No. 772,023. PATENTED OCT. 11, 1904.

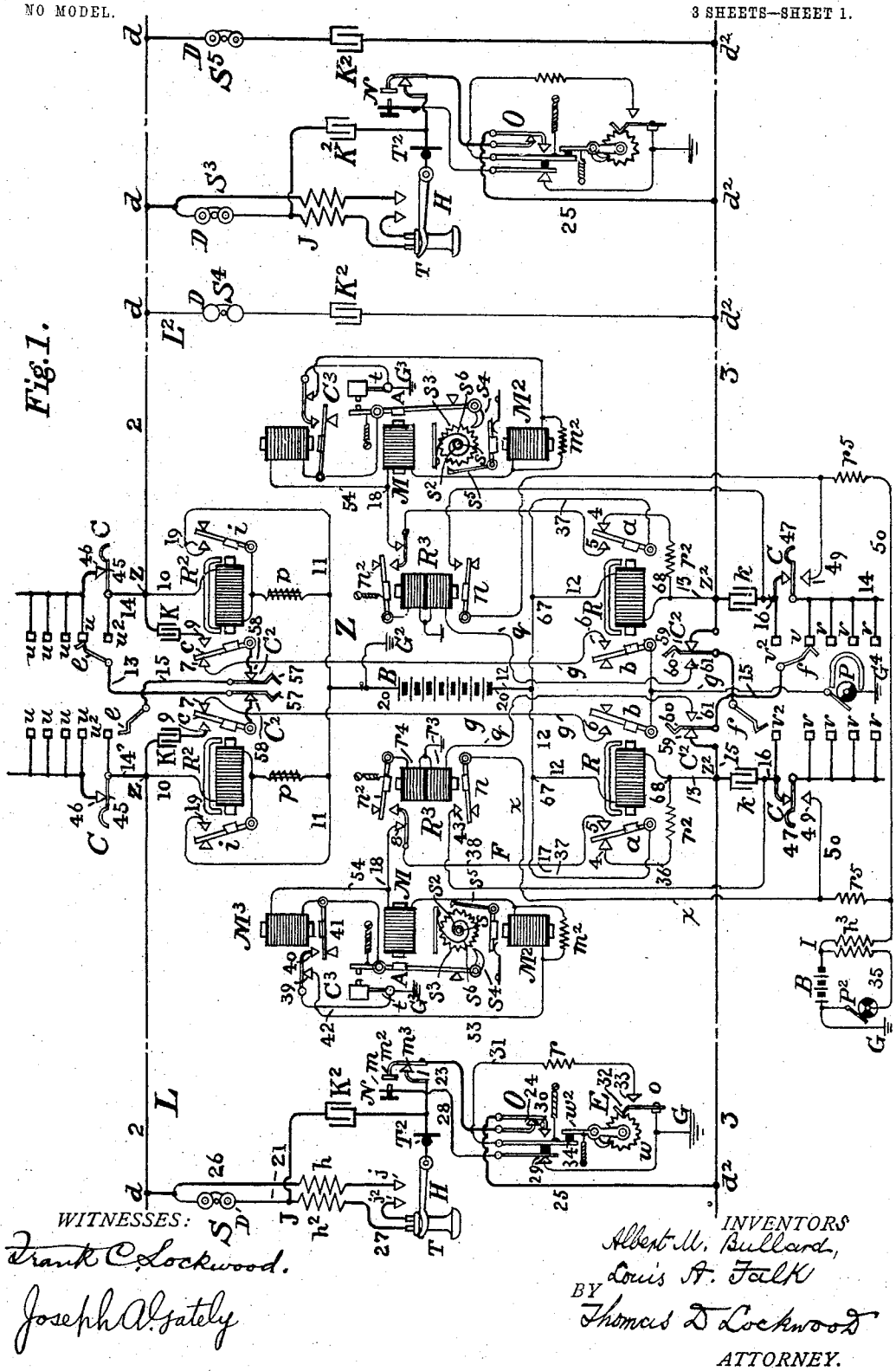
A. M. BULLARD & L. A. FALK.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM AND APPARATUS.

APPLICATION FILED JAN. 26, 1904.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.



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NO MODEL. 3 SHEETS—SHEET 2.

