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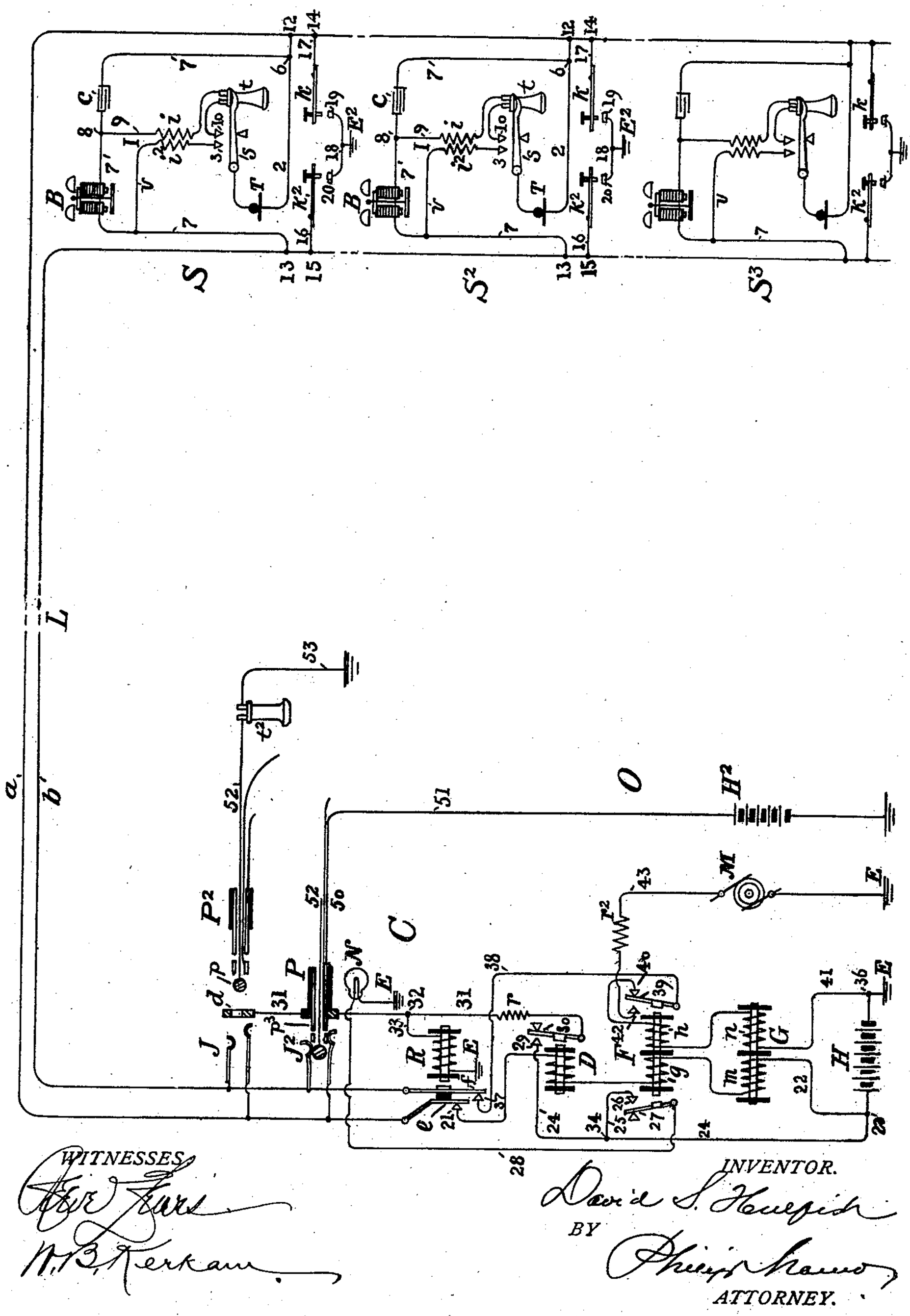
D. S. HULFISH.

SIGNALING AND SWITCHBOARD APPARATUS FOR TELEPHONE EXCHANGE CIRCUITS.

