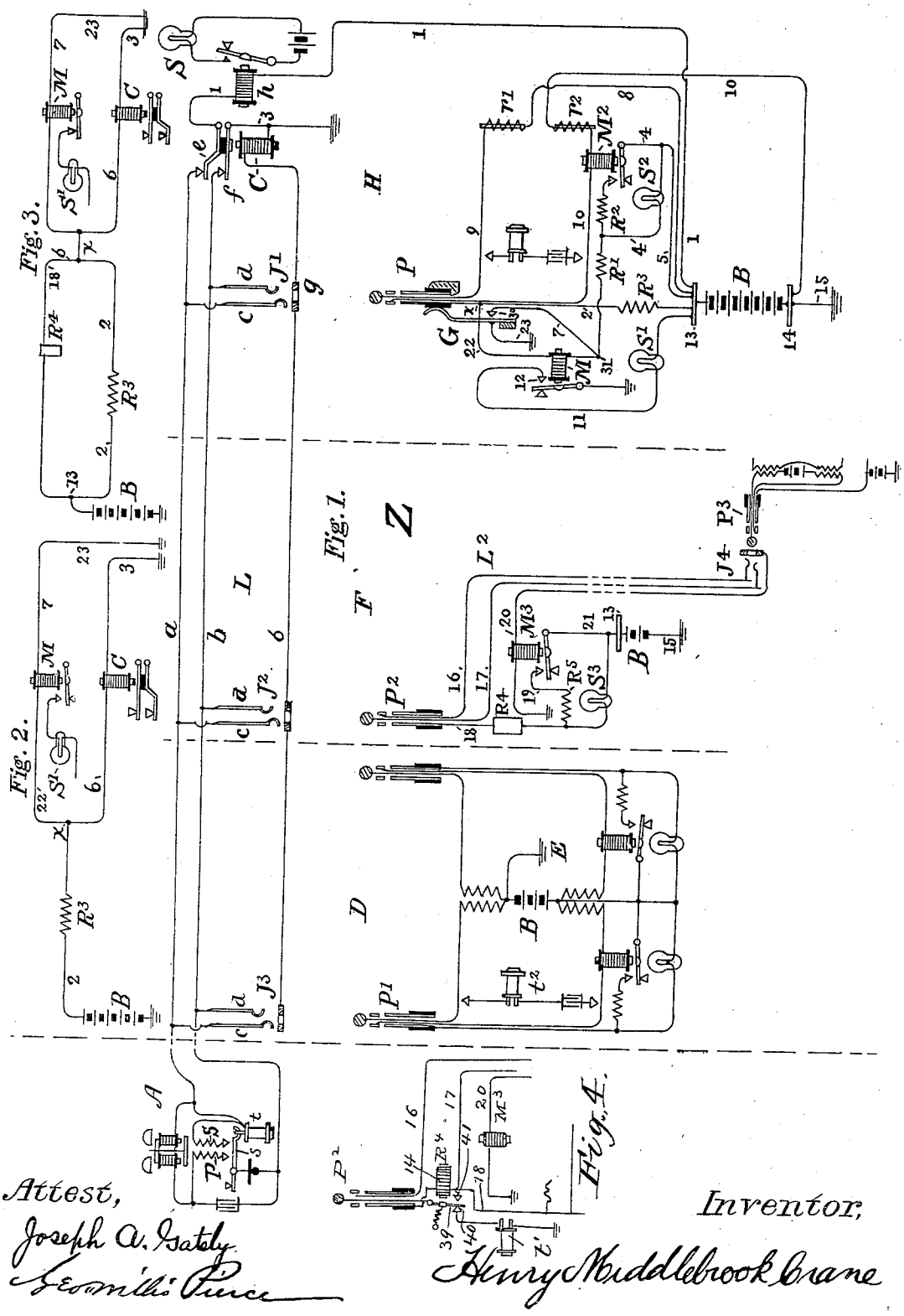
No. 620,745. Patented Mar. 7, 1899.

H. M. CRANE.

TELEPHONE CENTRAL OFFICE CIRCUIT.

(Application filed Oct. 31, 1898.)

(No Model.)



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TELEPHONE CENTRAL-OFFICE CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 620,745, dated March 7, 1899.

Application filed October 31, 1898. Serial No. 695,090. (No model.)

To all whom it may concern:

Be it known that I, HENRY MIDDLEBROOK CRANE, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Telephone Central-Office Circuits, of which the following is a specification.

