No. 743,594. PATENTED NOV. 10, 1903

G. K. THOMPSON.

TELEPHONE CIRCUITS AND APPARATUS.

APPLICATION FILED MAR. 31, 1903.

NO MODEL.

Fig. 1.

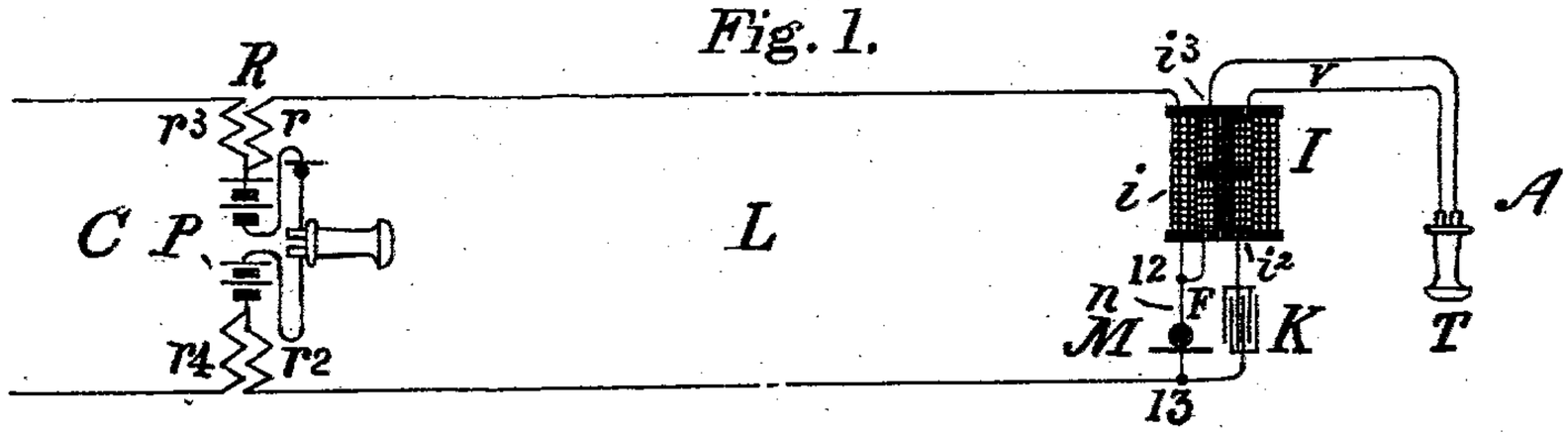


Fig. 2.

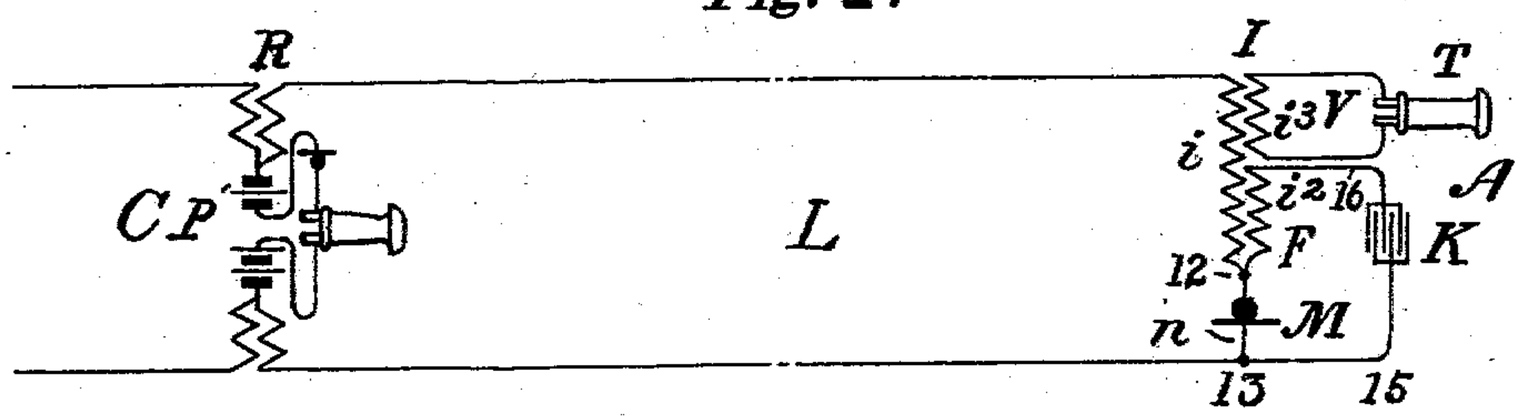


Fig. 3.