(Application filed Nov. 5, 1901.)

(No Model.)



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SIGNALING AND SWITCHBOARD APPARATUS FOR TELEPHONE-EXCHANGE CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 711,973, dated October 28, 1902.

Application filed November 5, 1901. Serial No. 81,252. (No model.)

To all whom it may concern:

Be it known that I, DAVID S. HULFISH, residing at Chicago, in the county of Cook and State of Illinois, have invented certain Improvements in Signaling and Switchboard Apparatus for Telephone-Exchange Circuits, of which the following is a specification.

This invention concerns central-battery telephone-exchange systems and apparatus, and relates in particular to polystation subscribers' circuits. Prior to my invention polystation or party lines were well known, and since each station of such a line or main circuit was provided with a magneto-electric call-generator the said stations were enabled to signal one another or the central station at will. Each of the several stations had its own particular code-signal, to which alone it responded, and the central-station operator was accustomed to ignore calls transmitted by any substation to another or others and to respond to such call-signals only as were intended for the central station as a prerequisite to a switch connection with some other line; but in the more modern system of signaling by means of a central-station source of current it has not been easy to devise an arrangement for signaling between several substations of the same main circuit, and it has been customary to signal the central station only, the apparatus and circuits being so arranged that the removal of the telephone-receiver from its hook and the consequent operation of the suspension-switch closes the main circuit through the telephone instruments, permitting the flow of current from the central source and the operation under such current of the signal-receiving device at the central station either directly or through the intermediation of a relay.

The object of my present invention is to enable the several substations of a party line or circuit to signal one another or the central station at will, according as communication is desired with a station on the same or another circuit. In carrying out this object I employ the metallic substation-circuit provided, as usual, with the central-battery line-signal and cut-off relay at the central station and having the electromagnetic bell in an inductively-closed bridge between the main conductors, the telephone instruments in a normally open bridge between said conductors, and the telephone supporting or suspension switch controlling the said telephone-bridge and adapted to close the same, and consequently the main circuit, permitting the battery-current to flow therein when the receiving-telephone is taken up from the switch-hook, all at the several substations. In association with these devices I provide at each substation means for grounding either of the main conductors of the circuit, and at the central station I employ a differential relay or electromagnetic switch controlling the local line-signal and also the connection of a call-current generator. The circuit of the central battery is closed through both of the main conductors, forming a metallic circuit when the suspension-switch at any substation is operated; but the electromagnetic switch then remains null and does not carry out either of its functions. When, however, either of the substation grounding-keys is operated, a grounded circuit formed of one of the main conductors and containing one coil only of said differential relay is established, and the said relay operates, bringing the call-generator into a second grounded circuit formed of the other main conductor. The call-current flows over this second circuit and, reaching all substations, may either ring the bells at each or may be diverted from them and conducted directly to ground, this depending on which key is pressed. The central-station signal is displayed in either case; but the operator can readily tell from the character of the signal displayed whether a substation is signaling the central station or another substation, and in the latter case takes no notice of the signal. This system of reciprocal signaling may be employed in association with circuits which terminate in a multiple switchboard at the central station. When that is the case, it is necessary to provide means for enabling each line to show itself busy when on such line being wanted it is already engaged either by two of its own stations or with a station of another line.

Although I have thought it best to illus-

trate and describe herein the busy-test system and its operation in conjunction with the system forming the subject-matter of this application, said busy-test system is described and claimed in a divisional application filed April 5, 1902, Serial No. 101,504. In conjointly employing these two systems I arrange a relay in the main metallic circuit, which when said metallic circuit is closed by the displacement of a receiver at any substation acts to connect the test-pieces of the several switch-sockets with a source of testing potential, and I also provide means for attaining the same end when the line in question is switched at any of its switch-sockets. I thus protect the said main circuit when already in use from interruption under all circumstances. Moreover, in the first case the busy test is set without operating the cut-off relay to disconnect the normal circuit connections; but in the latter case it is arranged that the application of the testing-current shall operate the said cut-off relay.

The drawing accompanying and illustrating this specification is a diagram of a polystation or party line or circuit extending from a central station to a plurality of substations.