The present invention relates to the interconnection of substation telephone-circuits through the intervention of a toll or trunk circuit, and has special reference to the means for guarding the circuits from interference while the preliminary steps are being taken to establish the connection.

The invention more especially concerns common battery or relay circuits in which where a call is given by a substation for a toll or long-distance connection a considerable interval of time may elapse between the reception of the call by the subscriber's operator and the final connection with the toll-line. With switchboards of the relay type if during this interval the calling subscriber keeps his telephone removed from the switch-hook, or having replaced it thereon again removes it, a false signal will result, as such an act on his part causes the line lamp-signal to be lighted, and any other circuit could be connected with that of the said calling subscriber while he is waiting to be switched to the previously-called-for line, for commonly in making a connection from the line of a calling subscriber to the toll or trunk the subscriber's or A operator answers the call in the usual way, and finding that the called-for connection is to be made with a toll-line informs the switching or B operator over an order-circuit of the desired connection and then leaves the said operator to make up the circuit, and until the latter performs this duty the calling-circuit is liable to the interference mentioned. It becomes very desirable, therefore, to provide means for causing a substation-line to test "busy" during the said waiting and unguarded interval and also to prevent the subscriber from operating his line-signal.

The invention relates mainly to the specific form of relay substation-circuits wherein a single battery is employed at the central station to produce the illumination of the line lamp-signal when the telephone is removed from the hook-switch at the substation, to furnish current for the conversation-circuit when two substations are looped together, and for operating the supervisory signals, &c.

In carrying out the invention the relay substation-circuit, provided with normally open terminals in switch-sockets or spring-jacks at the switchboard-sections of the several operators, terminates in a cut-off relay and line lamp-signal, as usual, at the answering or A operator's section. The answering operator is provided with the regular cord-circuit and associated apparatus whereby the call is received and answered, the said call being then communicated to the switching or B operator over an order-circuit. To enable the substation-circuit to test "busy" and to prevent the line-signal from being operated and to display a false signal, a special cord-circuit is provided whose plug is inserted in the answering-jack of the line upon the withdrawal of the regular cord-circuit plug (or preferably into a multiple jack of the same line at the same switchboard-section) and remains there until the B operator has made the connection with the trunk or toll circuit. This special cord-circuit is provided with two signals, one of which can be controlled from the calling-substation and by means of it the A operator can be signaled. The second signal is controlled by the B operator and adapted to be operated when she inserts the plug of the toll or trunk circuit into the jack of the calling substation-line and is a notice to the said A operator that the connection has been made and for her to withdraw the said special cord-circuit from the substation-line. There is a disconnect-signal in the said toll-line, located at the table of the B operator to indicate to her when to remove the connection upon the termination of conversation.

Referring to the accompanying drawings, which are illustrative of the invention, Figure 1 shows a relay substation-circuit connected with three multiple-switchboard sections D, F, and H. Figs. 2 and 3 are diagrams to show two different stages of the connections; and Fig. 3 is a detail of a portion of the switching-

operator's connections, showing more particularly the automatic listening-key.

L is a main telephone-circuit consisting of two conductors *a* and *b*, extending from the substation A to a central station Z, provided with open terminal spring-jacks or switch-sockets J', J^2, and J^3 at the multiple-switchboard sections H, F, and D and terminating in the armatures *e* and *f* of the cut-off relay C. From the armature *e* a conductor 1 extends to the bus-bar 13 of the grounded battery B and includes the helices of the relay *h*, whose armature is arranged to close a local circuit and light the line-signal S, the armature *f* being grounded by the wire 3.

6 is the busy-test conductor, which unites the several test-rings *g* at each switch-socket and has a ground connection through the helices of the cut-off relay C.

At substation A is shown a well-known arrangement including an induction-coil, the primary winding P and the secondary winding S of said coil terminating in contacts respectively, against which telephone hook-lever *s* is adapted to rest when the telephone is removed therefrom. This is the usually-adopted central energy arrangement, the direct current from the central-station battery B in the cord-circuit bridge flowing over the line through the telephone-receiver when the same is moved from its hook through the secondary winding S of the induction-coil and through the transmitter. The operation of the 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 short inductive circuit, which includes the primary P of the induction-coil and the condenser. The transmitter is in both local and main circuits, but by the voice currents or surges thus set up in the primary similar currents are inductively developed in the secondary and main line, which traversing the main circuit actuate the distant receiver. This induced effect is added to the strength variations produced in the direct or battery current produced by the operation of the transmitter therein.

