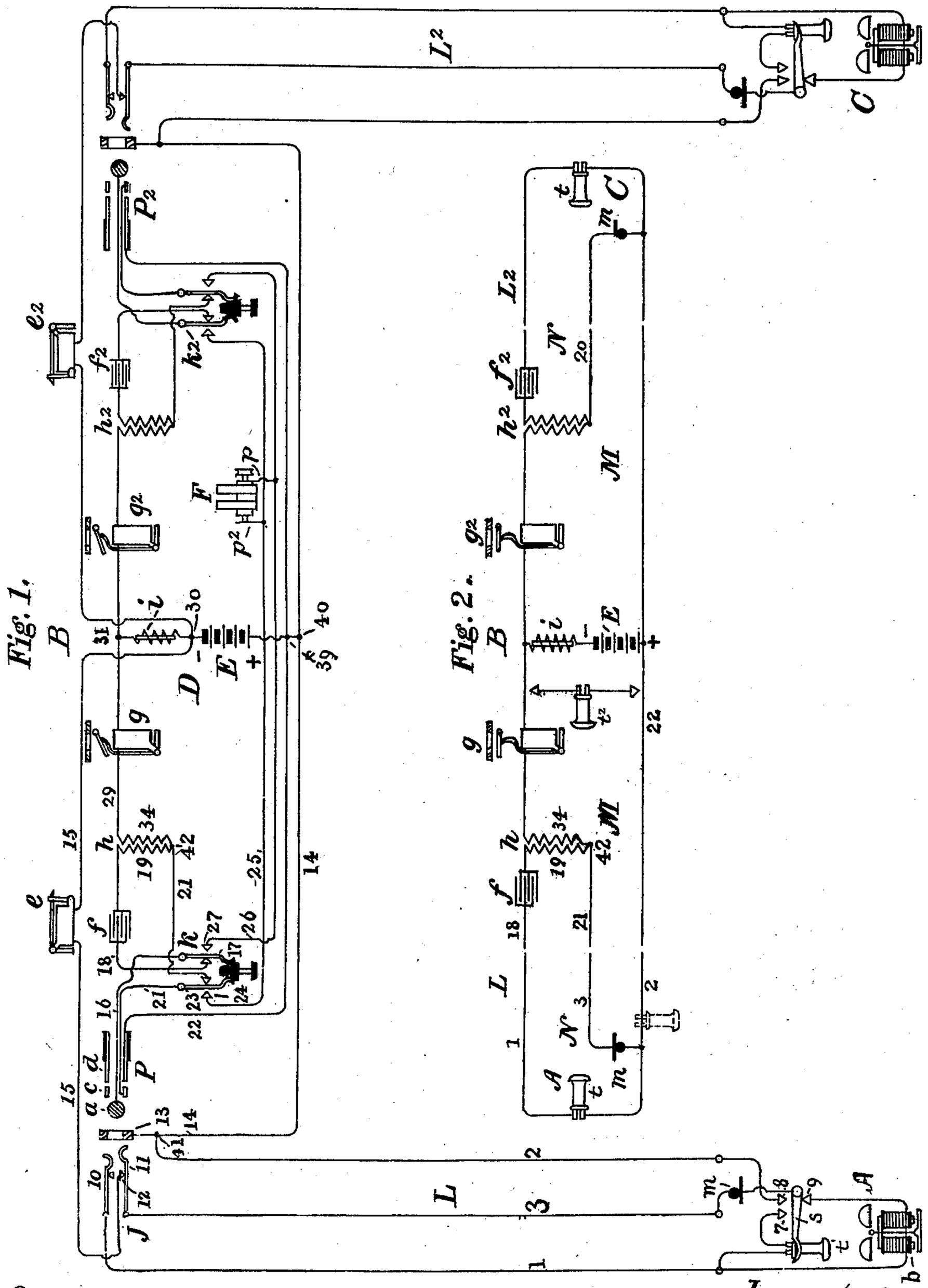
No. 666,213. Patented Jan. 15, 1901.

