each other, that a balance is obtained in the conductor containing the receiver, so that the currents or potentials at the receiver terminals, due to the operating of that receiver's transmitter, will so oppose or so supplement each other that little or no effect will be perceptible in the receiver.

Referring to the diagrams pertaining to local battery transmission, Figs. 1 to 4, inclusive, it will be noted that I have shown two independent induction coils so associated as to neutralize the effect of the transmitter on the local receiver, while incoming currents affect the receiver loudly. With coils of equal turns affecting the receiver as in Figs. 1 and 2 inclusive, neutralization is perfect when the line connection is open, and surprisingly near perfection when the line connection is closed. With well designed induction coils, the slight unbalancing due to closing the line connection is scarcely noticeable. The induction coils are arranged in such a way as to furnish the desired reactive electro-motive force or reactive current as the case may demand to neutralize local sounds in the receiver, while at the same time they are arranged so as not to affect adversely the sounds desired from the distant end of the line.

In Fig. 1, neglecting the line conductors, 31 and 32 and their associated induction-coil winding 33, and assuming that battery current is flowing in the primary circuit, passing through primary induction-coil windings 34 and 35 in the direction of the arrows adjacent to those coils respectively, and assuming the transmitter 36 to be operating, an increase in current in the primary coils will induce potentials at the terminals of the secondary coils 37 and 38 tending to cause current to flow in the direction indicated by the arrows adjacent to those secondary coils, respectively. The two secondary coils 37 and 38 form a closed circuit with the receiver 39, the three elements being connected in series, and as, in this closed circuit, all potentials resulting from the operating of the transmitter 36 are at all times equal and opposite, no current to affect the receiver 39 will ever flow by such transmitter operating.

With the addition of the line conductors, 31 and 32, and their associated induction-coil winding 33, the balance existing between the two induction coils is somewhat disturbed, but not to any great extent. By the addition of that winding, 33, the primary winding 35 is enabled to cause a potential upon the line conductors 31 and 32, and thereby to transmit speech over those conductors in response to the operating of transmitter 36.

Incoming speech over the conductors 31 and 32 acts through induction-coil winding 33 and induction-coil winding 38, causing a current in induction coil winding 38 which is effective upon the receiver 49. Further, any change in current in induction-coil winding 33 which would cause in induction-coil winding 38 a current in the direction of the arrow associated with 38, would cause also in the induction-coil winding 35 a current opposing the arrow associated with 35, thus giving a current in induction-coil winding 34 opposing the arrow associated with 34, and this current in turn would induce in induction-coil winding 37 a current in a direction opposing the arrow associated with 37 and therefore flowing through the receiver 39 in the direction of the arrow associated with 38, or in other words, in the direction of the current directly induced in the winding 38 from the winding 33; the two currents thus described, viz., the one produced directly through 33 and 38 to the receiver 39, and the one produced indirectly through 33 and 35 and then 34 and 37 to the receiver 39, therefore pass through the receiver 39 in the same direction and are effective upon the receiver 39.

In Fig. 2, neglecting the line conductors, 40 and 41 and their associated induction-coil winding 42, and assuming that current is flowing in the primary circuit, passing through primary induction-coil windings 43 and 44 in the direction of the arrows adjacent to these windings, respectively, and assuming the transmitter 45 to be operating, an increase in current in the primary windings will induce currents in the secondary windings 46 and 47 in the direction of the arrows associated with those secondary windings, respectively. The coils are shown equal, and as the currents in the secondaries supplement rather than oppose each other, the two windings will short-circuit each other, resulting in a condition of no potential across the terminals of the receiver 48. The receiver 48 therefore may be considered as being in a non-inductive position with reference to the secondaries of the induction coils, and also with reference to the transmitter 45, the relation becoming only approximately non-inductive when the line conductors 40 and 41 and their induction-coil winding 42 are added, due to the difference then existing between the two induction coils owing to the third winding upon one of them.

With the addition of the line conductors and their winding 42, the transmission of speech to the line conductors is possible through the action of the primary 43 upon the winding 42.