In practice the secondary winding of the coil, although having more turns than the primary, is made of low resistance, so that it shall not materially reduce the strength of the current supplied to the transmitter.

The answering operator is located at H and is provided with a regular cord-circuit and standard apparatus to receive and answer all calls in the usual manner. The said cord-circuit is not shown at this section, but is similar to that represented at section D. The special cord-circuit shown is provided with one plug P, whose tip-contact is connected by wire 9 with one winding *r'* of a retardation-coil, continuing by wire 8 to the bus-bar 13 of the battery B, while the sleeve-contact is connected by wire 10 to the other pole 14 of the said battery B, including in circuit the relay M^2 and the second winding r^2 of the retardation-coil. The test-ring contact of the plug is connected to the bus-bar 13 through resistance R^3. The plug P rests normally in the seat-switch G, whose spring (which is grounded by the branch 23) is then separated from its contact 30, which is connected by the wire 7 to the point 31 on the wire 22, which wire is joined to the conductor 2 at the point *x* and extends through the relay M, said point 31 and resistance-coils, rheostats, or equivalent resistance devices R' and R^2 to the front contact of the armature of the relay M^2. The wire 4 connects the wire 22 at a point between the resistances R' and R^2 with the armature of relay M^2, including in its circuit the lamp-signal S^2, and a wire 5 extends from the wire 4 to the bus-bar 13, as shown. The wire 11 extends from the bus-bar 13 to the front contact 12 of relay M, the armature of which is grounded and includes the lamp-signal S'.

The switching or B operator is located at section F, at which are arranged the terminal plugs P^2 of the toll or trunk circuits L^2, whose terminal jacks J^4 may be at another switchboard at the same station or at a distant central station. The sleeve of the plug P^2 is connected by the wire 16 with the upper spring and the tip by the wire 17 with the lower spring of the said jack, and the test-ring contact of the plug is united by wire 18 through the automatic listening-key R^4 and lamp-signal S^3 to the bus-bar 13. The test-ring of the jack J^4 connects by wire 20 through relay M^3 to ground at section F.

A sufficient portion of a cord-circuit to illustrate the invention is shown associated with the jack J^4.

The listening-key R^4 and its connections are clearly shown in Fig. 3, wherein r^4 is an electromagnet connected in the wire 18. 39 is the armature of said magnet, connected to the tip of the plug P^2 and vibrating between contacts 40 and 41, the former connected to ground through telephone *t'* and the latter connected to wire 17. It will thus be seen that in operation telephone *t'* is, for testing purposes, connected normally through armature 39 with the tip of plug P^2, but that when the plug is fully inserted into its jack the electromagnet r^4 becomes excited and cuts out telephone *t'* by drawing armature 39 over against contact 41.

A cord-circuit of the regular type is shown at the switchboard-section D, which represents a section at which other subscribers' lines are answered by another A operator, to which the substation-circuit L is multiplied.

Although several batteries B of different numbers of cells are shown in the drawings, there is really but a single battery, from different points of which the several circuit-conductors extend, and which thus by suitable circuit connections is enabled to subserve a variety of purposes. They are, however, indicated as different batteries for the avoid-

ance of the complication necessarily consequent on the multitude of lines crossing one another which otherwise would be required.

