No. 632,296. Patented Sept. 5, 1899.

T. C. WALES, Jr. & K. W. WATERSON.

TELEPHONE SWITCHBOARD AND CIRUITS.

(Application filed June 6, 1899.)

(No Model.) 3 Sheets—Sheet 1.

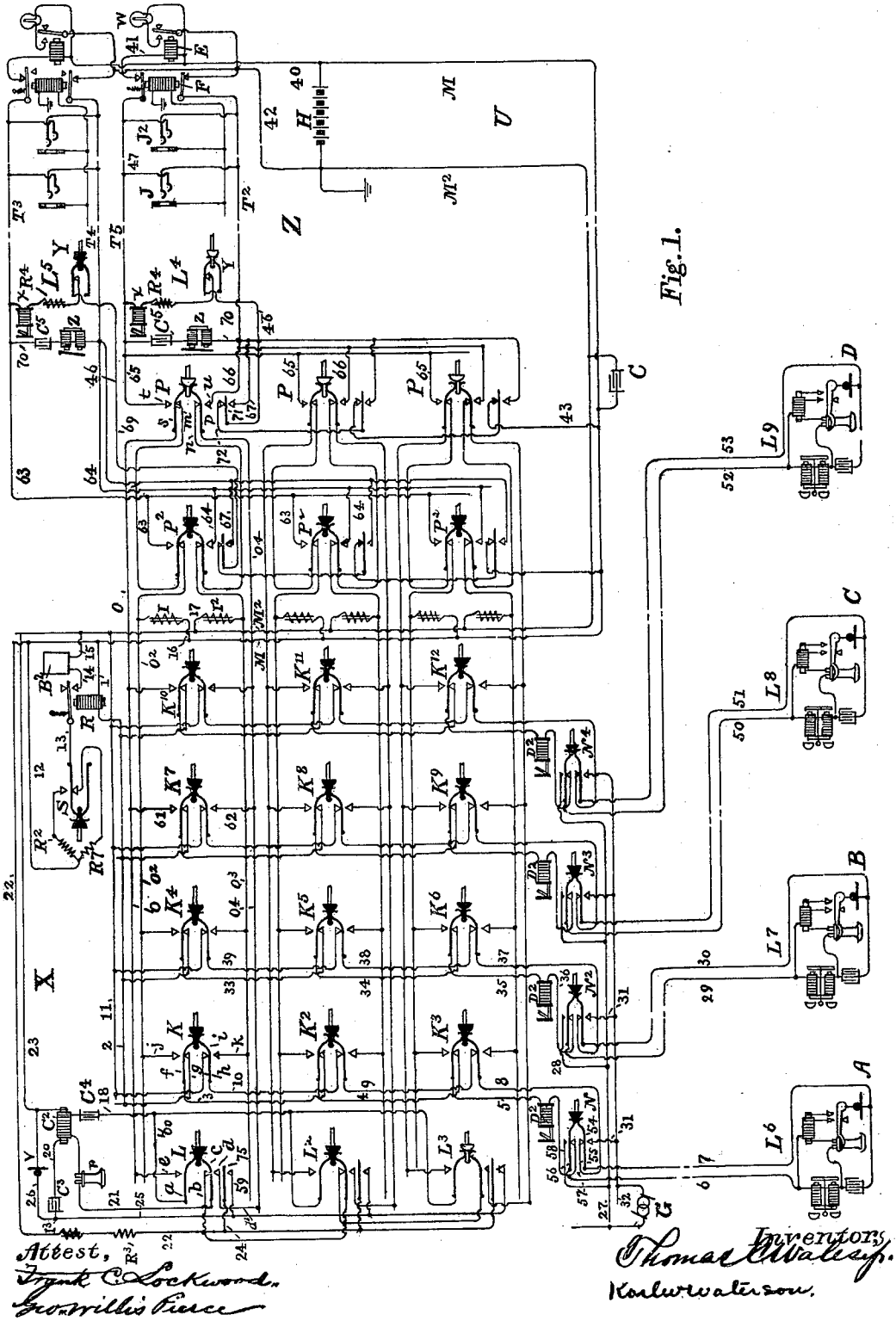

Fig. 1.

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(No Model.) 3 Sheets—Sheet 2.

Fig. 3.