G. K. THOMPSON.

TELEPHONE EXCHANGE CIRCUIT AND APPLIANCE.

(Application filed Feb. 9, 1900.)

(No Model.) 2 Sheets—Sheet 1.



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Joseph A. Gately
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Inventor,
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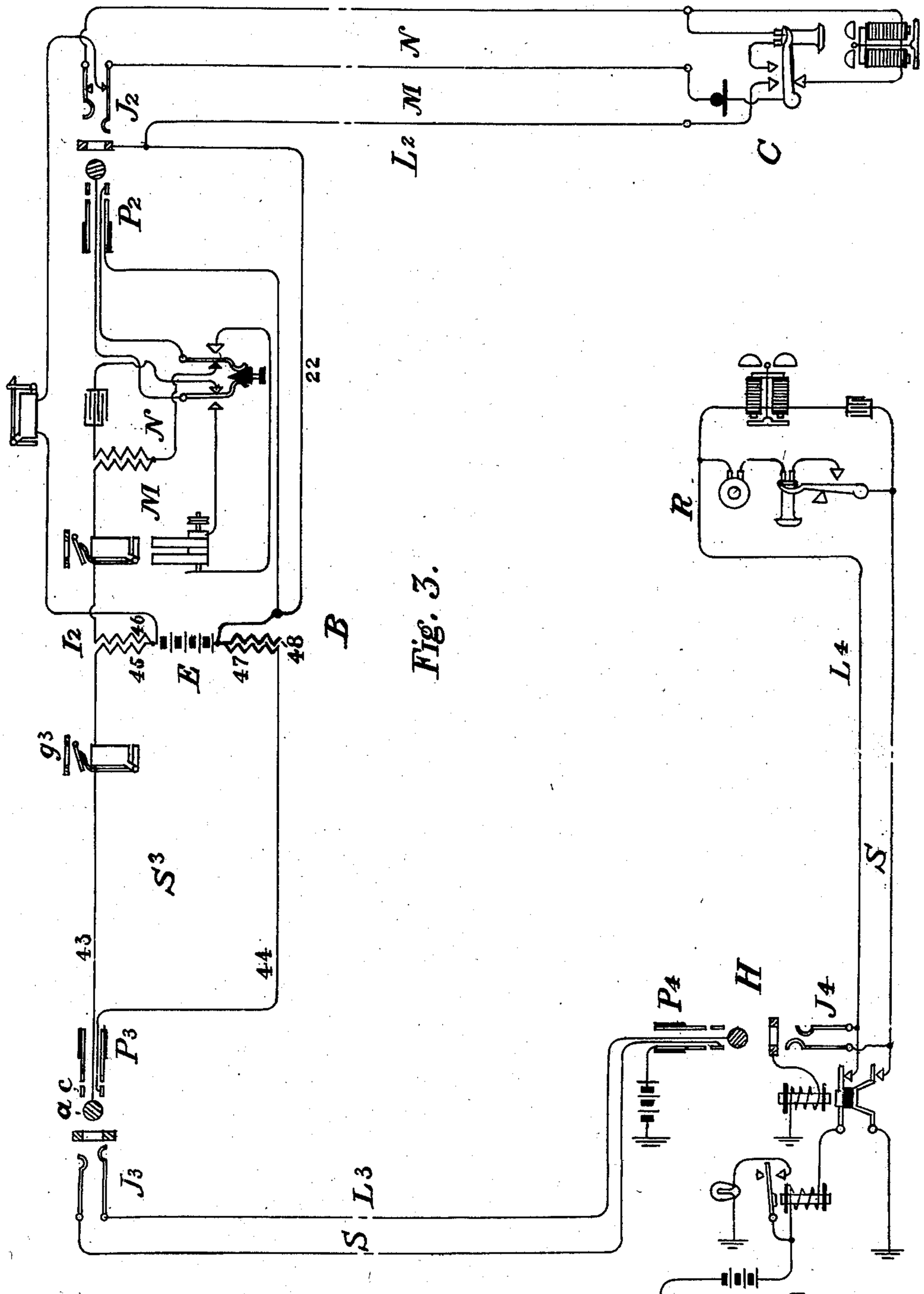

Fig. 3.