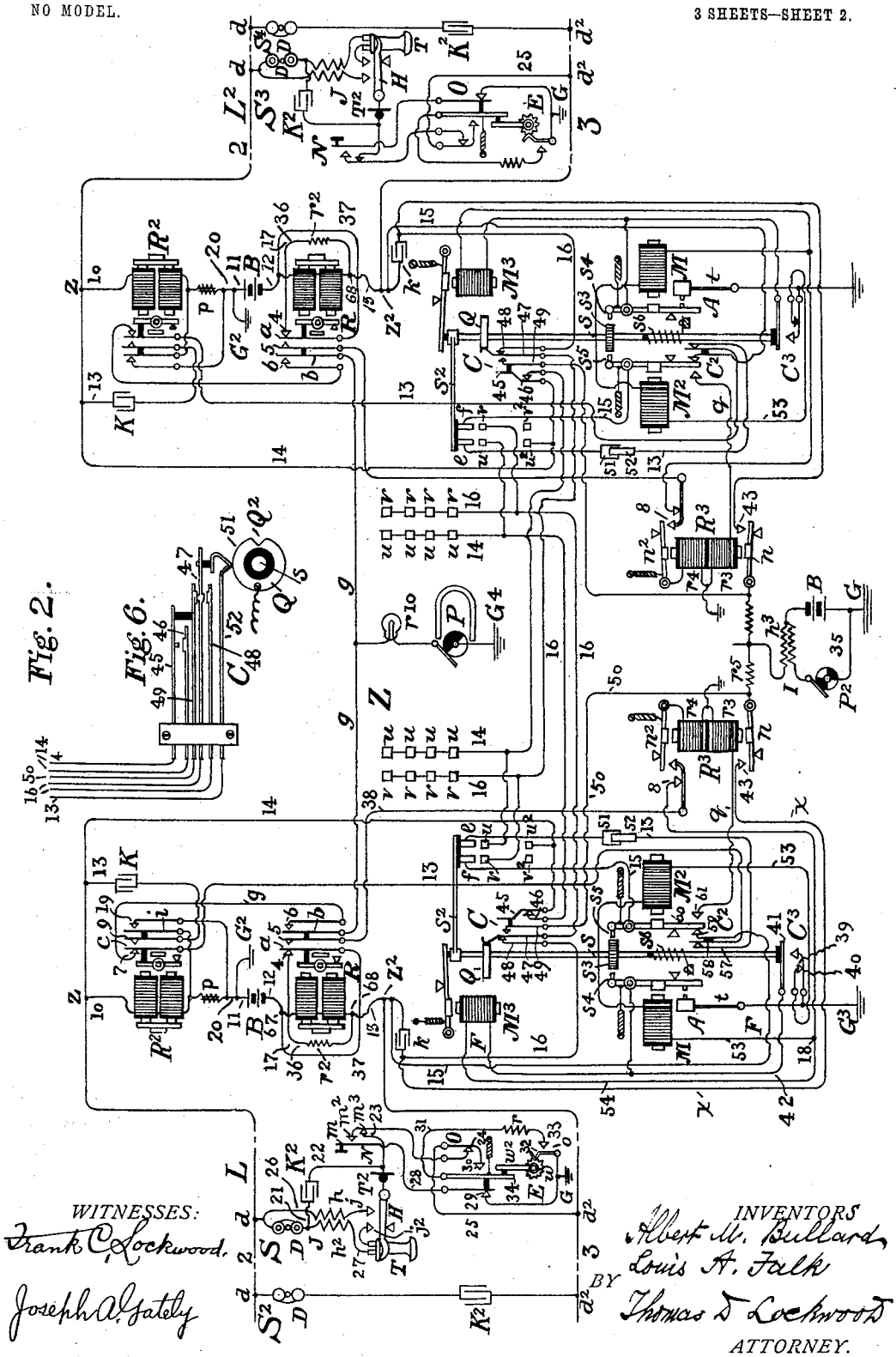

Fig. 2.

Fig. 6.

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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 7.

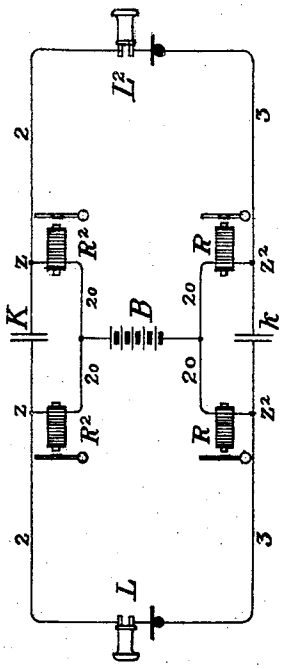


Fig. 4.

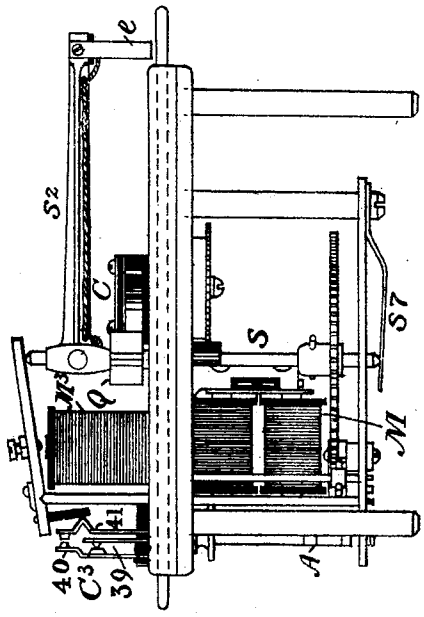


Fig. 3.

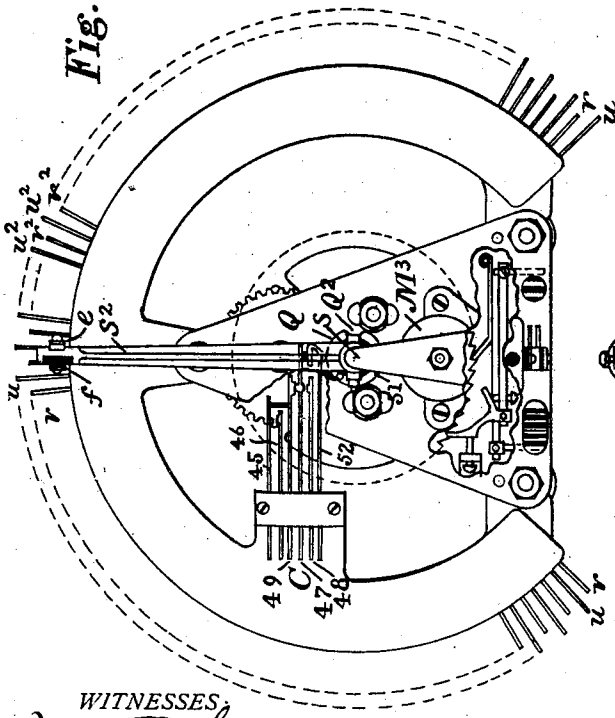
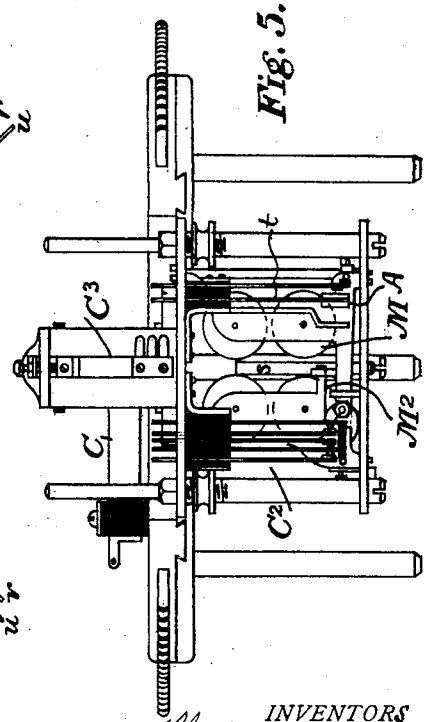


Fig. 5.



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UNITED STATES PATENT OFFICE.

ALBERT M. BULLARD, OF NEW YORK, N. Y., AND LOUIS A. FALK, OF BOSTON, MASSACHUSETTS, ASSIGNORS TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 772,023, dated October 11, 1904.