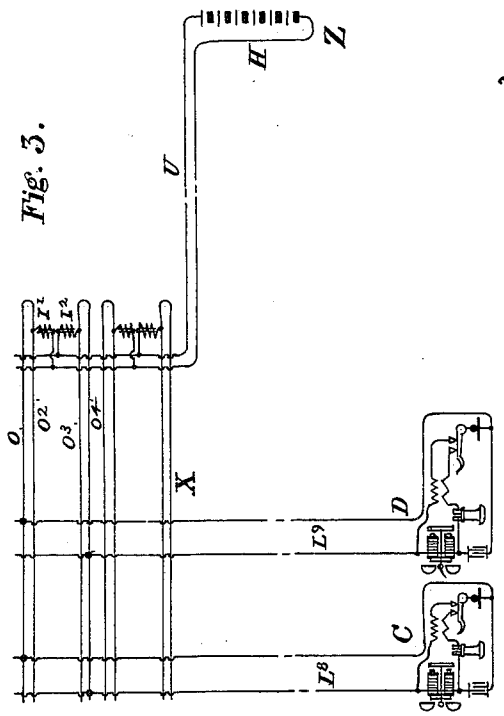


Fig. 5.

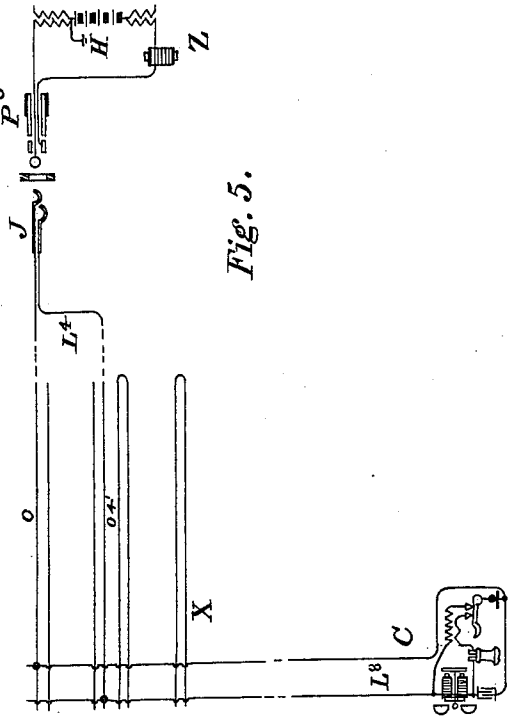


Fig. 2.

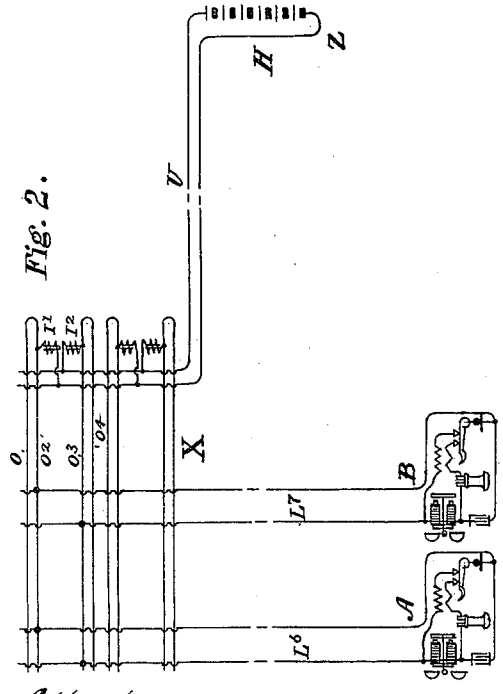
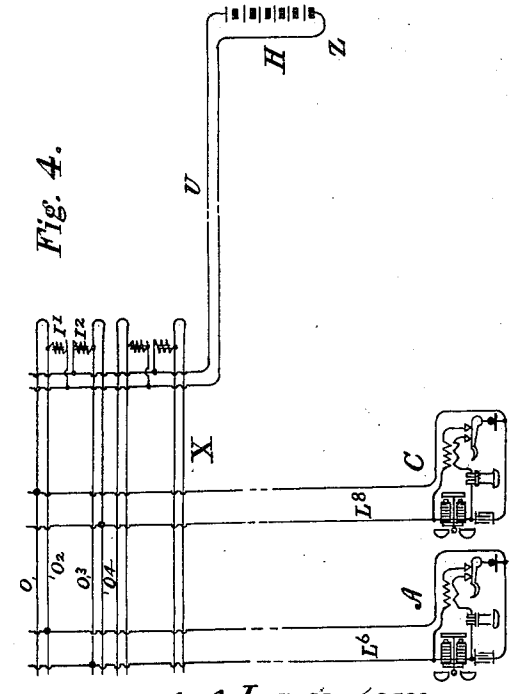


Fig. 4.