Incoming speech over the conductors 40 and 41 produces a current in the winding 46 which becomes effective upon the receiver 48. Further, and change in current in induction-coil winding 42 which would cause in induction-coil winding 46 a current in the direction of the arrow associated with 46 would cause also in induction-coil winding 43 a current opposing the arrow associated with 43, thus giving a current in induction-coil winding 44 opposing the arrow associated with 44, and this current in turn would induce in induction-coil winding 47 a current in a direction opposing the arrow associated with 47 and therefore flowing downward through the induction-coil winding 47, and upward through the receiver 48, or in other words, in the direction of the current induced in the winding 46 directly from the winding 42; the two currents thus described, viz., the one produced directly through 42 and 46 to the receiver 48, and the one produced indirectly through 42 and 43 and then 44 and 47 to the receiver 48, therefore pass through the receiver 48 in the same direction and are effective upon the receiver 48.

In Fig. 3, unequal coils are shown as applied to the circuit of Fig. 1, the inequality shown being one of number of turns in the windings. The ratio between the turns of induction-coil winding 138 and the turns of induction-coil winding 137 is shown as of one to two, while the ratio between the turns of induction-coil winding 135 and the turns of induction-coil winding 134 is as of two to one; thus the potential across winding 135 will be always twice the potential across winding 134, while the potential induced in the winding 138 will be always equal and opposite to the potential induced in the winding 137, the result being the same as obtained in Fig. 1 with equal coils, subject also to unbalancing by the addition of the line conductors and their induction-coil winding 133, but subject further—also to readjustment to produce perfect balance after the addition of the line circuits, if so desired.

In the assumption of the paragraph above that the potentials across the windings 135 and 134 are at all times proportional to the number of turns in the windings, an equality of resistance per turn and of inductance per turn is involved; and in the further assumption that simultaneous, equal and opposite potentials are produced at the terminals of the induction-coil windings 138 and 137, proper equalities or proportions in the elements of the magnetic fields, etc., of the coils, are involved, it being easy, in the present development of telephony and its associated arts, to produce induction coils having the attributes assumed for the various elements shown in the figures of the drawings accompanying this description.

In Fig. 4 the conditions of Fig. 2 are shown with modified induction coils; assuming the elements 140, 141, 142, 143, 145, 146, 148 to be identical with analogous elements of Fig. 2, the turns of the windings 144 and 147 may be greatly reduced or increased in number as compared with the analogous parts of Fig. 2, yet by the proper proportioning of turns, and by the proper control of the inductances of the induction coil, the receiver 148 may be made unresponsive to the operating of the transmitter 145, either without the elements 140, 141, 142, or with those elements associated as shown, and the balance may be obtained either perfectly for the elimination of side tone, or approximately only for the reduction of side tone to any desired degree.

Fig. 5 shows a circuit for common battery or central energy transmission where the transmitter current is received from the central office over one of the line wires and returns to the central office over the remaining line wire. In this circuit, two induction coils are used, the two primary windings, 49 and 50, being connected in series with each other and with the transmitter 51, the three elements and their connecting conductors forming the path through the substation telephone equipment from line conductor to line conductor for the direct current from the central office battery, 52. Across the terminals of the two primaries in series are placed the receiver 53 and the condenser 54, the receiver and condenser being in series with each other. Across the terminals of the receiver 53 are connected the two secondary induction-coil windings, 55 and 56, the two secondaries and the receiver being all in multiple with each other.

In the transmission of speech in the circuits of Fig. 5 the transmitter 51 being assumed to be operating, an increase in current in the primary windings 49 and 50, current being assumed to be flowing in the direction of the arrows associated with windings 49 and 50 respectively, will cause a current in the secondary induction-coil windings 55 and 56 in the direction of the arrows associated with those windings, respectively, those currents being simultaneous and equal and therefore neutralizing each other in their connection with the receiver 53, in the manner noted in connection with Fig. 2.

Incoming speech currents over the line conductors have a path from line conductor to line conductor through the receiver 53 and condenser 54, avoiding the inductances 49, 50, 55 and 56; thus practically the entire energy of received speech makes itself manifest upon the receiver 53, giving a very high efficiency for receiving speech, while eliminating or reducing side tone for transmitted speech.