Application filed January 26, 1904. Serial No. 190,719. (No model.)

To all whom it may concern:

Be it known that we, ALBERT M. BULLARD, residing at New York, in the county of New York and State of New York, and LOUIS A. FALK, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Automatic Telephone-Exchange Systems and Apparatus, of which the following is a specification.

This invention concerns automatic telephone-exchange systems, and has especial reference to automatically-operated telephonic exchanges designed to furnish facilities for the interconnection of telephonic circuits in relatively small communities, where all of the subscribers may be accommodated by a small number of substation-lines, the circuits of some or all of which may be of the party or poly station class.

The invention is of the same type as that described by Letters Patent of the United States No. 709,740, issued to Albert M. Bullard and Malcolm C. Rorty on September 23, 1902, for automatic telephone-exchange systems and apparatus, and constitutes an improvement upon the invention of said patent, to which reference is hereby made.

The objects of the present invention, generally stated, are to simplify the apparatus and at the same time to make it more effective, to avoid the necessity of employing substation call-generators, to provide for the efficient employment of a common central-station call-generator, to simplify the operation of transmitting calls from any substation to the substations of another circuit, to furnish improved means for preventing the interruption of or interference with engaged lines and for announcing their engaged condition to the substation of the line seeking to establish connection therewith, and to provide convenient means for the ready transmission of reverting call-signals or call-signals transmitted through the central station from any station to another station of the same line or circuit.

The said Bullard and Rorty patent, No. 709,740, describes and claims an automatic exchange system adapted for polystation-lines and employing a central and universal source of current for selecting, switching, and transmitter current supply, but provided at the substations with magneto-electric generators for use in generating and transmitting call-currents. In the system of this patent, which involves provision for switching both conductors of metallic circuits, the selection of a circuit by any other seeking to establish connection therewith is accomplished by successive interruptions or intermissions of the main-line current acting through appropriate motor mechanism at the central station, the said interruptions being produced by the operation of any suitable periodic circuit-breaker at the substation making the selection, while the absolute interconnection of such lines after one has been selected by the other is dependent upon the operation of other electromagnetic mechanism irresponsive to the selecting-current interruptions, but responsive to the establishment in the circuit of a steady current, which occurs when, the circuit-breaker having ceased to operate, the circuit is steadily closed through the substation telephone apparatus. The motor apparatus for selecting and connecting is controlled by a double-armature relay in the main circuit.

In carrying out the objects of the present invention, which does not in any sense depart from the general plan of the invention of said patent or from the general principles underlying the system thereof, the relay which controls the selecting and connecting motor mechanism has been transferred from its position directly in the line to a position on one side of the source of current in the normal terminal loop of the line, which loop when the said line is connected for conversation becomes the current-supply bridge, a change in position that results in a great increase in the efficiency of the relay, for since the said relay so placed is no longer in the talking-circuit the convolutions of its exciting-coil may now be increased to any desired extent. On the other side of the source of current in the same loop is placed a relay of like impedance constituting practically an electromagnetic or

automatic ringing-key and organized to control the operation of ringing up the desired substation of a line with which connection has been established, current for the purpose of such ringing being provided by a central-station generator which may be common to the system. The coils of these selecting and ringing relays, one on each side of the source, now serve as the impedance devices necessary to block the passage through the bridge of voice-currents while permitting the ready passage of a sufficient steady current, and the special impedance-coils previously employed may thus be dispensed with. At the substation instead of two ringing-keys and a call-generator there is now provided a single call-signal key, and the substation manipulation necessary is thus simplified, as the operation of selecting and calling another station of the same line is now exactly the same as that of selecting and calling a station of another line. The central-station switch apparatus or motor mechanism of each line has fixed terminals of said line as well as those of all others, and when it is desired to establish communication between any station of a given line and any other station of the same line the movable terminals of such line are stepped round to the said fixed terminals thereof and brought into engagement therewith, after which the call is transmitted to the wanted station in precisely the same manner as it would be done if the said wanted station belonged to a different line. Furthermore, the substation bells, condensers, and telephones bridged between the main conductors are in the present invention connected in accordance with the standard practice of manually-operated exchanges, no permanent ground connection being required or attached. Pulsating or intermittent current of single direction is used for operating the substation call-bells, and the call-generator may be of any well-known type adapted to transmit quickly-succeeding impulses of the same sign, and in order that the relay serving as the automatic ringing-key shall not be disturbed by the passage of the call-current when transmitted over a calling-line to signal another station thereof the said relay is polarized and biased or otherwise adjusted to respond to such currents only as are opposite in sign to that of the ringing-current. By this expedient such portion of the ringing-current as may pass through the coils of the ringing-magnet tends, in fact, to hold the armature thereof more firmly in its normal position. The selecting-relay also is similarly polarized and arranged to respond solely to currents of definite direction, and the impedance of the two relays is substantially the same, so that each may balance the other. The call-current reaches the ringing-relay contacts of any line through a forward contact of the selecting-relay of the same line, or, in other words, through a special contact established when the selecting-relay is excited. This is for the purpose of preventing false calls over a line which has been called and connected, but which is in process of disconnection. The selecting-relay controls independent selecting, retaining, and connecting electromagnets, and it is required that the connecting-magnet shall not come into action until the selecting-magnet shall have brought the selector-arm or movable terminals or terminal contacts of a call-originating line into position where they confront the fixed or passive terminals of the wanted line. To secure such temporary inactivity, a high-resistance vibratory contact is inserted in the local circuit of the connecting-magnet. This consists of one contact-point carried by a weighted spring or spring of considerable inertia, agitated by and coöperating with the quick movements of the armature of the selecting-magnet, and another carried upon or associated with the armature-lever of the selecting-magnet. When the intermittent current of selection has ceased and has been succeeded by the steady connecting-current, the said contact has its resistance materially lessened, and the connecting-magnet is then operated by the correspondingly strengthened current. To keep the connecting-magnet fully under control, all current to it and to the selecting-magnet is led through the operating contacts of the selecting-relay, whose deënergization therefore deënergizes all magnets controlled by it.