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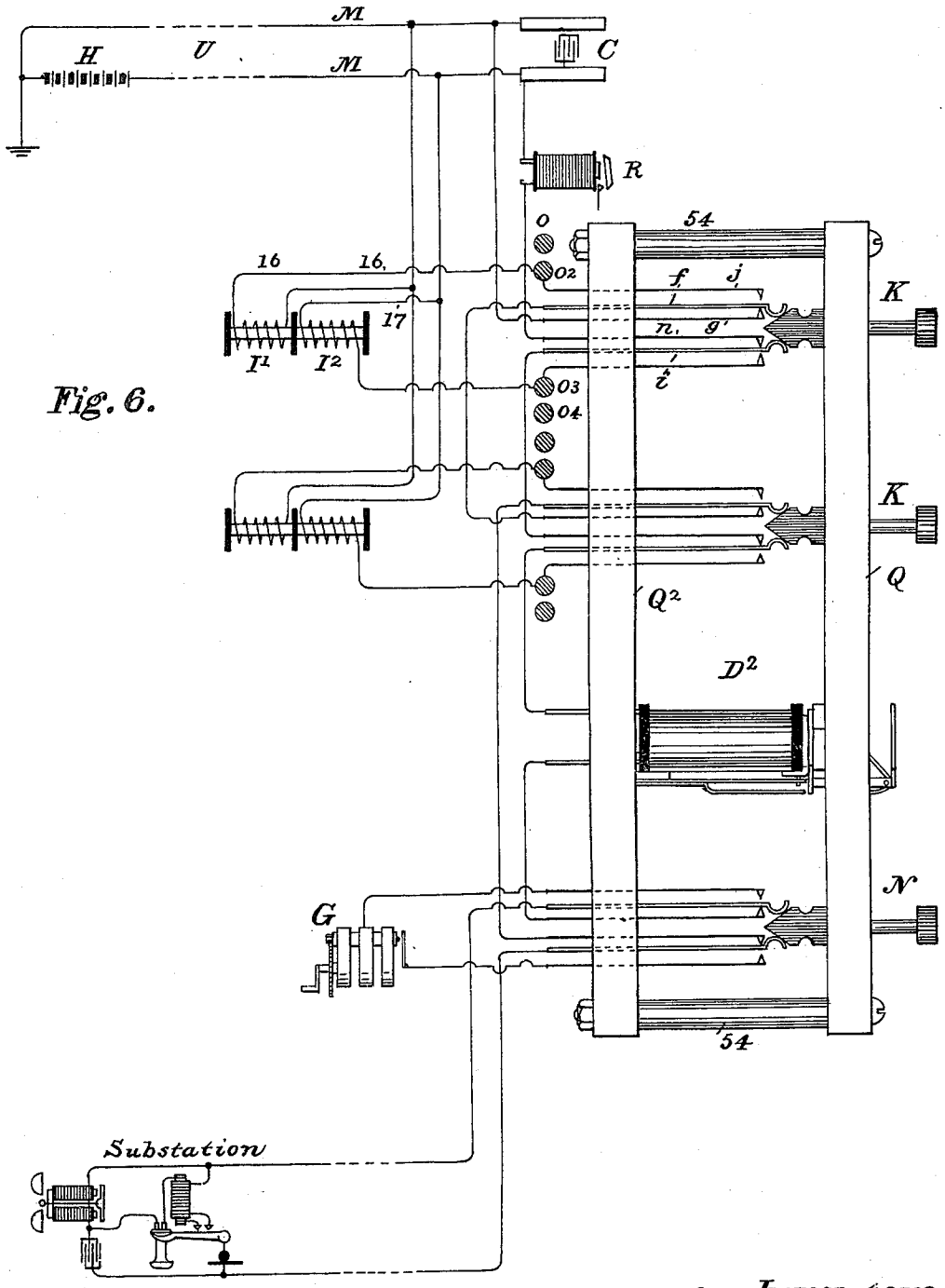

Fig. 6.

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UNITED STATES PATENT OFFICE.

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TELEPHONE SWITCHBOARD AND CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 632,296, dated September 5, 1899.

Application filed June 6, 1899. Serial No. 719,628. (No model.)

To all whom it may concern:

Be it known that we, THOMAS C. WALES, Jr., residing at Newton, and KARL W. WATERSON, residing at Lowell, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone Switchboards and Circuits, of which the following is a specification.

A telephone central office comprises, as is well known, a switchboard upon which are arranged the terminals of a number of electric conductors connecting the central office with a corresponding or greater number of substations, and also the terminals of other conductors which connect the said central office with, it may be, several other central offices having likewise switchboards provided with the terminals of substation-circuits, each of the switchboards having means for receiving calls, for testing circuits, and for uniting any two of the substation-circuits, whether they are both directly connected to the central office at which the call originates or connected with different central offices.