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE CIRCUIT AND APPLIANCE.

SPECIFICATION forming part of Letters Patent No. 666,213, dated January 15, 1901.

Application filed February 9, 1900. Serial No. 4,646. (No model.)

To all whom it may concern:

Be it known that I, GEORGE K. THOMPSON, residing at Malden, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone-Exchange Circuits and Appliances, of which the following is a specification.

The herein-described invention relates mainly to such branch telephone-exchanges as are frequently installed in hotels, factories, or large business establishments, an exchange of this class being complete within its own area for the interconnection of lines normally centering at the local switching-station, but generally provided also with facilities for switching any of its local substation-lines to the substation-lines of the main telephone-exchange to which the branch exchange may be auxiliary, or, in fact, to substation-lines of any external exchange. In the present invention a common central source of current is placed at the switching-station and may supply current for such signals as are manifested within the switching-station whether transmitted from the substations or local at said switching-station and also for the substation telephone-transmitters.

Heretofore in telephone-exchanges which have had their substation-transmitters and signal-sending appliances supplied with current from a common and centralized source each substation has been provided with a transmitter induction-coil having primary and secondary windings both normally discontinuous, but organized to be brought into operative condition by the movement of the telephone-supporting switch when the receiver is taken therefrom, the secondary winding being then brought into a closed bridge of the main circuit and the primary being brought into a short extension of the said main circuit, forming practically a local primary circuit, while the transmitter itself was in a section of conductor common to the circuits of both primary and secondary. Under these conditions there was also a condenser at each substation normally in its call-bell branch to maintain the conductive incompleteness of the circuit, so that the call-signal could be sent by closing the circuit when the receiving-telephone was taken from the hook-switch, but connected in the local primary circuit in series with the transmitter and the primary winding of the induction-coil when the circuit was thus closed pursuant to the movement of said switch. This arrangement and its mode of operation are disclosed in United States Patent No. 620,745 to Henry M. Crane, dated March 7, 1899. The receiving-telephone at the substation may under this plan of connection be connected either in the main line or in the primary circuit together with the condenser, but in practice the latter position has been preferred, as when connected in the main line it tends to reduce the available strength of the battery-current supplied to the transmitter.

The characteristic feature of the present invention is that the condenser and transmitter induction-coil are both placed at the central or switching station. Important advantages involved in this centralization of the induction-coil and condenser are that they are thereby brought under the eye and direct control of skilled operatives or electricians, and that a small number of these appliances are thus rendered sufficient for the service of a large number of lines. The lines centering at the switching-station are switched together when communication between any two substations is desired by means of switch-cords, having terminal switch-plugs adapted for insertion in switch-sockets of the several lines. A sufficient number of such cords are of course provided, and the transmitter induction-coils and the condensers are associated with the conductors of said switch-cords.

In this invention each substation-circuit has three main conductors, which are diversely associated according as signals are being transmitted in one direction or the other or as the telephones are being used. Thus when the substation telephone-receiver is in place on its supporting-switch the circuit is arranged for the transmission of signals from the switching-station to the substation through a particular pair of the three circuit-conductors. When the receiver is re-