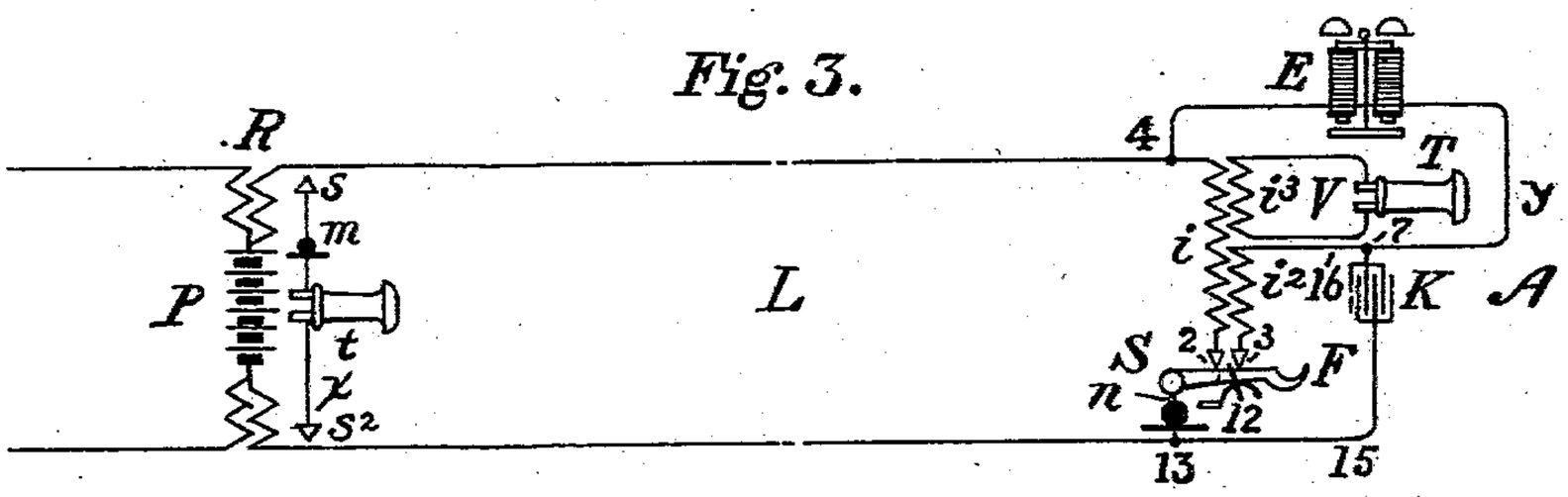
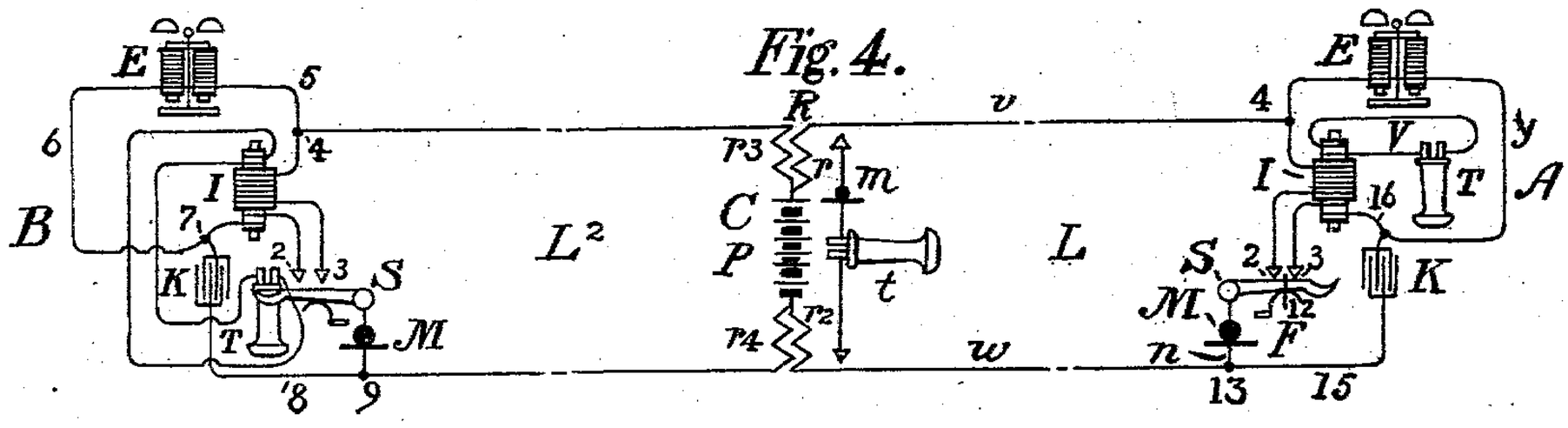


Fig. 4.