Private branch exchanges have recently been introduced in places where it is desirable that a small number of closely-related substations—for example, departments of the same business—shall have exceptional advantages of prompt intercommunication, and where it is also desirable that some or all of such a group of substations shall have facilities for communication through a main central office with the other substations of the telephone-exchange at large. Such conditions are frequently met with in public buildings, manufacturing establishments, hotels, large department stores, and similar institutions. In such private branch exchanges there is a switchboard, and the principal duty of its operator is to interconnect by its means local substation-circuits, while a considerable portion of the work is also the establishment of conversation-circuits over the trunk-circuits which extend between the branch exchange and a main central office to substations having lines normally converging to the said central office in answer to calls made either by the substations of the branch exchange or by those of the main central station. The present tendency is to equip the central stations with automatic means for switching operations as far as is feasible, instead of the manually-operated means which so far have been employed, and consequently to increase the capability or facilitate the work of the operators; and the form of switchboard in favor now, termed the "common battery" or "central electric-energy multiple board," represents in part the advance in this respect.

The present invention relates to the switchboard and its associated circuits for use at a private branch exchange which is connected to a distant central office by trunk-circuits, the central office being provided with a switchboard of the common or central-energy type. In the said branch exchange part of the exchange substation-circuits are adapted to be switched to each other or interconnected with the circuits local at such exchange only, while the remainder of the circuits can be connected with all of the others and by means of the said trunk-circuits with the central station also. When any of the substation-circuits are switched to one another for conversational purposes, they are supplied with current from the common source at the central station over special conductors for that purpose, and when the substation-circuits are switched to the central station over a trunk-circuit the current for the substation-transmitters is in like manner supplied from the central station, but over the trunk-circuit. The substation-conductors extend vertically across the switchboard and are provided with a series of connecting-keys, and at right angles to the said conductors are connection-conductors adapted to be engaged by such keys, so that by depressing two keys in the same plane two substation-circuits may be linked or united to each other. Means are provided whereby the trunk-circuits from the distant central office are adapted to extend across the switchboard of the private exchange and have connections with a part of the said connecting-keys, so that by the depression of a certain key a substation can be connected with the central office.

By the invention the employment of plugs

and cords is obviated, the operator is made aware that pressing a given key of any line will always establish a given connection of such line, and all the advantages of the common battery-switchboard are obtained in a small private branch exchange.

The accompanying drawings illustrate the invention, wherein—

Figure 1 is a diagram of a switchboard at a private branch exchange from which extend conductors to four substations and wherein two trunk-circuits and a current-supply circuit extend to a distant main central station. Figs. 2, 3, 4, and 5 illustrate the manner of switching together of the private branch substation-circuits for the several classes of service to which they are adapted; and Fig. 6 is an end view of an organized switchboard for a private branch exchange, the circuits thereof being shown diagrammatically.

Referring to the drawings, A, B, C, and D are substations connected to the private branch exchange X by their respective circuits L^6, L^7, L^8, and L^9, the exchange being connected to the distant central office Z by the trunk-circuits L^4 and L^5 and by the current-supply circuit U. The substations are provided with the common battery telephone apparatus, the usual high-resistance call-bell being normally in circuit with a condenser and adapted to be shunted by the hook-switch, which operation leaves the telephone, condenser, and primary of induction-coil in a localized portion of the main circuit and the secondary of the said induction-coil in the main circuit direct.

The conductors of the substation-circuits extend vertically across the switchboard and through their signaling-keys N, N^2, N^3, and N^4, respectively, and their front contacts including in one conductor the line-signal D^2 and continuing through the series of keys K from their springs *f* and *i* and front contacts *g* and *h* to the conductors 11 and 2, which connect with the respective conductors M^2 and M of the current-supply circuit U, which conductors connect with or are united to the opposite poles of the centralized source of electric energy H at the central office Z.

The back contacts of the keys K, K^2, K^3, K^4, K^5, and K^6, associated with substation-circuits L^6 and L^7, are connected by branches *j* and *k* with the respective connecting-conductors o^2 and o^3 of a series of switchboard connections which extend longitudinally through the switchboard, and the said conductors o^2 and o^3 are connected to the conductors of the current-supply circuit U by the branches 16 and 17, respectively, including in their circuits impedance-coils $I I^2$.

G is a call-generator having main leads or conductors 27 and 32, from which extend branches 58 and 31 to the back or operative contacts of the calling-keys N N^2, &c.