L is the metallic line-circuit, and *a b* represent its main conductors, respectively. It is connected with the switchboard C at the central station O and extends outwardly therefrom to the substations S, S^2, and S^3.

At the central station, H is the central source of current, connected between the mains *a b* of the circuit and having a ground connection at one of its poles 36. G is the usual impedance-coil, having windings *m n* in the two main conductors, respectively.

F is a differential relay or electromagnetic switch having its two coil-windings *g* and *h* in the said two main conductors; but the said coils are wound or connected to oppose one another when a current from the source H flows in the metallic circuit L. The said electromagnetic switch is therefore irresponsive or null to such a current. Obviously, however, a similar current flowing through one only of its windings will magnetically excite the appliance, which thereupon will operate to attract its armatures. Under the conditions of this specification the coil *g* is the one which alone acts to excite the core.

R is the cut-off relay; D, a relay controlling the application of the busy-test potential to the test rings or points *d* of the switch-sockets J J^2 when the circuit is engaged by communication between two of its own stations.

M is the independent or call generator, usually a magneto-electric alternating-current generator.

N is a signal device to indicate incoming calls, and *r* r^2 are resistance devices. The switch sockets or jacks J J^2 sufficiently indicate that the switchboard C is or may be a multiple switchboard.

The signal device N is connected in a branch circuit 28, extending to earth or return through the armature and fixed contacts 27 26 of the switch-relay F from point 34 of conductor 24. This branch circuit, and therefore the said signal N included therein, is controlled by the said relay-switch F.

The call-generator M is in the normally disconnected branch circuit 43, leading from earth to the front stop 42 of the armature 39 of relay-switch, which armature normally makes contact with the back stop 40, thereby maintaining the normal connection of the main conductor *b*. The normal connection of main conductor *a* as it enters the central station and after passing its switch-socket branches is through contact-pieces *e* and 21 of the cut-off relay, winding of relay D, coil *g* of differential relay F, coil *m* of the impedance-coil, and conductor 22 to the source H at its ungrounded pole 23, while that of conductor *b* is by way of the cut-off-relay contacts *f* and 37, conductor 38, movable and fixed contact-points 39 and 40 of the differential relay F, coil *h* of said relay, winding *n* of the impedance-coil G, and conductor 41 to the grounded pole of the source H at 36. The call-generator connection is thus controlled by the differential relay F, and when the latter becomes excited and the armature-contact 39 transferred from the back stop 40 to the front stop 42 the normal connection of the main conductor *b* with the source H, including the coil *h*, is broken and the call-current generator M is united to the said main conductor in place thereof.

The apparatus at all of the substations is alike. At each is the usual electromatic call-bell B and the condenser *c* in a bridge 7 together between points 12 13 of the main conductors *a* and *b*, respectively, and the said bridge also, as usual, is held conductively open, but inductively closed, for the passage of the rapidly-changing call-currents by means of the said condenser.

T is the telephone-transmitter; *t*, the receiver; I, the transmitter induction-coil with its primary winding *i* and secondary winding i^2, and *s* the suspension-switch, serving as a support for the receiver when the station apparatus is not in use and controlling the continuity of the telephone-bridge *v* and local circuit. The said telephone-bridge *v* is shown as extending between the same points 12 13 of the main circuit-conductors and as leading through the transmitter T and the secondary winding i^2 of the induction-coil. It is open normally or while the switch *s* is held depressed by the weight of the receiver in said switch at the point 3. The said switch also controls the local circuit, which includes the receiver *t* and the primary coil *i* and which may be regarded as looping from point 6 to point 8 of the bridge 7, so that it includes the condenser *c*. The transmitter T, besides being in the telephone-bridge, is in this local circuit also.

Two grounding-keys *k* k^2 are attached to

the two main conductors *a* and *b*, respectively, at the points 14 15 in each substation. The said keys have front contact-anvils 19 and 20, both connected to earth at E^2. Normally they produce no effect on the circuit; but when either key is depressed it grounds its own main conductor directly. Moreover, when key *k* is depressed it not only connects its own main conductor *a* directly to earth, but also connects the other main conductor *b* to earth through the inductively-closed bridges 7 of their respective bells B. So, also, key k^2 when depressed grounds the main conductor *b* directly and also grounds the other main conductor *a* through the telephone-bridge of any substation or substations where such telephone-bridge is closed by the displacement of the receiver from the suspension-switch.