WITNESSES:

Frank C. Lockwood.

Joseph A. Gately

INVENTOR.

George K. Thompson.

No. 743,594. Patented November 10, 1903.

UNITED STATES PATENT OFFICE.

GEORGE K. THOMPSON, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE CIRCUITS AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 743,594, dated November 10, 1903

Application filed March 31, 1903. Serial No. 150,473. (No model.)

To all whom it may concern:

Be it known that I, GEORGE K. THOMPSON, residing at Newton, in the county of Norfolk and State of Massachusetts, have invented certain Improvements in Telephone Circuits and Apparatus, of which the following is a specification.

This invention relates to variable-resistance transmitters and their operation, and especially concerns substation or subscriber's station circuit arrangements for instruments of this character by means of which the disturbing effects which tend to be exercised by such transmitters on the associated receiver or receivers at the same station may be prevented, or at any rate greatly reduced.

In the arrangement of telephone substation-circuits for common and central battery exchange systems which heretofore have been customary the substation apparatus comprises the call-bell, the telephone transmitter and receiver, an associated induction-coil, the regular suspension-switch serving as a support for the receiver when unemployed and operating by the displacement and replacement of said receiver, and a condenser. When the said switch is in its normal or resting position, with the receiver suspended upon the hook, the circuit is through the call-bell and condenser. The presence of the condenser renders the circuit conductively discontinuous, and a steady current, such as that of a central battery, therefore cannot flow therein; but the circuit thus constituted is well adapted for the passage of the alternating currents of the central-station call-generator, which therefore may readily be transmitted therein for the operation of the polarized call-bell. When the receiver is taken from the hook for use and the switch in consequence moves to its second position, the telephone-circuits of the substation are brought into operative relation with the main or line circuit and the central source of current. The arrangement of substation telephone-circuits until recently preferred has been substantially that shown in and described by the United States patent to Charles E. Scribner, No. 669,710, of March 12, 1901, which provides that the main telephone-circuit having a source of current at the central station shall at the substation include the telephone-transmitter and one winding of the induction-coil and that a shunt-circuit containing the telephone-receiver, a condenser, and the other winding of the induction-coil in series with each other shall be arranged about or around the transmitter; but when the substation telephone-circuits are thus arranged, and when the sensitive and powerful transmitters requisite in the operation of long main circuits are employed it is found that while there is satisfactory reproduction of the desired sounds or words in the receiver at the distant substation there is also an undesired and undesirable production of an echoing or resonant sound, colloquially termed the "side tone," in the home receiver—that is to say, in the associated receiver at the same or transmitting station. Moreover, in the operation of central-source telephone-exchanges involving toll or inter-urban lines it is often desirable in the interest of efficiency to supply the substation-transmitters with working current under higher voltage than has ordinarily been employed, and under such conditions the microphonic action is materially intensified, so that in addition to the side tone there is present an increased tendency to create and manifest in the home receiver buzzing and crackling noises and sounds, as well as to take up and reproduce all such sounds as are being produced in the immediate proximity of the instrument. The noise in the ear of the person using the telephone becomes under these circumstances so loud as to be both unpleasant and confusing and operates to disturb and disconcert the user, making it very difficult for him to follow the conversation or intelligently receive the message. Attempts have heretofore been made to attain some of these objects by specially-designed induction-coils with associated balancing resistances, examples of this class of device and arrangement being disclosed by Letters Patent of the United States issued to Theodore Spencer, No. 501,472, dated July 11, 1893, and to Charles E. Scribner, No. 552,730, dated January 7, 1896; but such arrangements, while

fairly satisfactory with transmitters of moderate power operating under the local-battery conditions shown in said patents, are not completely successful under present conditions, and apparently are not of a character capable of improvement or further development in such manner as to meet such prospective conditions as are now in sight.