The switch-conductors o^2 and o^3 continue through the front contacts and springs of the keys P^2 P in series, and from the springs of the outermost key P other conductors *o* and o^4 return through the switchboard, parallel with conductors o^2 and o^3, and have branches 61 and 62 to the back contacts of the keys K, associated with the substation-circuits L^8 and L^9. The upper back contacts *t* of the vertical series of keys P are connected by branches 65 with the conductor T^5 of the trunk-circuit L^4, and the lower back contacts are united to the other conductor T^2 by the branches 66, while the upper and lower back contacts of the vertical series of keys P^2 are connected to the conductors T^3 and T^4 of the trunk-circuit L^5 by the branches 63 and 64. The central-station terminals of the trunks L^4 and L^5 are the same as those of any relay-controlled substation-circuit. They may have multiple sockets J and J^2, as shown, cut-off relay F, and line-lamp signal *w* in connection with the common battery H.

L, L^2, and L^3 are listening-keys. The back contacts of their springs *a* and *c* are connected by branches *e* and d^2 with the conductors *o* and o^4, while the springs *a* of the said keys are respectively connected in parallel with the conductor 18, and the springs *c* and their front contact-points *b* in series with the conductor 21, these conductors containing in their circuit the operator's telephone *r*, secondary of induction-coil C^2, and condenser C^4. The auxiliary springs 75 are connected by branches 24 to the wire 22, which includes the resistance R^3 and choking-coil i^3, and thereby to the current-supply conductor M, the other supply-conductor M^2 being furnished with a branch 23 to the primary of induction-coil C^2, the condenser C^3, and telephone-transmitter V, the latter being in a shunt-conductor 26. From a point between the transmitter and the condenser C^3 a wire 25 extends to the contacts 59 of the keys L L^2 L^3, which contacts are adapted to engage the springs 75, branching from the wire 22.

B^2 is a "buzzer" or electrotome connected by branch 15 on one side to the current-supply conductor M^2 and on the other by branch 14 to the normally-open contact of the armature of relay R, the said armature connecting by wire 13 to a contact-spring of the key S, which rests upon its inner contact-point and is thus in circuit with the coarse-wire resistance R^7, which is connected with the battery-conductor M by wire 12, there being also associated with the key S a fine-wire resistance-winding R^2 in an open branch from wire 12, which is adapted to be included in circuit when the key S is pushed in to engage its back contact.

The keys P^2 and P are each provided with a spring 71, normally resting on an upper contact 72, and conductors 43, containing the several contact-springs 71 and points 72 of the said keys of each class in series extend to the battery-conductor M, the upper spring 71 of each class being connected by wire 46 for keys P and wire 69 for keys P^2 to the upper conductor of its outgoing trunk-circuit

through a key Y, impedance-coil R^4, and an annunciator x, while the lower contacts of the said springs of the keys P^2 and P connect by wires 67 to the lower conductors T^2 T^4 of the trunk-circuits. Bridges 70 between the conductors T^3 T^4 of the interoffice trunk-circuit L^5 and the conductors T^2 T^5 of trunk-circuit L^4, respectively, each contain a buzzer z and a condenser C^5.

The circuits L^6 and L^7 of substations A and B are examples of substation-circuits adapted for local interconnection with the substation-circuits of the branch exchange only and cannot be switched to the central station Z, while the substations C and D can be switched to the central office, as well as to A and B and to each other, as will presently be described.

Fig. 6 shows in vertical section a concrete form of the switchboard and consists of a rigid frame having a front board Q, upon the face of which are shown the calling-keys N, line-signal D^2, and connecting-keys K in two planes. The keys P are also in the same plane with the keys K and cannot of course be shown in an end or side view. At a suitable distance in the rear of the board Q there is a second board Q^2, held to the former by bolts 54. The springs of the several keys are supported by the board Q^2, as are also the switch connection crossing conductors o, o^2, o^3, and o^4 and the other wires, which for the sake of clearness are shown in diagram.