In the operation of the invention it will be assumed that the operator at H has received a call necessitating the use of a trunk-line L^2 and that this has been responded to with a normal cord-circuit similar to that shown at section D, after which the call has been transferred to the B operator by an order-circuit. The A operator then withdraws the plug P of the special cord-circuit from its seat (the spring being released making connection with the contact 30) and inserts it in the jack J'. If the main circuit be provided on this switchboard-section with a duplicate jack as well as the answering-jack, the answering-plug of the normal cord-circuit may remain until the special plug P has been inserted in the said duplicate jack or socket. I have, however, indicated but one jack. Current then flows through the circuit leading from battery B, through conductor 2, resistance-coil R^3, test-ring contact of plug P, test-ring *g* of jack J', conductor 6, cut-off relay C to ground. The current flowing over this circuit will excite the cut-off relay C, thereby extinguishing the substation-line lamp S and at the same time raising electric potential of the rings *g* of the line-jacks of this line L throughout the switchboard, and thus establish a busy-test condition. The current flowing from battery B over the wire 2 has another path from the point *x* via the wire 22, relay M, wire 7, spring of the switch G, and wire 23 to ground, so that the circuit through wires 22, 7, and 23 is in multiple with the circuit through conductors 6, cut-off relay C, and wire 3, as is more simply shown by the diagram Fig. 2, and by making the resistance R^3 and that of the windings of the relay M and the cut-off relay C of suitable magnitude the current in the branch circuit through the said relay will not be strong enough to cause the operation of the said relay M. Current also flows from battery B, through conductor 8, winding r', conductor 9, tip of plug P, lower spring *d* of jack J', over one side *b* of the line L, through the substation-telephones, and back over the other side *a* of the line, to the upper spring *c* of jack J', to sleeve-contact of plug P, conductor 10, relay M^2, winding r^2, and by conductor 10 to the battery. The relay M^2 being in this circuit is energized and attracts its armature to the front contact, thereby shunting the lamp-signal S^2, which thus remains undisplayed when the substation-receiver under these conditions is not on the switch-hook. The breaking of the current in this circuit by hanging up the telephone releases the armature of relay M^2, which, opening the shunt around the lamp S^2, permits the same to light. Should the telephone be again removed from the hook-switch, the current in the above circuit is again established and the relay M^2 operates and the lamp S^2 is shunted and therefore extinguished. Thus by repeated movements of the hook-switch and the consequent lighting and extinguishing of the lamp-signal the subscriber, while waiting for the trunk connection, will be able to attract the attention of the A operator, and at the same time the line will be held busy by the raised potential of its switchboard test-rings, and so not be subjected to any interference. When the switching or B operator is ready to attend to the connection, she inserts the plug P^2 into the substation-circuit jack J^2, which appears at her section F, and thus trunks the said circuit directly to the toll-operator, whose business it is to insert the plug P^3 of a cord-circuit into the jack J^4 of the trunk and make any other connection that may be desired with the other plug of the cord-circuit. With the plug P^2 in the jack J^2 and the plug P in jack J' there will be from the battery B to the point *x* two paths for the current, one by way of conductor 2 and resistance R^3 and the second by way of conductor 18, lamp-signal S^3 and its shunt, (for when the plug P^3 was inserted in jack J^4 current from the battery in its test-ring contact energized relay M^3 and attracted its armature,) and from rear contact of plug P^2 to test-ring of jack J^2, test-conductor 6 to the test-ring of jack J', and to the point *x*. In other words, the circuit consisting of conductors 18 and 6 is placed in parallel with the circuit consisting of conductor 2. This circuit is schematically shown by Fig. 3. By reason of the current from the battery B to the point *x* having the two paths, as described, the resistance between the battery and the said point will be diminished, and a current correspondingly increased will flow from the point *x* by two paths to earth, one path through cut-off relay C and the other through the plug-seat switch G and relay M to earth. Relay M, by reason of its share in the increase of current, will now respond, closing the circuit through the lamp-signal S' and causing it to light. This being the signal to the A operator that the substation-line has been connected to the trunk L^2, she withdraws the plug P from the jack J' and restores it to its seat G, and in so doing breaks the contact between the spring and its contact 30, which opens the circuit through relay M and extinguishes the lamp S'. Moreover, as the relay M^2 is at the same time demagnetized the shunt around the lamp S^2 is broken, but the said lamp-signal S^2 controlled thereby does not operate, because its circuit also is now opened.

At the section D is shown a cord-circuit, by means of which the presence of current in the test-circuit 6 may be determined by a second A operator. In making the test to determine whether the circuit L is or is not busy the plug P' is touched to the ring *g* of the jack J^3, and if the line is busy a circuit will be found from battery B, wire 2, rear contact of plug P, test-ring *g*, test-conductor 6, tip of plug P' and its conductor to left-hand upper winding of the cord-circuit re-

peating-coil, and to ground, and the operator's telephone t^2 being switched into the circuit or a branch thereof by the regular listening-key in a manner well understood the usual click, indicating the busy condition of the line, will be heard in the said telephone.