The objects of the present invention are to reduce such side tone and other disturbances to the lowest possible point and generally to prevent the disturbing effects attributable to undesigned or abnormal action of the transmitter from manifesting themselves in the associated or home receiver and to effect this without materially reducing the volume of transmission. To these ends the invention contemplates the employment in the substation telephone apparatus and in association with the main circuit the transmitting and receiving telephone intruments and the usual condenser of said station of an induction-coil having three independent helices or windings, one of which is connected directly in the main line and the other two in two short or local circuits, respectively, one of which local circuits likewise includes the substation transmitter and condenser, while the other contains the substation-receiver. The main-circuit winding of the said induction-coil may be regarded as the principal one, since the mutual induction between it and each of the others is much greater than that existing between the two other windings reciprocally, which indeed is made as small as possible. For this reason and because it is concerned both in transmitting and receiving and has, moreover, preferably a greater number of turns than the other two the said main-circuit winding is herein termed the "main" or "principal" winding, the other or remaining windings being conformably termed the "minor" or "subordinate" windings or helices. One of the said local circuits is in part constituted of a portion of the main-circuit conductor, and the substation-transmitter is connected in such portion, being thereby placed in the said main as well as in the said local circuit, and thus adapted to receive current from the central source over the main-circuit conductors and to develop the necessary speech variations therefrom in the said local circuit, which variations, by means of the induction-coil, are again inductively impressed upon the said main circuit and pass over the conductors thereof to operate the distant receiver. Under these conditions the said voice variations do not produce any sensible or annoying side tone in the home receiver, nor is the said receiver perceptibly affected by noises microphonically taken up by the associated transmitter, since the said receiver has no conductive connection with the transmitter and since the minor coil-winding with which it is in circuit has no such simple or effective inductive relation with the other minor coil-winding in circuit with the transmitter as is sustained between the minor winding of the transmitter local circuit and the principal or main-line coil-winding. The minor coil-winding of the receiver local circuit is, however, also in effective inductive relation to said principal winding, and the receiver therefore, while no longer perceptibly affected by external noises at its own station and no longer subject to the piercingly-loud side-tone reproduction of the home transmitter, remains perfectly and satisfactorily responsive to and adapted to reproduce as conversation the voice-currents which reach it from a distant station and are transferred to its local circuit inductively.

In the drawings which accompany and illustrate this specification, Figure 1 is a diagram of a single substation-circuit with a source of current at the central station and with the peculiar induction-coil and circuit arrangement that characterize the invention, a suitable form of induction-coil being shown in longitudinal section. Fig. 2 is a similar diagram dispensing with the form of the induction-coil and more clearly indicating the circuit arrangement of the several windings of said coil. Fig. 3 is a diagram of a similar circuit, showing the connections of the substation call-bell and telephone-switch and indicating the detachability of the central-station telephone instruments; and Fig. 4 illustrates the application of the invention to a through talking-circuit, formed by switching together at a central station two component substation-circuits.

L is a main telephone-circuit extending between two stations A and C, the latter being shown as a central station and the former as a subscriber's or substation.

The apparatus at the substation A comprises the telephone-transmitter M, receiver T, and condenser K, together with an induction-coil I of construction presently to be explained. There is also the usual telephone-switch S and call-bell E. In Fig. 4 L^2 is a second telephone-circuit and extends from another substation B to the central station C. It is shown as being switched or connected at the said central station to the circuit L, so that the circuits L and L^2 are the components of a compound talking-circuit extending between the substations A and B through the central station C.

At the central station the substation-circuit includes a suitable source of current P, such as a battery, a telephone-transmitter *m* and receiver *t* being also provided, whereby conversation may be exchanged with the distant station A or B. In Figs. 1 and 2 the battery is shown as being centrally divided and the telephone instruments as being placed between the two halves thereof, and this arrangement is in some cases found convenient. In Figs. 3 and 4, however, the source of current P remains undivided in the more usual manner, and the operators' telephones may then by the switches ordinarily employed be bridged

between the conductors of the circuit in a well-understood manner and as indicated in the said figures where the bridging switches (not shown) are symbolized by the contact-points s s^2 at the extremities of the telephone-bridge x.

The central-station devices include a repeating induction-coil R, the two windings of which are centrally divided, so that one-half of each is connected in its appropriate main circuit on each side of the battery P, the halves r and r^2 of one winding being in circuit L and the winding comprising the two portions r^3 and r^4 being connected in any second or associated main circuit L^2.