In the operation of the invention we will suppose, first, that a call is made from the substation A for a connection with substation B. The telephone at A being removed from the switch-lever, a shunt-circuit is closed about the bell, and current flows from battery-main M to wire 1, relay R, conductors 2, 3, 4, and 5, passing through points g and springs f of the keys K, K^2, and K^3, line-signal D^2, contact-points 57 and springs 56 of calling-key N, conductor 6, substation apparatus of station L^6, and returning via conductor 7, spring 54 and point 55 of key N, conductors 8, 9, and 10, including contact-springs i and points h of the keys K^3, K^2, and K, conductor 11 to the return supply-conductor M^2 of the source of current H. The line-signal D^2 and relay R are operated, and when the armature of the latter engages its front contact-stop current flows from battery-main M through conductor 12, resistance R^7, contact-point and spring of key S, conductor 13, armature of relay R, wire 14, buzzer B^2, and wire 15 to main M^2 of the supply-circuit, and the said buzzer B^2 is operated and constitutes an audible signal auxiliary to the visible signal D^2. The operator pushes in one of the local switch-keys—say the key K—belonging to the calling substation line L^6, and current then flows from battery-main M, branch 16, impedance-coil I, switch connection conductor o^2, branch j, spring f, conductors 3, 4, 5, and 6 to substation A, then back by conductors 7, 8, 9, and 10, spring i of key K, branch k, switchboard connection conductor o^3, branch 17, and impedance-coil I^2 to main M^2 of the common source of current. By depressing the listening-key L a listening-circuit is established as follows: From the outside of the impedance-coils by way of contact m and spring s of key P, conductor o, contact e, and spring a of key L, conductors 60 and 18, condenser C^4, secondary of induction-coil C^2, conductor 21 and operator's telephone r, spring c and contact-point d of key L, conductor o^4, spring p and contact n of key P, and through similar contacts of key P^2 to the outside impedance-coil I^2 and supply-conductor M^2. When the key L is pushed in, a third contact closes the battery-circuit through the operator's transmitter, as follows: From the conductor M, conductor 22, impedance-coil I^3, resistance R^3, conductor 22, branch 24, spring-contacts 75 and 59 of key L, conductors 25 and 26, transmitter-electrodes V, and conductor 23 to the return supply-conductor M^2. The primary of the induction-coil C^2 with a condenser C^3 in series is put in circuit in parallel with the said electrodes. Thus while the to-and-fro talking-current may readily pass through the primary winding of the induction-coil, no direct current from the battery passes through it. The telephone is thus bridged across the substation-line and the operator is enabled to listen and take the call.

To connect the substation circuit L^6 with the circuit L^7, the operator pushes in the local key K^4 in the same horizontal plane as that of the key K, or where circuit L^7 crosses the switchboard connections o^2 o^3 by means of which the circuit L^6 was answered. The ringing-key N^2 is operated, whereupon a call-current flows from the generator G via conductors 27 and 28, contact 58, and spring 56 of the key-conductor 29, the bell and condenser at station B, conductor 30, spring 54 and contact 31 of the key and by return-conductor 32 to the generator. When the telephone at station B is removed from its hook, the telephone instruments of the circuit L^7 are switched into connection with the source of current-supply H by way of conductors 29, 35, 34, and 33, spring f and branch contact j of key K^4, switchboard-conductor o^2, impedance-coil I, and supply-conductor M, returning from supply-conductor M^2 by impedance-coil I^2, switchboard-conductor o^3, contact-branch k and spring i of key K^4, and conductors 39, 38, 37, and 30 to the substation B. By this line of conductors current is supplied to the signal D^2, which operates, indicating that the subscriber has responded by taking down his telephone and is supplied also to the transmitter at station B; and as substation-circuit L^6 is already united by the key K to the same switchboard-conductors o^2 o^3 the two circuits L^6 and L^7 are now switched together for conversation and the battery H is connected in bridge to supply transmitter-current for both through its conductors M M^2 and their impedance-coils I I^2. The line-signals D^2 may serve also as discon-

necting-signals, and when either telephone is restored to its hook its respective signal, no longer held by its electromagnet, is restored by gravity. This entire connection of such circuits, as $L^6 L^7$, is illustrated by the diagram Fig. 2.