The busy-test system, which constitutes the subject-matter of my aforesaid divisional application, will now be explained in detail.

Referring again to the central-station appliances, it will be seen that a busy-test conductor 31 unites the several switch-socket test-frames *d*, and a connection 24 from the source H or any similar source of testing potential extends to said test-frames through the contacts 29 30 of the special relay D and a resistance *r*. The magnet-coil of the cut-off relay R is in an earth branch 33 from test-conductor 31 at point 32. When two substations of the same circuit are talking together, it is quite as necessary to protect the circuit from interruption as it is when the line is switched for communication between one of its own stations and a station of another line; but under such conditions it is required that the cut-off relay shall not be operated. This is accomplished by the use of relay D. When two stations of the same circuit are in communication, their receivers are taken from their suspension-switches and the metallic circuit is completed, so that the current of battery H can flow therein through the magnet-coil of relay D. The said relay is thus excited, and the contact 29 30 is made, establishing an electrical testing potential upon test-rings *d* by connecting them through conductors 31 and 24 with the source H at pole 23. The resistance *r* is of such magnitude that with a normal adjustment of the cut-off relay R any current passing through the said relay R is insufficient for its operation. Hence the busy test employed during the communication between two stations of the same circuit can be applied without operating the cut-off relay, and therefore without interfering with the circuit connection between the main circuit L and the source H, whose current is required for the supply of the substation-transmitters.

P is the answering-plug of an ordinary switch-cord, (not shown,) and, as usual, its local or sleeve contact-surface p^3 registers with the test-ring *d* of any socket wherein it is inserted. The said sleeve-contact is united by the local cord conductor 50 and its extension 51 to the battery H^2 and ground. Thus whenever the said plug is inserted in a socket *d* to answer or make a call the current from battery H^2 flows over the local circuit thereby established to operate the cut-off relay R in such local circuit and to impress a test potential upon all other switch-socket test-pieces belonging to the same subscriber's circuit.

It is now evident that when the line is engaged in a local communication between two of its own substations the busy-test potential is impressed upon its test-rings through the intermediation of the extra relay D and that during the engagement of said line by switching it to another line for communication between stations of the said two lines the busy-test potential is impressed upon the test-rings by way of the third or local plug-contact, the conductor thereof, and the battery connected therewith. In the former case it is necessary to retain the normal connection of the source H, and accordingly means are provided to prevent the operation of the cut-off relay R; but in the latter case it is desirable to disconnect said battery H, and the cut-off relay is made to operate. In either case should the line protected be desired for connection by another one the test is made in the usual way, as indicated by the test-plug P^2, which may, as is customary, be the companion plug of a pair associated with a switch-cord, the tip-conductor *p* of such plug being for this purpose united by the conductor 52 to the test-circuit 53, which contains the operator's receiver *t*. The tip of the plug in making the test is applied to the test-ring, the operator meanwhile listening at the receiver, and if the line is busy the test potential impressed upon said rings is manifested as a sound in the receiver, which otherwise is silent.

In the general operation of the signaling devices of the system let it be assumed that a person at any substation, as S^2, wishes to communicate with another station of the same circuit—for instance, S. He first takes up the receiver from the suspension-switch *s* and listens to ascertain whether or not the line is already employed by some other station. Finding the circuit free, he returns the receiver to the switch-hook, and then to operate the bell at station S presses the grounding-key *k*. This results in the ringing of the bell at all the substations; but as each has its own code-signal and as the key is operated in a manner to correspond with station S only all other stations will disregard the ringing of their bells. When the said key is operated, a ground-circuit is closed over main conductor *a* between the ground connection at pole 36 of battery H and the key ground connection at substation S^2. This is traceable from pole 23 of said source by conductor 22, impedance-coil *m*, the coil *g* of the differential electromagnetic switch F, relay D, contacts 21 and *e* of cut-off relay R, main conductor *a*, point 14 on said conductor at sub-