Recurring to the substation apparatus, the telephone-receiver T hangs when unemployed upon the hook of the switch S, as shown at station B, Fig. 4. The transmitter-circuits at such times are open at points 2 and 3, and the ringing-circuit is established between points 4 and 9 of main conductors v and w, respectively, by way of conductor 5, bell E, conductor 6, junction-point 7, condenser K, and conductor 8. This ringing-circuit is conductively discontinuous by reason of the inclusion of the condenser therein, and is therefore impassable to steady currents; but the call-bell is readily operated by alternating currents of appropriate strength transmitted from the central station for the purpose. When the receiver is taken from the hook-switch for use, the bell need not be and in practice is not disconnected, but remains in a permanent electromagnetic shunt y, extending between points 4 and 7 and about the main line, the bell-magnet being of such resistance and impedance that its presence may be disregarded.

The substation induction-coil I has three independent windings or helices. The winding i^2 extends over one half and the winding i^3 over the other half of the length of the core, and these are termed "minor" or "subordinate" windings, while the outer winding i extends over the other two and the entire length of the core and is termed the "principal" winding. These windings are all thoroughly insulated from each other and from the core and are so relatively disposed that the mutual induction between the principal winding i and each of the two minor windings is at a maximum, while that between the two minor windings is at a minimum. In other words, the coil is constructed to facilitate induction between the principal winding and either minor winding and to minimize induction between each minor winding and the other. The principal winding i, moreover, has a sufficient number of turns wound inductively over the windings i^2 and i^3 to give maximum efficiency in both transmitting and receiving. The principal winding i of the induction-coil I is connected directly in the main line or circuit.

F and V are local circuits contained wholly within the substation.

The transmitter M, the condenser K, and the minor coil-winding i^2 are serially connected in the local circuit F, this local circuit F being set off or looped from two points 12 and 13 of the main-circuit conductor and constituted in part of the portion n of said main-circuit conductor included between said two points. The conductor-section n, extending between the points 12 and 13, is of course common to the main circuit L and the local circuit F, and the transmitter M is connected therein, being thus well placed to receive a supply of current from the source P at the central station in the main circuit, and by its operation to produce the necessary variations in the local circuit, which variations are then inductively transferred to the main line and distant receiver through the intermediation of the induction-coil I. The telephone-switch S is also placed in the said common section of conductor n and is enabled thereby to control both the main circuit and the local circuit F. As hereinbefore stated, these circuits are both held normally open at the switch-contacts 2 and 3, the switch being then maintained in its lowest position by the weight of the receiver upon the hook. When, however, the receiver is displaced, the switch moves to its second or higher position and establishes contact between the two switch-points 2 and 3 and between both and the main-circuit conductor w through the transmitter. The main circuit is thereby conductively closed, and although the local circuit F includes the condenser K it also is operatively completed. The said local circuit F, beginning at the switch S, may be traced as follows: the said switch S, the common section of conductor n, including the transmitter M, point 13, conductor 15, condenser K, conductor 16, winding i^2 of the induction-coil, and the switch-contact 3. The second local circuit V is not under the control of the switch S, but remains constantly closed. It is formed by connecting the terminals of the induction-coil winding i^3 with those of the telephone-receiver T, which may be of standard construction and resistance. It therefore contains the said minor winding i^3 of the induction-coil I and the said receiver. Thus connected it has been experimentally demonstrated that the side tone and the liability to disturbance by the tendency of the transmitter to microphonically take in sounds produced in its vicinity are so materially reduced as to be no longer noticeable and that neither the transmission nor the reproduction of conversation are adversely affected.

In the system or organization of telephone-circuits for station apparatus described herein good results have been reached by employing a standard seventy-five-ohm receiver, a two microfarad condenser, and an induction-coil with a main or principal helix wound with No. 26 wire to a resistance of about thirty ohms and having its two minor helices each wound with No. 31 wire to a resist-

ance of about twenty-six ohms. These proportions or magnitudes are not, however, in any sense absolute or precise and are stated merely as being convenient for the satisfactory construction and operation of the invention.

The said invention, having thus been fully set forth, is claimed, as follows:

1. In a telephone-circuit substation apparatus, the combination of the main circuit; the station-receiver; a condenser; two associated local circuits, one containing the said receiver, and the other containing the said transmitter and condenser and formed in part of a section of said main circuit; and an induction-coil having three helices or windings, one connected in said main circuit, and the other two in the said local circuits respectively; substantially as set forth.