moved from the switch-hook, the circuit arranges itself for use in sending signals from the substation to the central station and is now formed of a second pair of the said three conductors, one conductor having been thrown out of use and another substituted therefor. Again, when the substation-line is switched at the central station for conversation and its receiver has been taken from the hook all three conductors are concerned in the operation, one constituting the principal portion of a subcircuit, including a condenser at the central station and serving as a primary talking-circuit, another forming the principal portion of a second subcircuit containing an impedance-coil and a source of transmitter-current supply, both at the central station and serving as the secondary talking-circuit, and the third, constituting a section common to and completing both of the said two subcircuits, includes the substation-transmitter, which by such connection is in both primary and secondary circuits and is thereby adapted to receive its current-supply through the latter circuit and when operated to set up electrical waves in the former circuit, which by the induction-coils are inductively propagated in the secondary circuit, and thereby to the distant receiver. In this last combination of the three circuit-conductors the induction-coil, working in association with the substation-transmitter and placed at the central station, has its two windings placed respectively in the primary and secondary talking-circuits, and while the substation receiving-telephone is preferably placed, as shown in full lines, in the primary subcircuit it may without departure from this present invention be placed in the secondary subcircuit, as indicated by dotted lines. Disconnection or supervisory signals (one for each substation-circuit) may be included directly in the secondary or through conversation circuit at the central station, and thus placed will be operated when the telephone of the corresponding substation is replaced upon its hook.

Whenever two substation-circuits, both of the three-conductor type, which dispenses with the presence at the substation of the transmitter induction-coil, are to be united at the central or switching station, the switch-cord circuit employed to effectuate such union will have the circuit arrangement of the switch-plugs at both ends of the cord alike, there being a separate and independent induction-coil and condenser for each plug or practically for each of the two united substation-circuits; but since it often occurs that a substation of a branch exchange is to be placed in communication with an outside substation belonging to the main telephone-exchange or some other exchange on the call of one party or the other a certain number of switch-cords should be provided wherein the circuit connections of one plug only are associated with the condenser and induction-coil in the manner described herein, while those of the other plug have no such associated devices, but may be of the ordinary or standard "common battery" type.

In the accompanying drawings, Figure 1 is a diagram illustrating the invention by showing its application to two circuits of a branch telephone-exchange and to switching devices at the central station thereof. Fig. 2 shows the electrical arrangement of two such telephone substation-circuits united at a central station to constitute a through-conversation circuit containing the invention. Fig. 3 is a diagram illustrating the interconnection of a branch exchange-circuit involving this invention and a substation-circuit of an outside exchange, the switch-cord at the central station of the branch exchange being suitably modified to correspond with such diversity in substation-circuit character.

Referring to Figs. 1 and 2, L and L^2 are substation-circuits of a telephone-exchange extending, respectively, from substations A and C to a central or switching station B, where D is a switch-cord circuit, (being one of any number necessary to transact the business of the station,) by means of which the said substation-circuits may be united for through communication.

Each substation-circuit consists of three main conductors 1, 2, and 3, the reciprocal relation of which varies according to the work for which the circuit as a whole is arranged at any particular period of time. Normally the main conductors 1 and 3 constitute a loop-circuit closed at the substation through the call-bell *b*, but open at the contact-spring 10 of switch-socket J in the central station, and the said loop may be traced as follows: from spring 10 over conductor 1 to bell *b*, lower contact-point 9 of telephone-switch *s*, telephone-transmitter *m*, conductor 3, and the associate contact-spring 11 of the switch-socket. The circuit as thus arranged is adapted for the transmission of call-signals from the central station to the substation, and this may be done in the ordinary way by inserting the appropriate switch-plug P or P^2 in the substation switch-socket and by then manipulating the call-key *k* or k^2. Assuming that key *k* is depressed, we may now trace the ringing-circuit as extended from the two switch-socket contact-springs by way of the plug-tip *a*, which is engaged by socket-spring 10, cord-strand 16, spring 17 of ringing-key, contact-point 27, conductor 26, to terminal *p* of the call-generator F and from terminal p^2 thereof by conductor 25 to contact-point 24 and spring 23 of the ringing-key, cord-strand 21, and ring-conductor *c* of the switch-plug to the socket-spring 11. It will be observed that main conductor 3 in its normal arrangement, as hereinbefore described, is extended from socket-spring 11 by the contact-stop thereof and conductor 15; but so far as the circuit for operating the substation-bell *b* is concerned this extension is a spur or discontinuous conduc-

tor having no relation to the function of the ringing-circuit, which has been traced.