I claim—

1. In a telephone-switchboard system the combination of a main telephone-circuit branching to the switch-sockets or spring-jacks at the several sections of a multiple switchboard, and having a call-signal at the answering section only; a cut-off relay at the said answering section controlling the connection between the said main circuit and its call-signal; a test-circuit conductor branching to contacts in the said switch-sockets respectively, and grounded through the winding of the said cut-off relay, with a loop-plug and cord-circuit at the said answering section, the said plug being adapted for insertion in one of the said switch-sockets, and thereupon to close the main circuit through a relay, to establish a testing-current upon the several switch-socket test-contacts, and to close a local circuit through the said cut-off relay; a seat for the said plug when not in use; a switch contained therein and operated by the removal and replacement of the said plug; a supervisory signal associated with the said plug and cord-circuit; a relay controlling the same connected in parallel with the said cut-off relay and in a branch of the local circuit thereof; and a subsidiary call-signal also associated with the said plug and cord-circuit, and controlled by the relay in the main-circuit connections thereof; the circuits of the said supervisory and subsidiary signals being both led through the said plug-seat switch, substantially as set forth.

2. The combination in a multiple-switchboard system, with a grounded test-conductor uniting the test-pieces of the switch-sockets of a telephone-line; and a cut-off relay contained in the circuit thereof; of a normally-disconnected source of test-current; a main conductor including a resistance device extending therefrom; a normally-discontinuous branch thereof including a signal-controlling relay; and switching devices adapted when operated to close the circuit of said source through the said cut-off relay and signal-controlling relay in parallel branches, and to establish a testing potential upon the test-pieces of the said switch-sockets, as set forth.

3. The combination of a telephone line-circuit extending between a substation and a central station, and associated at the latter with a multiple switchboard; a cut-off relay controlling the normal call-signal connection and terminal of said line-circuit; switch-sockets for said line at the several sections of said multiple switchboard; and a fixed test-circuit conductor uniting the test-contacts of the said sockets and grounded through the said cut-off relay; with a special cord-circuit at the call-signal switchboard-section of said line, having a single plug normally resting in a grounding plug-seat switch; a battery with one pole grounded and a conductor extending from the other pole to the test-contact of said plug; a branch extending from said conductor through the said plug-seat switch; and a signal-controlling relay included in said branch; whereby when the plug is inserted in one of the said switch-sockets the circuit of the said battery is closed through the cut-off relay, and the said signal-controlling relay in parallel, and the fixed test-conductor energized; substantially as set forth.

4. The combination in a multiple-switchboard system, of a grounded test-conductor uniting the test-pieces of the switch-sockets of a telephone-line; a cut-off relay contained in the circuit thereof; a normally-disconnected source of current; a main conductor extending therefrom and containing a resistance device; a normally-discontinuous branch thereof including a signal-controlling relay; switching apparatus adapted to close parallel branches of said source through the said cut-off relay and signal-relay respectively for the operation of the former only, and to connect the said source with the several switch-socket test-pieces; all at the call-signal section of the said switchboard; a trunk-circuit terminal switch-plug at a second section of said multiple switchboard inserted in the switch-socket of said section to establish the connection of a trunk-line therewith; and a second main conductor of the said source controlled by the said trunk-plug and its switch-socket, and connected in parallel with the said first-named main conductor and the resistance device included therein, and in series with the cut-off and signal relay branches thereof, substantially as and for the purposes specified.

5. The combination of a telephone line-circuit extending between a substation and a central station, and associated at the latter with a multiple switchboard; a cut-off relay controlling the normal terminal of said line-circuit; switch-sockets for said line at the several sections of said switchboard; and a fixed test-conductor uniting the test-contacts of the said sockets, and grounded through the said cut-off relay; with a special cord-circuit at the call-signal switchboard-section of said line having a single plug adapted to be inserted in the section switch-socket of said line-circuit; a grounding plug-seat switch in which said plug normally rests, a source of current with one pole grounded, a conductor extending from the other pole thereof, to the rear sleeve or test contact of said plug; and a resistance in circuit therewith; a branch extending from said conductor through the said plug-seat switch, and a signal-relay included therein; a normally open local circuit of said source containing a supervisory signal and having its continuity controlled by the said signal-relay; a trunk-circuit terminal switch-plug at a second section of said multiple switchboard adapted for insertion in the line-circuit switch-

socket there, and having also its rear sleeve or test contact connected with said source; whereby when the said special cord-plug is withdrawn from its resting-socket and inserted in its switch-socket, and the trunk-plug inserted in its sectional switch-socket, the current through the said signal-relay is increased, and the said relay enabled to operate its lamp-signal, and indicate at the said call-signal switchboard-section the trunk-line plug connection at the said second section; substantially as set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 25th day of October, 1898.

HENRY MIDDLEBROOK CRANE.

Witnesses:

GEO. WILLIS PIERCE,

FRANK C. LOCKWOOD.