Another feature of improvement concerns the means for preventing the establishment of connection by a third line with a line which is already engaged. In the Patent No. 709,740, to which reference has been made, the movable terminals are both normally detached from their own line, and their attachment is controlled by a discriminatory testing-relay; but in the present invention the circuit between the subscriber's line and the selector-springs or movable or active terminals thereof so far as the test-relay is concerned is normally closed, and the talking-circuit does not pass through either the circuit or contacts of the said test-relay at all. When the movable terminals of a line seeking connection with another make contact with any pair of multiple fixed contacts of a desired but already busy line, a test-circuit is established including the test-relay as at present connected and a current is caused to circulate therein. The said test-relay being thus operated acts to break the operating-circuit of the selecting, connecting, and retaining magnets, which being thus bereft of their energy are demagnetized, and the selector-arm parting company with the contacts of the line wanted instantly rises and returns to the starting-point, and by appropriate means the calling-substation is advised that the line wanted is for the present engaged.

The undesired ringing or chattering of sub-

station bells on a polystation-line, which otherwise tends to occur while one station on such line is making selection of another station either of the same or any other line with which communication is to be established, is prevented by introducing additional inductive resistance or impedance into the current-supply bridge on the grounded side of the battery. This is preferably placed between the ringing-relay and the earth connection and is arranged to be cut out or short-circuited when the said ringing-relay is excited.

In the drawings which accompany and illustrate this specification, Figure 1 is a diagrammatic representation of the central station and substation connections and appliances of two substation telephone-circuits, which may be polystation-circuits wherein many of the contact-springs are for clearness of delineation shown as being separated from the electromagnets which actuate them or control their operation. Fig. 2 is another diagram of the same system, showing in a more literal manner the several instrumentalities employed and their arrangement, the several contacts being more closely associated and identified with the electromagnets or other means arranged for their actuation. Figs. 3, 4, and 5 represent different views of the selecting and connecting or switching mechanism at the central station of a single main circuit, Figs. 3 and 4 being, respectively, plan and side views thereof and Fig. 5 a rear view. Fig. 6 is a detail view showing the preferred actual arrangement of a group of commutator-springs associated with the central-station motor-mechanism revolving shaft of each line, and Fig. 7 is a diagram of the compound talking-circuit formed of two constituent substations.

Although two substation-circuits only are indicated, it is to be understood that in practice a number of such circuits will enter the same central station from substations and that each is there provided with its own individual mechanism, whereby it may by appropriate action taken at any of its own substations select, connect with, signal, and establish through telephonic communication with any other main circuit entering the central station.

In the drawings, Z represents the central station, and L L^2 substation-circuits converging thereto, each from one or more substations S. Both circuits are shown as being polystation-lines, L leading by its main conductors 2 3 to the central station from substations S S^2, and L^2 from substations S^3, S^4, and S^5.

R is the controlling or selecting relay; M, M^2, and M^3, the selecting, retaining, and connecting electromagnets controlled thereby; R^2, the ringing or call-transmitting relay, and R^3 the test or interference-preventing relay, each line being equipped at the central station with an independent set of such instrumentalities and their subsidiary devices.

B represents the central and common source furnishing current for switching, busy signals, and transmitter-supply, and it is to be understood that though shown at several different places in the drawings there is, in fact, but a single source represented, and an important feature of the invention is that although the coördinate operation of a considerable number of main and auxiliary circuits is provided for the said circuits may all receive energy from a common source without confusion, several new combinations being thus organized. It is, however, manifest that while the invention as a whole includes the use of a common source of current it is not in any sense restricted to the employment of but a single common source, it being manifest to persons skilled in the art to which said invention appertains that one, two, or more such common sources of current may be employed, as may under the engineering conditions of any particular case be deemed desirable or expedient. For example, two batteries may be employed each to supply current for one-half of the total number of main circuits composing the system and their auxiliary subordinate circuits, in which case when the compound talking-circuit is formed of constituent circuits supplied with current from the said two sources, respectively, its two supply-current bridges will each contain its own battery.

The selecting and connecting or motor mechanism consists, substantially as in the beforementioned patent, No. 709,740, of the magnets M, M^2, and M^3, together with the vertical selector-shaft *s*, carrying the selector-arm s^2 and having a star or ratchet-actuating wheel s^3 and retracting or counter springs s^6 and s^7. The armature of the selecting-magnet M carries a pawl s^4, which propels the actuating-wheel and revolves the shaft. The armature of the retaining-magnet M^2 carries a pawl s^5, which engages and holds the ratchet and shaft in the position to which it has been advanced, and the main function of the magnet M^3 is to depress the vertical shaft *s*, and thus bring the contacts *e* and *f*, carried by the selector-arm s^2 and constituting the movable terminals or contacts of a line, into engagement with the fixed terminals or passive members *u* and *v*, (usually of another line,) which by the revolving motion of the shaft they have been made to confront. When the movable terminals of any line have been thus brought into engagement with a given set of fixed terminals, they bestride the same, substantially in the manner shown and described in the said Bullard and Rorty patent, No. 709,740, to which reference has been made, and the shaft *s* is thus during the pendency of a connection between two lines prevented from yielding to the retracting influence of its counter-spring

s^6 notwithstanding the disengagement of the retaining-pawl s^5 from the ratchet-wheel s^3, which comes about when the connection is fully established. Thus the said counter-spring s^6 does not become effective to return the shaft s to its normal position until the excitement of the connecting-magnet M^3 is discontinued and the vertical shaft caused by the elevating counter-spring s^7 to rise, so that its contact members $e\,f$ are freed from their engagement with the said fixed terminals u and v, with which they have been connected.

In Fig. 3 a few only of the pairs of fixed terminals $u\,v$ of the several lines are shown, as at the two ends and middle of the arc-shaped switch-plate; but it is of course to be understood that the entire peripheral space of said switch-plate may be filled with such terminals, which extend outwardly to the dotted concentric circles respectively.

A cam Q, associated with the vertical shaft s, controls one set of changeable contacts, C, another group, C^2, being controlled by the operation of the armature of the stop-pawl or retaining-magnet, and a third group, C^3, by the connecting-magnet, either directly, as indicated in Figs. 1 and 4, or, as shown in Fig. 2, through the medium of the longitudinal movements of the vertical shaft s. The general arrangement and operation of this selecting and connecting mechanism itself is not essentially different from that of the same mechanism and its actuating-magnets as disclosed by the patent of Bullard and Rorty, No. 709,740; but the arrangement and function of the several contacts of the said groups is in several respects dissimilar, and therefore may require more extended description.