We have now to consider the rearrangement of the circuit which ensues when a call is transmitted from the substation to the central station. This operation is automatically performed by the act of taking the substation telephone-receiver from the switch, which severs the connection through the bell *b* between the main conductors 1 and 3 and establishes a connection between conductors 2 and 3, which previously constituted a loop analogous to that already described, but open at the substation and closed at the central station. This signaling-circuit, completed by the contact made between the substation-switch *s* with the contact-point 8, extends from the plus pole of the central-station source of current-supply E (usually a battery) by way of point 40, conductor 14, point 41, main conductor 2, switch-contact point 8, switch-lever *s*, main conductor 3, switch-socket spring 11, contact-stop 12, conductor 15, including signal annunciator or relay *e*, and point 30 to the minus pole of the battery E. Obviously when this loop is closed at the substation-switch *s* the signal instrument *e* is operated and the central-station operator understands that a call-signal has been sent in.

The switch-cord circuit D, terminated at its ends by the switch-plugs P and P^2, is associated with the common source of current-supply E, the condensers *f* f^2, the ringing-keys *k* k^2, the induction-coils *h* h^2, the impedance-coil *i*, and the supervisory signals *g* and g^2. The tip-conductor of the plug at each end connects through a resting-contact of the ringing-key with one plate of the condenser and from the other plate of the condenser continues by way of the two windings of the induction-coil in series, the supervisory signal, and the impedance-coil to one pole of the battery, while the rear sleeve-conductor *d* of the plug, which engages the socket-frame or test-ring of the switch-socket connects with the other pole of the battery by wire 22. The forward sleeve or ring conductor of the plug connects through the remaining resting contact of the ringing-key with a point 42 on the tip-conductor strand intermediate of the two induction-coil windings, by which it appears that the tip and ring plug-conductors are united within the cord-strand, forming a loop through the condenser and induction-coil primary, and that the ring and rear sleeve plug-conductors are united within the cord, forming another loop extending through the induction-coil secondary, the impedance-coil, and the battery. The conductor 14 unites the socket-frame 13 with the plus pole of the battery normally for signaling purposes, but is permanently attached, since it does no harm, and when the plug is inserted is merely a second conductor between the said socket and the battery parallel with the plug-sleeve conductor 22. Since the circuit arrangement of both plugs is in this cord-circuit the same, it will be understood that the foregoing description applies to both.

When in pursuance of a call transmitted in either direction a line is switched at the central station by the insertion of the plug P in the socket J, the substation-telephone being at the same time removed from the switch-hook, the conversation-circuit thus constituted utilizes all three of the circuit-conductors in the manner now to be described, the circuit formation being in every essential respect that indicated more simply in Fig. 2, wherein the two substation-circuits L L^2 are united at B to form a through talking-circuit between A and C. Each of these substation-circuits now has its three conductors formed into two subcircuits N and M, N being the primary and M the secondary subcircuit of the respective substation-transmitters *m*. The primary subcircuit of substation-circuit L may be traced from contact-point 7 of the telephone-switch *s* at substation A by main conductor 1 to switch-socket J and socket-spring 10, thence by the plug-tip *a*, cord-strand 16, spring 17 of ringing-key *k*, condenser *f*, primary winding 19 of induction-coil *h*, conductor 21, including spring 23 of ringing-key, ring-contact *c* of plug, switch-socket spring 11, main conductor 3, transmitter *m*, and switch-lever *s*. The secondary subcircuit from the plus pole of the central-station battery leads by conductor 22, sleeve *d* of plug, socket-ring 13, main conductor 2, switch-point 8, switch-lever *s*, transmitter *m*, main conductor 3, switch-socket spring 11, ring-contact *c* of switch-plug and cord-conductor 21, point 42, secondary winding 34 of induction-coil *h*, strand-conductor 29, signal *g*, point 31, and impedance-coil *i* to the opposite end of the battery. It is evident therefore that the main conductor 3, extending from the substation-switch *s*, and its continuation 21 to the point 42 between the induction-coil windings is a section of conductor common to both primary and secondary circuits.