2. In a telephone-circuit substation apparatus, the combination of the main circuit; the transmitter; the receiver; a condenser; an induction-coil having a main or principal winding or helix connected in said main circuit, and two subordinate windings or helices, the mutual induction between the main winding and each subordinate winding being greater than that between the said two subordinate windings; a transmitting local circuit containing the transmitter, the condenser, and one of the said subordinate induction-coil windings; and a receiving local circuit containing the receiver, and the other subordinate induction-coil winding; substantially as set forth.

3. A subscriber's or substation organization or system of telephone-circuits, consisting of a main circuit extending outward from said station to a distant station; an induction-coil having a main or principal winding included in said main circuit, and two subordinate or minor windings; an associated local circuit set off or looped from two points of the conductor of said main circuit, and constituted in part of the portion of said conductor included between said two points; a telephone-transmitter connected in said common portion of conductor and thereby included in both of the said main and local circuits; a condenser and one of said minor induction-coil windings included also in said local circuit in series with said transmitter; a telephone-receiver; and a second associated local circuit containing the said receiver and the other minor winding of said induction-coil; substantially as specified.

4. The combination in a telephone-exchange substation apparatus or system of telephone-circuits, of an induction-coil having a principal and two minor windings; a main-circuit loop or connection including the said principal winding; an associated local circuit formed in part of a section of the conductor of said main circuit, the said conductor-section being thereby made common to both circuits; a transmitter included in said common section of conductor and thereby in both of the said circuits; a telephone-switch also in said common conductor-section controlling both of said circuits; a condenser; a receiver, and a second local circuit; the said condenser and one of the said minor induction-coil windings being connected in the said first-mentioned local circuit in series with one another and with said transmitter, and the said receiver and the other minor induction-coil winding being serially connected in the said second local circuit; substantially as described.

5. In a telephone system, the combination of a main telephone-circuit extending between a central station and a substation; and a source of electrical energy at said central station included in said main circuit; with substation devices and circuits comprising an associated local circuit formed in part of a section of the conductor of said main circuit; a telephone-transmitter connected in said common section of conductor and thereby included in both main and local circuits to receive current from said source in the former, and to produce voice-vibrations therefrom in the latter; a condenser; a telephone-receiver; a second associated local circuit; and an induction-coil having a principal winding connected in said main circuit, and two minor windings connected respectively, one in series with said transmitter and condenser in the said first-named local circuit, and the other serially with said receiver in the said second local circuit; substantially as set forth.

6. In a telephone system, the combination of a main telephone-circuit extending between a central station and a substation; a source of current such as a battery connected therein at said central station; telephones comprising a transmitter and receiver at both of said stations; and an induction-coil at the said substation having a principal winding connected in said main circuit, and two minor windings connected up in independent local circuits, one with the substation-transmitter, and the other with the substation receiver; the mutual induction between each minor winding and the principal winding being greater than that between the said two minor windings; substantially as set forth.

7. In a telephone system, the combination of a main telephone-circuit extending between a central station and a substation; a source of current such as a battery connected therein at said central station; telephones comprising a transmitter and receiver at both of said stations; two associated local circuits, a condenser, and an induction-coil having a principal and two minor or subordinate windings all at said substation; the substation-transmitter being connected in a portion of conductor common to the said main and to one of said local circuits, the principal induction-coil winding in the said main circuit, the condenser and one of the said minor induction-coil windings in the said local circuit

which includes the transmitter, and the substation-receiver and the other minor induction-coil winding in the remaining local circuit; substantially as specified.

8. In a telephone system, the combination with a conversation-circuit extending between two substations through a central station, and formed of two component substation-circuits united for through communication at said central station; telephones comprising a transmitter and receiver at each substation; and a battery or like source of electrical energy associated with said component circuits at said central station and adapted to supply current independently to the substation-transmitters of both; of two associated local circuits, a condenser, and an induction-coil having a principal helix or winding and two minor windings at the substation of each component circuit; the substation-telephone transmitter being connected in one of the said local circuits and also in the main circuit, the principal induction-coil in the main circuit, the condenser and one minor induction-coil winding in the local circuit which includes also the said transmitter, and the substation-telephone receiver and the remaining induction-coil winding in the other local circuit; substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 27th day of March, 1903.

GEORGE K. THOMPSON.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.