If one of the substations C or D—say the former—wishes to be switched to the central office Z for through communication with a substation-circuit centering there, the removal of the telephone causes current to flow, as previously described, from battery H through the main circuit L^8 for the operation of line-signal D^2 by way of conductor M, relay R, the various local keys, the line-signal D^2, the substation apparatus, and back to battery-conductor M^2 through the reverse contacts of the said local keys. The relay R and the signal D^2 operate, the former actuating the buzzer, which sounds to attract the operator's attention, and the latter indicating what substation has called. To listen in, the operator may manipulate any desired one of the keys K^7, K^8, or K^9 and the corresponding listening-key L, L^2, or L^3, this being subject, of course, to the limitation that some of the switchboard connection-conductors may already be engaged. When the operator has ascertained that a central-office substation is wanted, she may switch the calling-circuit to one of the trunk-circuits L^4 or L^5, and after obtaining the connection of the desired line allow the subscriber to call the substation thereof, or may herself obtain the desired connection and have the substation thereof signaled, notifying the calling party when the connection is made. We will suppose that the latter is done and that the subscriber after giving his order hangs up the telephone. Withdrawing the key K^8 the operator pushes in one of the disengaged trunk-line keys—say P. Current will then flow from battery H through conductor 40, relay E, conductor 41, armature of relay F, trunk-conductor T^5, trunk-line signal x, resistance R^4, cut-off key Y, conductor 46, spring 71, and contact 67 of key P, trunk-conductor T^2, lower armature of cut-off relay F, and conductor 42 to the opposite pole of the battery. The trunk-line relay E now operates and current flows through line-lamp w, making it glow to signal the central station, and as the signal x is now bridged across the trunk-circuit L^4 and in the path of the said current it will be operated thereby. The operator at the private-branch-exchange switchboard may also listen in on the trunk-line, as her telephones are bridged across the appropriate switchboard connection-conductors o o^4. The central-office operator in response to the operation of line-lamp w now inserts an answering-plug (not shown) into the answering-jack J, and by switching her telephones to the trunk-circuit may talk to the operator at the private-branch board, and when the desired connection has been made the latter operator informs the substation C of the fact. The line-signal D^2 and the trunk-signal x are left in operation in the through-circuit, the former falling by gravity to signal for disconnection when the subscriber at C hangs up his telephone, and thereby opens the line, and the latter falling when the central-office operator withdraws her plug. When both signals have fallen, the operator at X restores the switchboard-keys to their normal position. Fig. 5 shows the substation C switched through the switchboard of the private exchange X and one of the trunk-lines L^4 to the central office Z, P^3 being the plug of the central-station cord-circuit, which circuit may have the usual divided repeating-coil and the centralized battery H bridged in between the cords. Whenever substations A or B desire to be connected with substations C or D, or vice versa, the respective switchboard-keys in the same plane are manipulated, and the two circuits concerned will be united to each other, although the connections j and k of the keys of the A and B circuits are with the switch connection-conductors o^2 and o^3, while the connections 61 and 62 of the keys of the C and D circuits are with the connection-conductors o and o^4, for the reason that these respective upper and lower parallel connection-conductors are normally connected to each other through the springs and front contacts of the keys P P^2. This will be evident from a consideration of Fig. 3, where a connection between substations C and D is illustrated, and from Fig. 4, where a connection between substations A and C is shown.

If a central-office subscriber wishes a connection to one of the private-branch-exchange subscribers, the operator inserts a plug in one of the multiple jacks J and by means of the usual ringing-key operates the buzzer z to attract the attention of the branch-exchange operator. When a plug P^3 is inserted into a jack J of the trunk-lines, the polarity of the trunk-conductors is reversed from their normal condition, and current flows from the battery-conductor M, conductor 43, contact 72 and spring 71 of key P, conductor 46, key Y, resistance R^4, trunk-signal x, trunk-conductor T^5, branch 47, tip of plug P^3, repeating-coil, and to ground, and the trunk-signal x operates. The private-branch operator by pushing in either of the keys P or P^2, according as the signal has been received over line L^4 or L^5, may now listen, receive the order, and make the connection wanted, the remainder of the operation being identical with putting up a connection for the substation C, as previously described.

We claim as our invention—

1. The combination in a telephone switching system, of a branch exchange, a main central station connected thereto by trunk-circuits, a source of current at the central station connected to the branch exchange by a supply-circuit; and two divisions of substation-circuits associated with the said branch exchange, both adapted for local interconnection, and one division adapted also for con-

nection with the central station over said trunk-circuits, each substation-circuit extending across the branch-exchange switchboard through a call-key, a line-signal and a series of local connecting-keys, and terminating in the current-supply circuit; with a plurality of pairs of switchboard connection-conductors, the members of each pair being normally united in series by central-station-trunk-circuit-connecting keys at one end, in which keys are located the terminals of the said central-office trunks, the connection-conductors of each pair being provided with branch contacts in the local connecting-keys as described, and with branches containing impedance-coils extending to the supply-conductors leading to the respective poles of the said source of current, as set forth.

2. The combination in a telephone switching system, of a branch exchange, a main central station connected thereto by trunk-circuits, a source of current at the central station connected to the branch exchange by a supply-circuit, and two divisions of substation-circuits centering at the said branch exchange, both adapted for local interconnection, and one also for connection with the central office over said trunk-circuits, each substation-circuit extending across the exchange-switchboard through a call-key, a line-signal, and a series of local connection-keys, and terminating in the current-supply circuit; with means for uniting all the substation-circuits together in pairs for local service, and for uniting the circuits of the designed division only, also with the central-office trunks, the said means consisting in a series of sets of switchboard connection-conductors crossing all substation-circuits, each set comprising two pairs of conductors, and associated with a local connection-key of each line, the conductors of the said pairs being provided with branch contacts in the connecting-keys respectively of the two divisions of substation-circuits, and the conductors of one of the pairs having branch connections containing impedance-coils to the mains of the said current-supply circuit; and a trunk connection-key for each set of said switchboard-conductors at one end thereof, normally uniting in series each member of each pair with the corresponding member of the other, controlling also terminals of the said trunk-circuits, and adapted on operation to sever the normal connection between the members of the said two pairs of conductors, and to establish connection between the members of one of the said pairs, and the trunk-circuit terminals, substantially as described.