The substation receiving-telephone *t* is preferably placed, as shown in full lines, in the circuit of main conductor 1, and when so placed is connected in the primary subcircuit. It may, however, if desired, be connected, as indicated in dotted lines, in main conductor 2, and in that event when the line is switched for conversation would be in the secondary subcircuit. It is, moreover, manifest that the substation-transmitter *m* instead of being placed, as shown, in the main conductor 3 outside of the switch-lever *s* might be connected between the receiver *t* and the switch-contact point 7 and that such change of position would be immaterial and would not be productive of any change in operation. In fact, such a change in location would practically amount merely to a lengthening out of the said main conductor 3, so that it might include the switch *s* bodily—that is, it would consist merely in transfer-

ring the transmitter from one side of the switch to the other.

The operation of this system is easy to be understood. To call from the substation, the only operation required is to remove the receiver *t* from the switch *s*. A circuit for the battery E is closed, as already described, through the signal device *e*, which is thereupon displayed, and the call is answered by the operator, who inserts the plug P and switches in her answering-telephone t^2 in the ordinary way. When the circuit is organized for the transmission of speech, which occurs when the line is switched at the central station, and when the receiver is taken from the hook at the substation, the battery-current flows through the transmitter *m*. The operation of the said transmitter produces variations in its resistance, and consequently variations in the difference of potential between its terminals. These fluctuations cause telephonic waves corresponding to the sound-waves of the voice to flow or oscillate in the primary subcircuit N, which includes the condenser *f* and the primary induction-coil winding 19. By the voice currents or surges thus produced in the said primary circuit and through the primary winding 19 similar currents are inductively developed in the secondary winding 34 of the induction-coil, and these traversing the main circuit reach and actuate the distant receiver, whether the same be placed at the central station or at a distant substation. In the latter case the interconnection at the central station implies the union of the two ends of one substation secondary circuit with those of the other. When the plugs P P^3 are in the sockets of two lines, the battery-current flows through the two signal devices *g* g^2, causing them to display a given signal indicating that the substation-telephones of the said two lines are in use, and on the termination of conversation the opening of the circuits by the operation of the telephone-switches as the receivers are replaced on their hooks produces a different signal or a changed signal indicating a discontinuance of such use and that the lines concerned may now be disconnected.

Fig. 3 illustrates apparatus and circuits whereby one of my three-conductor substation-circuits, terminating, for example, in a branch exchange, may be interconnected with an outside substation-circuit of the more ordinary type, terminating in a separate central station. This may be done by providing a trunk-line of any suitable construction extending between the central stations and by means of a switch-cord circuit at the branch-exchange switching-station which has the circuit connections of one of its plugs P^2 arranged on the plan of the cord-circuit illustrated by Figs. 1 and 2, with similar associated appliances, while the main circuit connections of the companion plug P^3 consist merely of two conducting-strands 43 and 44, extending inwardly from the tip and ring contact-surfaces *a* and *c*, respectively, of the said plug and united at their inner ends to form a closed loop including the central-station battery E. The supervisory signal is connected in conductor 43. Instead of the impedance-coil *i*, associated with the common battery, as in Figs. 1 and 2, the cord-circuit as modified has a repeating-coil I^2, having part of its winding on one side of the battery and part on the other. The windings 45 and 47 are in the loop of plug P^3, one on each side of the battery, and these are in close inductive relation with two other windings 46 and 48, which are associated with the conductors of plug P^2. The winding 48 is in practice left in a discontinuous condition at one end, since if connected there with the cord-strand 22 it would be short-circuited. Its presence, however, even in such discontinuous condition is useful as adding to the inductive effect. It will be seen that by means of this form of cord-circuit the three-conductor substation-circuit L^2, entering central station B, can be interconnected with the ordinary substation-circuit L^4 of the common battery-relay type belonging to central station H through the trunk-line L^3, the plugs P^2, P^3, and P^4 being inserted, respectively, in the sockets J^2, J^3, and J^4. In the talking-circuit as thus organized one conductive section S extends from the substation R to the branch central station B and includes the substation-circuit L^4, the trunk L^3, and the switch-cord loop S^3 of plug P^3, and the said section S is inductively united by the repeating-coil I^2 with the subcircuits M and N of the substation-circuit L^2, leading to substation C.