The normal terminal loop of the substation-circuits in the central station leads through the battery B and extends between the point z on main conductor 2 and the point z^2 on main conductor 3 by way of conductor 10, the coil of the ringing-relay R^2, impedance-coil p, conductor 11, the battery B, conductor 12, and the coil of the controlling-relay R. This loop thus contains the controlling and ringing relays in series, one on each side of the battery. When the main circuit by means either of the extension-conductors 13 and 15, leading to its active or movable terminal contacts $e\,f$, or the extension-conductors 14 and 16, similarly leading to its passive or fixed terminals $u\,v$, is united to another such main circuit to constitute a compound talking-circuit between the substations S and S^3 or S^2 and S^5, as the case may be, the said loop being permanently connected becomes a bridge 20 of the said talking-circuit, by means of which current from source B passes to line through the relay R on one side and the relay R^2 on the other for the supply of the telephone-transmitter at the substation, the passage of such steady current to either constituent circuit from the bridge of the other being barred by the inclusion in the uniting extension of one of the condensers K on one side of the circuit and one of the condensers k on the other. The impedance necessary for each main circuit to preserve the individuality of said circuit, to protect it from interference with and from other talking-circuits supplied by the same source, and also to prevent the voice-currents developed by the transmitter of its own substations from being short-circuited through the battery-bridge 20, is provided by the coils of the said relays R R^2, which not being in the talking-circuit may have their turns increased to any desired extent.

At each substation the apparatus is the same, comprising the regular call-bell D, the telephone-receiver T, and transmitter T^2, and the condenser K^2, together with the interrupting device E for selecting and connecting with other lines, including the set of commutating spring-contacts O and the set of interrupter-springs o, the hook-switch H, the induction-coil J, and the calling-key N. The switch H in a usual manner controls the conductive continuity of the substation-bridge between the points $d\,d^2$ on the mains 2 and 3, respectively, maintaining the same open or closed for steady currents, according as the receiver T hangs thereon or is removed. In the former case the bridge is completed through the condenser K^2 and while permitting ringing-currents to pass for the operation of the bell D is impervious to the steady current of the source B; but in the latter case conductive continuity is established. When the receiver hangs upon the hook, the substation-bridge is established between the said points d and d^2 through bell D, conductor 21, condenser K^2, conductor 22, key-resting contacts 23, commutator-springs contact 24, and conductor 25; but when the receiver is taken from the hook and the switch H thereby operated the condenser is short-circuited and the bridge is made conductively continuous, the circuit between d and the key-contacts 23 being formed through the telephone branch 26, the induction-coil winding h, the switch-point j, the switch-bar, and the transmitter T^2. The receiver T in a manner well understood may be connected in series with the other induction-coil winding h^2 in the branch 27, extending from a point between the bell-magnet and the condenser to the other switch-point, j^2.

The set of springs O has two normally closed contacts 24 and 29, the former being included in the bridge between the mains and the latter in the signaling earth connection 28. It also has a normally separated contact 30 in a separate ground connection 31, which connection is arranged to be transiently established for main conductor 3 during the operation of the selective interrupter E and adapted to be periodically and rhythmically made and broken in the set of springs o by the operation of the said interrupter. This

ground connection 31 contains a resistance device r to balance the resistance of the ringing-relay R^2 and line-conductor 2 and to compensate for their absence from the circuit when during the selection the said conductor 2 is disconnected, and the main conductor 3 is alone connected and forms the line portion of a grounded circuit between the substation earth connection G and the central-station earth connection G^2, attached to one end or terminal of the source of current B.

The interrupting device E, considered as a whole, may be of any preferred form adapted for producing periodic and rapidly-successive makes and breaks of the circuit, a convenient type of appliance being that shown and described in the Bullard and Rorty patent, No. 709,740, hereinbefore referred to. The same is conventionally represented herein by the star-wheel w and the rotary arm w^2, attached thereto, the latter shown as being normally held by a spring firmly against the contact member 34 of the set of springs O. The said star-wheel is adapted to successively establish and disestablish contact between the members 32 and 33 of the interrupter-springs o. In the operation of any such device the number of successive interruptions is proportionate to the distance to which the arm w^2 is turned on its axis, to be retracted when released by any suitable counter-spring or spring-motor, the said distance being in practice determined for each call, in the manner described by said patent, by a detachable limit-pin which can be placed in any one of a number of holes on the external face of the mechanism, an external arm on the interrupter-shaft being revolved until it is stopped by said pin and being then released.

The commutator and interrupter springs O and o are arranged to have the condition or relation of their contacts altered when the interrupter is operated. When the arm w^2 is turned to select and connect with the line of another substation, its normal pressure upon the spring contact member 34 of the set O is relaxed, and the said member being thus permitted to yield to the influence of its own spring is brought sharply into position to disestablish contacts 24 and 29 and to establish contact 30. This new condition is maintained until the arm w^2 in its return motion again reaches and presses upon the contact member 34, and in such return motion the circuit of conductor 31 is alternately opened and closed by the successive unions and separations of the contact members 32 and 33 of the interrupter-springs o to produce the successive impulses of current in the main circuit which are requisite for the operation of the central-station selecting mechanism.

The sole calling or signaling key N has two contact members normally engaging one another at 23 and a third contact member m, preferably furnished with a manipulating-button and connected by conductor 28 to ground through one separable contact 29 of the set of springs O, and when operated the said normally engaged members are separated and the third member m establishes contact with that one of them which is united to main conductor 3. With each pressure of the key, therefore, the substation-bridge $d\,d^2$ is opened, and the main conductor 3 is united to the earth at G.

The main conductors 2 and 3 of each substation-line have movable or active central-station terminal members e f and are also provided with multiple fixed or passive switch terminals contact-pieces u v, one of each for every other substation-circuit of the exchange, and with one pair of special fixed contact-terminals or contact members u^2 v^2, termed "reverting-terminals," which are adapted to be engaged by the active terminals of their own circuit when the station with which communication is desired belongs to the same substation-circuit as does that which is establishing the connection.