Fig. 6 shows a circuit for common battery or central energy transmission where the transmitter current is received from the central office over both of the line wires in multiple and returns to the central office over an earth circuit, or over a common return conductor. In this instance also, the two primary windings, 57 and 58, of the two induction coils, are placed in series with each other and with the transmitter 59, the three elements being in series with the two line conductors by the tap from the middle of the induction-coil winding 60. Induction coil windings 60 and 62 may be identical or may have any desired ratio. Secondary induction-coil windings 62 and 63 are associated with the receiver as shown, and an increase in the current flowing in the primaries 57 and 58 in the direction of the arrows associated with those windings will cause currents to flow in the secondary windings 62 and 63 in the direction of the arrows associated with 62 and 63 respectively. These currents so supplement each other as to neutralize each other with reference to the receiver 64, thus having no effect upon that receiver in response to the operating of the transmitter 59.

The action in sending may be described specifically as follows: Current with the transmitter at rest flows continuously from battery 61, over the line conductors in multiple, thence through the two halves of winding 60 in multiple and acting non-inductively upon the core of that winding, thence through the winding 57, acting inductively upon the core of that winding, thence through the winding 58, acting inductively upon the core of that winding, thence through the transmitter 59, at rest, thence to earth and through earth to the battery 61, the point of beginning. The volume of this current varies in response to variations in the resistance of the transmitter 59 to effect speech transmission. Assuming a decrease in the resistance of the transmitter 59, the current flowing in the above described path will increase, and as that current increases, flowing in the direction of the arrows shown adjacent to windings 57 and 58, induced currents will be set up in windings 62 and 63 in the directions of the arrows shown adjacent to those windings, which two currents may be traced independently, as follows: First, current generated in induction-coil winding 62 flows from winding 62 through conductor 79, conductor 80, receiver 64, conductor 81, conductor 82 and to winding 62, thus flowing through the receiver 64 from conductor 80 to conductor 81; second, current generated in induction-coil winding 63 flows from winding 63 through conductor 83, conductor 81, receiver 64, conductor 80, conductor 84, and to winding 63, thus flowing through receiver 64 from conductor 81 to conductor 80. The two currents just described are simultaneous, and the physical construction of the two induction coils containing windings 62 and 63, respectively, may be such as to make the said currents equal; as they are opposite in the direction of their simultaneous flow through the receiver 64, they will tend to neutralize each other, and if they are equal they will cancel each other perfectly, and no effect will be perceptible in the receiver 64. The increase in current in the induction-coil winding 57, in addition to its effect in inducing a current in the winding 62, also has induced a current in the winding 60 which finds its circuit over the line conductors and to the apparatus of the central office equipment, thus effecting the transmission of speech as a result of the operation of the transmitter 59 without affecting in any way the receiver 64 associated with that transmitter. For incoming speech transmission, however, the induction-coil winding 60 is inductive and acts through the winding 62 to affect the receiver 64.

The figure illustrates unequal induction coils, the structural features of which may be modified to produce a perfect balance in the receiver 64 for currents set up by the transmitter 59, or may be modified to produce only an approximate balance, as desired.

In Fig. 7 is shown a common battery substation circuit in which the line conductors 85 and 86 are bridged by two primary windings 87 and 88 of two induction coils, the transmitter 89 being included in series with the primary winding 88; the primary winding 87 has associated with it the secondary winding 90, the relation being that usually found between the two windings of an induction coil, and being that relation in which an increase in current in the primary winding 87 in the direction shown by the arrow adjacent to that winding will produce a current in the secondary winding 90 in the direction of the arrow adjacent to that winding; the primary winding 88 has associated with it a secondary winding 91, the relation being similar, namely, that an increasing current through the primary windings in the direction of the arrow adjacent will produce a current flowing through the secondary winding 91 in the direction of the arrow adjacent.

Considering Fig. 7 for transmission of speech, current may be assumed to be flowing from the plus terminal of the battery 92 over line conductor 85 and through primary winding 87 in the direction of the arrow, then over line conductor 86 to the remaining terminal of the battery; also from line conductor 85 through the branch path containing the transmitter 89 and the primary winding 88, flowing through the latter in the direction of the arrow adjacent thereto. If, now, in the operation of the transmitter 49 the resistance of that transmitter may be assumed to increase, the relation of the resistances of the two shunt paths, 87 versus 89 88, will vary, the path 89 88 because of its increased resistance will take less current and the path 87 because of the increased resistance of 89 88 will take more current, resulting in an increase in current flowing in the direction of the arrow in primary winding 87 and resulting in a decrease of current flowing in the direction of the arrow in primary winding 88;

increase of current in the direction of the arrow in primary winding 87 will produce a current in secondary winding 90 in the direction of the arrow adjacent thereto; decrease of current in the direction of the arrow in primary winding 88 will produce a current in secondary winding 91 opposing the direction of the arrow shown adjacent thereto; these two currents, that induced in winding 90 and that induced in winding 91, are simultaneous and opposite, and the two induction coils 87—90 and 88—91, may be so constructed physically that the two currents will be equal as well, thus neutralizing each other in the receiver 93. The increase of the resistance of the transmitter has increased the resistance of the substation unit as a whole, and by such resistance-change has varied the current flowing in the line circuit, thus causing a current wave at the central office apparatus, as desired.