3. The combination in a branch telephone-exchange, of a switchboard containing the terminals of a series of substation-circuits, a trunk-circuit, and a current-supply circuit, the substation-circuits being arranged in two divisions, both designed for local interconnections, and one also for trunk connections, and having conductors extending across the switchboard to a normal connection with the said current-supply circuit; a series of sets of connection-conductors transversely arranged on the said switchboard to cross the said substation-circuits, each set comprising two pairs of conductors one of which branches through impedance-coils to the said supply-circuit; a series of switching-keys for each substation-circuit, one at each intersection of such circuit with a set of connection-conductors, the keys of the circuits of the two divisions being organized to establish connection between the said circuits and the members of the two pairs of transverse conductors respectively; a trunk connection-key for each set of connection-conductors controlling the terminals of the four conductors thereof and of the trunk-circuit, and normally uniting each member of each pair of connection-conductors with a given member of the other, but adapted to sever the said normal connection and to unite the members of one of the pairs with the trunk-line conductors; and a listening-key associated with each set of the said connection-conductors, with branches from the said supply-circuit, and with the operators' telephones, and adapted to unite the said instruments with the said connection-conductors, and to close the circuit of the said supply branches through the transmitter, as set forth.

4. The combination in a telephone switching system, of a branch exchange, a main central office connected thereto by trunk-circuits, a source of current at the central office associated with the exchange by a supply-circuit; a plurality of private-branch-exchange substations divided into two classes of service both of which are adapted for local interconnection, one class of which is also adapted for connection with the central office over said trunk-circuits; the conductors of each of the substation-circuits extending across the exchange-switchboard, and having thereon means for calling, a signal for calls and disconnections, and a series of local connecting-keys; means for linking the substation-circuits together in pairs for local service, and for linking a part of said circuits with the central-office trunks, the said means consisting of a series of sets of connection-conductors each extending through a series of the connecting-keys of all the substation-circuits in one plane, and comprising two pairs of conductors, each member of each pair being normally united in series with the corresponding member of the other by central-office-trunk-circuit-connecting keys at one end, which keys are provided with terminals of the said central-office trunks, the conductors of the said pairs being provided with branch contacts in the said connecting-keys respectively, of the two classes of substation-circuits; and with impedance branches from the conductors of each of said united trunks to the respective conductors of the current-supply circuit, as set forth.

5. The combination of a branch telephone-exchange, a main central station connected thereto by trunk-circuits, a source of current at the central station connected to the branch exchange by a supply-circuit; and two divisions of substation-circuits converging to the said exchange, both designed for local interconnection, and one division also designed for connection with the central office over said trunk-circuits; and a switchboard across which each of the said substation-circuits extends to a normal terminal connection with the said current-supply circuit; with means for uniting any two of the substation-circuits together for local service, and for uniting the said circuits of one of the said divisions with the central-station trunks; the said means comprising a series of sets of connection-conductors arranged also on the said switchboard transversely to the said substation-circuit conductors, each set including two pairs of conductors; a series of switch connection-keys for each substation-circuit, placed at the intersections of such circuit, and the several sets of connection-conductors respectively, the keys of the circuits of each of the two divisions being organized to unite the circuit it represents, and the members of one of the two pairs of transverse conductors; and a trunk connection-key for each set of connection-conductors, containing movable terminals for one pair of the said conductors, and fixed terminals for the conductors of the other pair, and for the trunk-circuit, and being adapted to form connection between the said movable terminals and either pair of fixed terminals, alternatively; substantially as and for the purposes set forth.

6. A switchboard for a branch telephone-exchange consisting of a rigid framework, adapted to support the switching appliances, which consist of a series of substation-line-terminal conductors extending across the said framework, and uniting with the conductors of a current-supply circuit, each line including in its circuit the contacts of a calling-key, an annunciator, and the contacts of a series of local connecting-keys; a series of sets of connection-conductors extending across the said frame substantially at a right angle to the substation-circuit conductors, each set comprising two pairs of conductors; and having contact branches from the conductors of one of the pairs leading into the keys of a portion of the substation-circuits, and from the conductors of the other pair into the keys of the remaining portion of the said circuits; a key or switch normally uniting the two members of each pair of a set of connection-conductors with the corresponding members of the other pair; branch connections including impedance-coils extending from one pair of each set of connection-conductors to the mains of the said source of current-supply; and a listening-key or switch for each set of connection-conductors; substantially as specified, and for the purposes set forth.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, this 31st day of May, 1899.

THOMAS C. WALES, JR.
KARL W. WATERSON.

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