station S^2, branch 17, key *k*, contact-anvil 19, conductor 18, and ground E^2. There being no current through the other coil *h* of the electromagnetic switch F, that in the coil *g* is effective and the said switch is operated, and, attracting its armature 39, breaks the normal circuit of conductor *b* and unites the said conductor, of which said armature is the terminal, to the source M of call-current of which front stop 42 is the terminal. The current of said call-generator then passes over the grounded circuit of main conductor *b*, which circuit extends from the ground connection of said generator to the ground of the key *k* at substation S^2 by way of generator M, conductor 43, resistance r^2, contacts 42 and 39 of the relay-switch F, conductor 38, contacts 37 and *f* of the cut-off relay R, main conductor *b*, and reaching the several substations through their inductively-closed bell branches 7 in parallel to main conductor *a*, and thus to the key *k*, the ringing-current dividing between said bell branches at the points 13.

The operation of the relay-switch F includes the attraction of its armature 27, which closes the circuit 28 of the lamp-signal N; but as the code-signals are distinctive and quite different from the central-station signal, the flashings of said lamp-signal, which when such code-signals are being transmitted are transient and fluctuating, will be ignored by the operator, who on observing such brief flashings readily understands that one substation is calling another. Having obtained a response from the substation wanted, the person who has called from S^2 ceases to operate key *k* and again removing the receiver from switch *s* begins the conversation. At the same time the main circuit tests "busy" against all comers, because the relay D by operating has connected the test-rings *d* with a battery through conductors 24 and 31 and resistance *r*.

The battery H is retained in connection with the circuit to supply transmitter-current, because the cut-off relay has not operated, the current through resistance *r* being insufficient for its operation, and since current now flows through the neutralizing-coil *h*, also of the relay-switch F, the said switch has become null, disconnecting the call-generator and causing the flashes of signal N to cease.

Let it now be assumed that a substation—say S—desires to obtain a connection through the switchboard with a substation of another circuit. The receiver *t* is to be removed from the switch *s*, as in the former case, so that the person desiring to use the line may find out whether it is disengaged; but in this case finding the circuit free the receiver is not replaced, but remains off the hook until the close of the communication. The key k^2 is now to be steadily depressed, no code-signal being required in the transmission of a central-station signal. The line conductor *a*, as in the former case, constitutes a grounded circuit for the current of source H, the route of such circuit at the central station being the same as before, but at the substation being from main conductor *a* through the closed telephone-bridge 7 to key k^2 and ground by way of point 12, conductor 2, transmitter T, suspension-switch *s*, point 3, secondary induction-coil winding i^2, conductor *v*, points 13 and 15 on main conductor *b*, branch 16, key k^2, contact-anvil 20, and connection 18. Since this circuit includes the coil of relay D and the exciting-coil *g* only of relay F, these relays both become operative and perform their several functions. Armature 27 of the latter is now steadily attracted, maintaining the branch circuit 28 of signal N steadily closed and the said signal steadily displayed until the call is answered. The substation-bells are not rung, because although the armature 39 of the relay-switch F is attracted and the call-generator thereby united to conductor *b* the currents of said generator are shunted from the bells by the resistanceless ground applied to conductor *b* at the key k^2 of the calling-substation. The resistance r^2 is of such magnitude as to prevent the call-currents from attaining an undesirable strength while thus substantially short-circuited. When the call is answered by inserting the answering-plug P in the socket J^2 of the calling-line, the busy-test potential is impressed upon the test-rings of the multiple-switch sockets in the regular way through the third or local plug and cord conductor, and since current can now flow through said cord conductor to the cut-off relay R by way of a path independent of the resistance *r* the said relay is operated in a manner and for a purpose well understood.

The use of the impedance-coil G is in part to regulate the current admitted to the line and partly to prevent waste or diversion of the voice-currents when two stations of the same circuit are conversing.