P is the central-station call-generator and in transmitting call-currents to a substation is controlled by the key N of the call-originating substation through the mediation of the ringing-relay R^2 of the calling-line. It is a power-actuated constantly-running generator, adapted to develop a pulsatory or intermittent unidirectional current, and may conveniently be an alternating-current generator having a commutator adapted to collect and deliver to the external circuit the several current impulses of like sign generated by the armature during one half period of its successive revolutions and to suppress the interposed impulses of opposite sign developed during the other half of the said revolutions. The ringing-current of this generator passes to the substation wanted—say S^3—always over conductor 2 of the appropriate substation-circuit, the same being reached by conductor g through a forward contact 6 of armature b of the controlling-relay and a back contact 7 of armature c of the ringing-relay R^2.

P^2 is an electrotome or rhythmical circuit-breaker in a local circuit 35 of the battery and is associated with the connecting devices of the several lines through an induction-coil I to furnish to a calling-line for the information of a calling-substation and in a manner presently to be explained a tone-signal to be heard in the station-receiver whenever the line desired is found to be already engaged.

The controlling, ringing, and test relays R, R^2, and R^3 are in Fig. 1 shown as being each provided with two armatures. The armature a of relay R has forward and back or working and resting contacts 4 and 5, while armature b has a forward or working contact 6 only. Armature a, in conjunction with its resting contact 4, controls a shunt-circuit 36, including a suitable resistance r^2, round its

own electromagnet, and in conjunction with its front contact 5 controls the local circuit F, which contains the magnets M, M^2, and M^3. This circuit leads from the battery B through conductors 12 and 37, the armature *a*, its contact 5, and conductor 38 to point 18, where it bifurcates, one branch, 53, leading to earth through the magnets M and M^2, in series, and the other, 54, through the connecting-magnet M^3 and the vibratory resistance A. This vibratory resistance consists of coöperative contact-points carried one upon a portion of the armature-lever of the selecting-magnet M and the other by a weighted spring *t*. These are normally separated, and during the operation of the selecting-magnet in its step-by-step motion of the actuating-pawl s^4, though a brief contact is established at each attraction of the armature, this is instantly succeeded by a separation, the point carried by the weighted spring being so sharply struck that it moves farther than the armature-point can follow. These rapidly-recurring contacts and separations have the effect of a high resistance and prevent the premature operation of the connecting-magnet M^3, since during selection the circuit of said magnet has no alternative path; but when after selecting the selecting-magnet remains excited, with its armature steadily attracted, the two contact-points come firmly together, and the resistance of the connecting-magnet branch of the local circuit F is so reduced that the said magnet is enabled to operate and to depress the selector-shaft. This magnet also operates the contact-springs C^3, opening the selecting and retaining magnet branch of circuit F by separating their members 39 and 40 and closing a short circuit 42 round the vibratory resistance A by uniting the contact members 40 and 41. The second armature *b* of relay R and its forward contact 6 are, as already pointed out in the call-current circuit-conductor *g*, between the generator P and the ringing-relay. The ringing-circuit is led through this extra contact to prevent the brief transmission of a ringing-current over a line which has been duly called and connected, but which has finished its communication and has begun to disconnect. When two lines are united, the controlling and ringing relays are both excited and the local circuit F of the calling-line is closed through the connecting-magnet M^3 to maintain the connection. Since the call-current passes through the resting contact of the ringing-relay R^2, its circuit is obviously broken while the said relay is excited; but in disconnection the retraction of the relay-armature is quicker than the release of the connecting-magnet and the consequent disconnection, and the ringing-circuit was therefore liable to come into operation and transmit an undesired ring before disconnection could be effected; but the controlling-relay is as prompt in its recovery as the ringing-relay, and by passing the ringing-current lead *g* through a forward contact thereof on its way to the ringing-relay contact 7 it is interrupted at the former as soon as or before it can be closed at the latter, and false call-signals are thus prevented. The armature *c* of the ringing-relay R^2 has forward and back contact-stops. When in engagement with the back point 7, connection is established, as previously indicated, between the ringing-lead *g* and the movable switch-terminal *e* of the line to which the said ringing-relay belongs, and thus between the call-generator P and any line with whose fixed terminals *u* the said movable terminal may be connected. When, on the other hand, contact occurs between said armature and its forward stop 9, the call-generator is disconnected and connection is established between the movable terminal *e* and its own main conductor 2 through the condenser K. When selection is being made by the operation of the interrupter at any substation, the discharges from the controlling-relay R pass over the line through the bell-bridges at other substations of the same circuit and over the main conductor 2 to earth G^2 at the grounded side of the battery. This tends to ring or produce a chattering in the bells of said bridges; but we have found that by placing the impedance-coil or inductive resistance *p* in series with the magnet of relay R^2 in conductor 11 the disturbing discharges are much reduced and the undesirable operation of the station-bells prevented. It is, however, desirable to short-circuit the said impedance when the connection between two lines is effected, and this is accomplished by the second armature *i* of the said relay R^2 when attracted into contact with its front stop 19.

In Fig. 2 the relays R and R^2 instead of being provided with two armatures, as shown in Fig. 1, are indicated as having a single centrally-pivoted armature controlling all of the several contacts which have been described and which are identified by similar letters of reference, the difference being thus in form only.

The test or interference-preventing relay has two independent exciting-windings r^3 and r^4. The first of these, r^3, is in a test-circuit *q* of the source B, which is closed and through which current can flow only when the active test-terminal *f* of a call-originating line is brought by its connecting-magnet M^3 into contact with a passive terminal *v* of a wanted line which is already engaged. When any line is thus busy, its passive terminals are all united to the ungrounded pole of the battery B, so that when the seeking-terminal *f* of another line touches any one of them the test-circuit *q* is closed and the test-relay of the calling-line becomes active and attracts its armatures *n* n^2. Three functions are then exercised. The local circuit F passes through the resting contact 8 of armature n^2, and therefore when

this armature moves forward such contact is dissolved, the said local circuit is broken, and the connecting-magnet M^3 becoming deënergized allows the shaft s to rise, and the formation of an interfering connection is prevented. The disconnected conductor 38 of said circuit F is transferred to a new connection through the said armature n^2 and the winding r^4 to earth, through which current flows to maintain the excited condition of the test-relay and to hold its armatures in their working position after the initially-exciting circuit q through the lower coil shall have been broken by the release of the vertical rod of the calling-line, and, finally, the contact formed by armature n with its front stop at 43 establishes a circuit x to the main line conductor 3 through the condenser k for the busy tone test signal produced by the circuit-breaker P^2, which signal may then be heard in the substation-receiver.