I claim—

1. The combination in a telephone-circuit, of two main conductors extending between a substation and a central station, and respectively forming portions of two associated subcircuits; a third main conductor constituting a complementary and common portion of both of said subcircuits; a condenser at the central station included in one of said subcircuits; a source of transmitter-current supply at the central station connected in the other subcircuit; a transmitter at the substation connected in the said complementary main conductor; and an induction-coil for said transmitter at the central station, having its two windings included in the said two subcircuits respectively; substantially as set forth.

2. The combination in a telephone-exchange circuit and central-station switch devices therefor, of a telephone receiver and transmitter at a substation; and a three-conductor circuit associated therewith, and having contact-terminals in a central-station switch-socket; with a transmitter-battery, a transmitter induction-coil, and a condenser, all at the central station; and an associated three-strand switch-cord and terminal plug, also at the central station, the said plug having terminal contacts for the cord-strands adapted to register in the switch-socket with

the three contact-terminals of said main conductors, in such manner as to close one circuit only through two of the said cord-strands, the said battery, the two windings of the induction-coil in series, the condenser, and the substation receiving-telephone, and a second circuit through the third cord-strand and the substation-transmitter between two points of the first circuit placed respectively at the central station between the two induction-coil windings, and at the substation between the telephone-receiver and the battery; substantially as described.

3. In a telephone system, the combination substantially as hereinbefore described, of a substation-circuit comprising three main conductors extending between a telephone transmitter and receiver at a substation and a switch-socket at a central station; with a triple-conductor switch-cord, and a terminal switch-plug therefor also at said central station, adapted to engage with said switch-socket; a condenser, the two windings in series of a transmitter induction-coil, and a transmitter-battery being connected in a loop through two of the said cord-strands between two contact-surfaces of said switch-plug, which when the said plug is placed in said socket are arranged to complete the circuit of said loop through the substation telephone-receiver; and the third of the said cord-strands being extended from a point on said loop between the two induction-coil windings to a third switch-plug contact-surface arranged to register with a third terminal contact within said switch-socket, and thereby complete a bridge-circuit through said strand, and the substation telephone-transmitter to a point on the loop-circuit at the said substation between the receiver and the battery.

4. In a branch telephone-exchange system, a substation telephone and signaling circuit having three main conductors formed normally into two conducting-loops, one closed at the central station through a signal-receiving instrument and a battery but open at the substation, and the other closed at the substation through the call-bell and open at the central station; combined with a hook-switch at the substation, and socket-and-plug switch devices at the central station controlling the terminals at said stations of the said three main conductors respectively; and adapted when changed from their normal position to disconnect the said signal-receiving instrument and to form of the said three conductors, for the substation-transmitter a primary and secondary circuit; one of the said three main conductors constituting a common section of both of said circuits; substantially as described.

5. The combination in a telephone-circuit of two main conductors extending between a substation and a switching-station, and respectively forming portions of two associated subcircuits; a third main conductor also connecting the said stations, and constituting a complementary portion of said subcircuits common to both; a telephone-receiver at the substation, and a condenser at the switching-station included in one of said subcircuits; a source of transmitter-current supply and a repeating-coil at the switching-station having a winding connected in the second subcircuit; a transmitter at the substation connected in the said complementary main conductor; and an induction-coil for the said transmitter at the switching-station having its two windings included in the said two subcircuits respectively; with a two-conductor main substation-circuit connected at one end through two other windings of the said repeating-coil and extending therefrom, through a second switching-station to a second substation, provided with a transmitter in the said main circuit, adapted to receive current from the said current-supply at the first-mentioned switching-station; as set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 6th day of February, 1900.

GEORGE K. THOMPSON.

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