When the main circuit L has been switched to another circuit at the central station and the cut-off relay has been operated as described above, the impedance-coil G, relay-switch F, and test-current relay D are severed from the said circuit and of course cease to exercise their several functions.

From what has been stated it is evident that no call-signal can be transmitted simply by removing the receiver from the switch, but that such action alone merely sets the automatic busy test; also, that to call other substations of the same circuit one key must be operated in correspondence with the code-signal of such stations, the receiver being in place on the switch, and that to call the central station from any substation the other key must be steadily depressed, the receiver being kept off the switch.

It is to be understood that while for clearness two sources H H^2 of steady current are shown and described a single source is in practice preferably employed, and also that such

single source in practice may be common to a number of main circuits.

Having thus described my invention, its nature and operation, I claim—

1. The combination in a telephone system, of a metallic exchange-circuit extending from a central station to a number of substations; an electromagnetic bell at each substation bridged between the main conductors of said circuit; a source of steady current normally connected at the central station between the said circuit-main conductors and grounded at one of its poles; a grounding-key at each substation adapted when operated to ground both of the said main conductors one directly and the other through the several substation-bells, and to form them into separate grounded circuits containing respectively the said central source of steady current, and the said substation-bells; an electromagnetic switch at the central station responsive to said grounding-keys, and having its exciting-coil in the said grounded circuit including said source; and a normally disconnected independent source of current also at said central station controlled by said switch and adapted on the operation thereof to be connected thereby in the said other grounded circuit together with the said substation-bells; whereby each substation may directly signal the other substations, substantially as described.

2. In a telephone-exchange system, the combination of a metallic telephone-circuit having two main conductors and extending between a central station and a plurality of substations; with an electromagnetic bell in bridge with a condenser between the said main conductors, a normally open bridge including the station telephone instruments, a switch to close the same, and a grounding device associated with both main conductors and adapted when operated to ground one of them directly and the other through the said telephone-bridge when closed by said switch, all at each substation; and a steady source of current such as a battery normally connected in said metallic circuit but grounded at one of its poles, a normally disconnected source of varying call-current such as an alternating-current magneto-generator, a call-receiving signal device in a normally open local circuit of said battery, and an electromagnetic switch-relay responsive to said substation grounding device and controlling the connection of the said call-current source and also the local circuit of the said signal device, all at said central station; the said grounding device when operated being adapted to organize the said two main circuit-conductors into two grounded circuits, one containing the said battery and the actuating magnet-coil of said electromagnetic switch, and the other containing the said source of varying call-current and the circuit-changing points of said electromagnetic switch; whereby the central-station signal may be operated by the grounding device of any substation, and whereby the current of the call-generator is diverted from, and prevented from operating the bells at other substations, substantially as described.

3. In a central-battery telephone-exchange, a metallic telephone-circuit having its two main conductors united at a central station to the two poles respectively of a battery one pole of which is grounded, and extending from said central station to a number of substations where said circuit is normally open; central-station apparatus comprising an electromagnetic switch having opposed magnetizing-coils in the said conductors and adapted to remain null when both coils are traversed by the same current, but to be responsive to like current in one coil only; and a generator of calling-current, and a signal-receiving device in a normally open local circuit, both controlled by said electromagnetic switch; and apparatus at each substation comprising an electromagnetic bell responsive to the currents of said call-current generator connected in an inductive bridge between the metallic-circuit main conductors; a normally open conductive bridge between said conductors containing the station-telephone instruments; a telephone suspension-switch controlling said open bridge and acting to close the metallic main circuit therethrough, and through the central battery and the two opposing coils of said electromagnetic switch; and two grounding-keys associated with the two main conductors respectively, both adapted when operated to establish a circuit for the current of the said central battery through one conductor only of said main circuit and one coil only of said electromagnetic switch and thereby operate said switch for the connection of said call-current generator to the other of said main conductors; said keys being also adapted severally one to direct the currents of said call-generator through the several substation-bells, and the other to divert said currents therefrom; substantially as and for the purposes described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 28th day of October, 1901.

DAVID S. HULFISH.

Witnesses:
LOUIS G. RICHARDSON,
ANNA B. RAYMOND.