It will be observed that transmission of the call-signal to any substation is always through the movable terminal e of the call-originating line and over the main conductor 2 of the circuit of said substation, also that the busy-test and busy-signal appliances depend for their operation upon current passing from a fixed terminal of a busy line to the active terminal f of a call-originating line and that the busy sound signal current passes to the distant receiver. For these reasons we find it sometimes convenient to speak of the movable terminal e and main conductor 2 as the "ringing-terminal" and the "ringing-conductor" and of the movable terminal f and main conductor 3 as the "test-terminal" and the "test-conductor."

The operation of the system will now be described, and any further explanation of the apparatus and circuits which may seem necessary will be included in such description. In seeking to establish communication between any two substations—for instance, S and S^3—the receiver T is first removed from the switch-hook H. This action completes the metallic substation-circuit through the normal central-station terminal loop, which includes the source B and the selecting and ringing relays R R^2, which circuit may be traced from the switch-hook contact-stop j, through winding h of induction-coil J, conductor 26, point d, line conductor 2, point z, conductor 10, relay R^2, impedance-coil p, conductor 11, battery B, conductor 12, relay R, main line conductor 3, point d^2, conductor 25, contacts 24 and 23, and transmitter T^2, to the lever of switch H. Incidentally the selecting-magnet is energized, but does not exercise any useful function at the present time, its movement at this stage of the operation being merely an inconsequent one inseparable from the closure of the line-circuit. The purpose of the preliminary lifting of the receiver is to insure the formation and maintenance of a metallic line-circuit at the end of the selecting operation. The interrupter E is next operated, the rotary arm w^2 being turned to the right and to the distance required, thus relaxing its pressure on the commutator-springs O and being then released. In its return to its resting position it operates the interrupting-springs o intermittently, producing makes and breaks of the circuit. As soon as the pressure on contact-lever 34 is relaxed contacts 24 and 29 of the commutator-springs O are dissolved, opening the metallic line-circuit at 24 and the earth connection of the ringing-key at 29, and contact 30 is established, connecting the interrupting device E in a grounded circuit formed for selection between the substation-ground G and the central-station battery-ground G^2, the said grounded circuit including the interrupter-springs contact, the selecting-relay R, and the resistance r. The substation-bridge being opened at contact 24, line conductor 2 and the ringing-relay R^2 are not in this selecting-circuit; but the inclusion of the resistance r keeps the current at substantially the same strength as though they were still present. The purpose of opening the key-circuit at contact 29 is to prevent an impatient subscriber from disturbing the operations by attempting to use the key and to send a call before the return of the interrupter-arm w^2 to zero. The periodic pulsations of current produced in the grounded selecting-circuit by the operation of the interrupter E in making and breaking said circuit in the springs o actuate the selecting-relay R and its armature responds to said pulsations, being attracted on each closure and retracted on each interruption, the number of both being determined by the operation of the interrupter E. Relay R controls three contacts. Normally its armatures a and b are retracted, armature a by contact with back stop 4 maintaining the normal shunt 17 round the winding of its own relay, extending between points 67 and 68 of the relay-bridge 20 and including a resistance r^2; but when the said relay is energized its armatures a and b are attracted to their front stops 5 and 6, the former breaking the shunt 17 and closing the local circuit F of the magnets M, M^2, and M^3 and the latter establishing the connection g between the call-generator P and contacts 7 of the ringing-relay. The retaining-pawl magnet M^2 is, as in the before-mentioned patent, No. 709,740, of Bullard and Rorty, arranged or adjusted to be sluggish in responding by the retraction of its armature to the momentary cessations of current occurring on the opening of circuit F by relay R, and its armature once attracted is therefore not retracted on the opening of the circuit F until said circuit shall have been open for a considerable period of time. A number of ways for securing said sluggishness are known to those skilled in the art, and one of these, the shunting of the magnet by