For received speech, a current wave from line conductor 85 will cause an increase of current simultaneously in windings 87 and 88, both in the direction of the arrows shown adjacent thereto, the coil 87 inducing in winding 90 a current in the direction of the arrow adjacent thereto, while the winding 88 will induce in the winding 91 a current in the direction of the arrow shown adjacent thereto; the two currents thus produced in the windings 90 and 91 therefore will supplement each other in their effect upon the receiver 93.

My invention places the receiver in a non-inductive or neutral position, where it receives no current from sending, but does receive current when receiving; this is accomplished by a scheme of balancing induction coils or of like connections, the balancing being made either perfect or only approximate, as desired.

My invention for placing the receiver in a strictly non-inductive position will naturally suggest modifications of existing circuits less accurate than my method here shown and described, improving those circuits. I wish to claim such improvements, although preferring to employ the more accurate methods.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent, is:

1. In a substation telephone set, the combination of line conductors, a transmitter, a receiver, and induction coils, said receiver being connected with said induction coils non-inductively for speech currents from said transmitter and a third winding on one of said induction coils and connected with said line conductors, whereby said receiver is inductively connected to said line, substantially as described.

2. In a substation telephone set, the combination of line conductors, a transmitter, a local battery circuit, a telephone receiver, and induction coils, said telephone receiver being connected with said induction coils neutrally with reference to speech currents set up by operating said transmitter and a third winding on one of said induction coils and connected with said line conductors, whereby said receiver is inductively connected to said line, substantially as described.

3. In a substation telephone set, the combination of line conductors, a transmitter, a receiver, and induction coils, said receiver being connected with a plurality of said induction coils and said line conductors being connected with but one of said induction coils, substantially as described.

4. In a substation telephone set, the combination of line conductors, two induction coils and a receiver, said receiver being connected with both of said induction coils and said line conductors being connected directly with but one of said induction coils, substantially as described.

5. In a substation telephone set, the combination of a transmitter, a receiver, and induction coils, said receiver being connected with said induction coils non-inductively with respect to speech currents resulting from operating said transmitter and inductively and non-conductively with reference to said line conductors, substantially as described.

6. In a substation telephone set, the combination of a transmitter, a local battery circuit, a telephone receiver and induction coils, said receiver being connected to said induction coils neutrally with reference to said transmitter non-conductively with reference to said line conductors and inductively with reference to said line conductors, substantially as described.

7. In a substation telephone set, the combination of a receiver, two induction coils, each of said induction coils having a primary energizing winding, a transmitter and a battery, said transmitter and battery being connected with said two primary windings of said induction coils, and said receiver being connected to the secondary windings of said induction coils non-inductively with reference to the current undulations in said primary windings caused by operating said transmitter and a tertiary winding on one of said induction coils and connected to said line conductors, substantially as described.

8. In a telephone substation set, the combination of two or more induction coils; a transmitter, a battery, said battery and said transmitter being connected with the windings of said induction coils to energize the magnetic fields of said induction coils, said battery to continue such energization and said transmitter to control such energization; a telephone receiver, said telephone receiver being connected to said induction coils non-inductively with reference to any currents induced in said induction coils by reason of

operating said transmitter; and terminals for the connection of line conductors to said induction coils whereby said line conductors are inductively and non-conductively related to said receiver, substantially as described.

9. In a telephone substation set, the combination of line conductors, a transmitter, a receiver, and inductive windings, said receiver being connected with a plurality of said inductive windings, and said line conductors being connected directly with but one of said inductive windings, substantially as described.

Signed by me at Chicago, State of Illinois and county of Cook, in the presence of two witnesses.

MORGAN BROOKS.

Witnesses:
KEMPSTER B. MILLER,
EVA A. GARLOCK.