a resistance m^2 about equal to its own, is shown. The pawl s^5 of this magnet having therefore engaged the star or ratchet wheel s^3 with the first pulsation of current during the process of selection remains engaged until the circuit F or that branch thereof which includes magnet M^2 is finally broken for an appreciable period of time, so that the ratchet-wheel and shaft s during its time of revolution does not fall back during the intermissions and so, also, that the two sets of springs C and C^2, actuated by the cam Q and the magnet M^2, respectively, shall be enabled to retain their working position until their respective actuating devices resume their positions of rest. The selecting-magnet M, responding to the operation of relay R, revolves the shaft s in a rapid succession of steps by means of the pawl s^4 and ratchet-wheel s^3 until the selector-springs or movable terminals e and f arrive at a point immediately confronting the fixed or passive terminals u and v of the desired line, each step in such revolution being maintained by the pawl s^5, which engages with said ratchet when the relay-armature a is attracted for the first time and which, as stated, continues such engagement until the circuit through the magnet M^2 is again permanently opened. As soon as the vertical shaft s advances from its zero position the condition of the group of contact-springs C is changed by the cam Q, which is secured to and revolves with said shaft. The actual arrangement in practice of this cam and its relation to the several contact-springs is indicated in Figs. 3 and 6, which show the cam Q in the form of a collar or disk mounted insulatively upon shaft s and having a zero-notch Q^2, wherein the bend of the master-spring 52 normally rests. When the mechanism is quiescent, the springs or points 47 and 48 are in contact with one another, as also are springs 45 and 46, these contacts maintaining connection between the line conductors and their passive terminal contacts v and u, respectively. On the movement of the cam Q the principal spring 52 passes out of the notch Q^2 and rides on the periphery of said cam, thus dissolving the said normal contacts and forming a new one between springs 47 and 49, whereby the fixed or passive contacts of the calling-circuit are temporarily severed and whereby the fixed contacts of the v series are connected through conductor 50, resistance r^5, and the secondary winding h^3 of the tone or sound busy-signal induction-coil I to the battery B and ground. The insulated metallic collar 51, forming the actuating-cam Q, and the spring 52, constantly bearing thereon, as shown in Figs. 3 and 6 and indicated in Fig. 2, are directly in the circuit of conductor 13. They jointly constitute a means of establishing continuity between the active terminal e, carried by the selector-arm s^2, and the main circuit-conductor 2. The changed condition of the springs C continues until the shaft s returns to its zero or resting position. The set of contact-springs C^2 has its condition changed when the retaining-pawl magnet M^2 is excited, and the change persists until such excitement ceases and until the armature of said magnet is again retracted. This set comprises contact springs or members 57, 58, 59, 60, and 61. In the resting condition of these 57 and 58 are in contact and are in the circuit of conductor 13, which unites the movable contact-terminal e to the line conductor 2 through the ringing-armature of the relay R^2, and 59 and 60 are also in contact, establishing a similar connection between the movable contact-terminal f and the line conductor 3. On the operation of the retaining-pawl magnet M^2 these contacts are dissolved and a new one is formed between the members 60 and 61, establishing the test-circuit connection temporarily between the said movable terminal f through conductor q and winding r^3 of the test-relay R^3. These springs resume their normal condition whenever the connecting-magnet comes into operation, and, as will presently be described, the circuit branch of magnet M^2 is broken and the magnet is de-energized; but on account of the sluggishness of the latter the said contacts are not restored until after the operation of the connecting-magnet there has been sufficient time for the operation of the test-relay should the line selected be found busy. When the active terminals e f of the selecting-line have been made, as has been described, to confront the passive terminals u v of the selected line, the controlling-relay maintains its excitement and the connecting-magnet M^3, which during selection has been kept inert by the vibratory resistance A, is excited and depresses the selector-shaft s, causing the said active terminals of line L to engage the passive terminals of line L^2 and to establish the desired connection. The set of contact-springs C^3, controlled by the said magnet M^3 and shown in Figs. 1 and 4 as being acted upon directly by the armature thereof, but in Fig. 2 as being placed under the shaft s to be operated upon by its descent, has now changed its condition. It comprises a normally closed contact 39, through which conductor 53 of the selecting-magnet branch continues to earth, and a normally open contact 40, which when closed short-circuits the vibratory resistance. Thus the operation of the connecting-magnet M^3 not only establishes connection between the two lines, but also effects the necessary change of the springs C^3 in such manner that contact is made between the members 40 and 41, short-circuiting the vibratory resistance A, thus reducing the resistance of its own circuit, while the preëxistent contact between members 39 and 40 is dissolved, producing the deënergization of magnets M and M^2, which have completed the performance of their several functions. The substation-circuits are now united by the cen-

tral-station mechanism, and the required substation S^3 must now be signaled. This is done by applying pressure to the call-key N at substation S, which act grounds the line conductor 3 by bringing the key-points m m^2 into contact and opens the metallic line-circuit by dissolving the normal contact between the members m^2 and m^3. If there is but a single substation upon the line which has been selected, a single pressure of the key will suffice; but if there are several such stations the key will be pressed several times to correspond with a predetermined code. The effect of the opening of the metallic circuit and the grounding of conductor 3 is that the controlling-relay R remains excited and retains its contacts in their working position, while the ringing-relay or electromagnetic ringing-key R^2 loses its excitement and suffers the contacts it controls to resume their normal state. The circuit of the call-generator P to the wanted line, which leads through a resting contact of the ringing-relay R^2 and a working contact of the controlling-relay R, is thereby established and may be traced as follows: from said generator P, grounded at G^4, through the lamp resistance r^{10}, conductor g, armature and fixed contacts b and 6 of relay R, armature-contacts 7 and c of relay R^2, conductor 13, contact between members 57 and 58 of the springs C^2, the active terminal e of the calling-line, and a passive terminal u of the wanted line. The pulsatory or intermittent call-current passes over main conductor 2 of the said wanted line through the bridged condensers K^2 and bells D of the stations thereof, the said bells accordingly being rung, and returns by way of main conductor of said line, point z^2, through the shunt 36, round relay R of said line, including resistance r^2, relay-points a and 4, and conductor 37, and in part through said relay itself, conductor 12, and to ground G^2 through the battery. The armature of the calling-line ringing-relay R^2 follows closely the manipulation of the substation-key N, falling back with pressure of said key, so that code-ringing is readily accomplished. The conductor 10, including the ringing-relay R^2 of the wanted line L^2, which extends from the point z of main conductor 2 to conductor 11 and ground G^2, forms, of course, an alternative path through which a portion of the ringing-current might be shunted; but during signaling the reactance of this path is so greatly increased by the electromagnetic resistance or inductance-coil p inserted therein that there is no appreciable loss of current. The bells at other stations S^2, &c., of the call-originating line L are during the foregoing operation prevented from ringing by the complete severance of main conductor 2 of said line from its active terminal e, such severance being due to the disexcitement of relay R^2 and the consequent retracted position of its armature c. When the called substation S^3 responds by taking his receiver from the hook-switch, the two relays R R^2 of line L^2 are in turn operated, the controlling-relay R acting to break its own shunt-circuit 36 and the ringing-relay R^2 to short-circuit the inductance-coil p. The two constituent lines are now fully connected for conversation and furnished with current for their substation-transmitters over a well-balanced supply and talking circuit, as generally indicated by the diagram Fig. 7. This through-circuit may be traced in detail through winding h of transmitter induction-coil J at station S, point d, main conductor 2, point z, condenser K, points 9 and c of relay R^2, conductor 13, including contacts 57 and 58 of springs C^2, the contacts 51 52 of commutator C, movable or active terminal e, a fixed or passive contact u of line L^2, conductor 14, contacts 46 45 of springs C, point z, and main conductor 2 of said line L^2, the connections of substation S^3 comprising point d, induction-coil J and the receiver T, assciated therewith, switch H, key N, commutator O, conductor 25, and point d^2, main conductor 3, condenser k, springs C and fixed terminal v of line L^2, the active terminal f, conductor 15, contacts 59 and 60 of springs C^2, and main conductor 3 of line L, point d^2 at substation S, and there by conductor 25, commutator O, and key N back to the telephones and induction-coil. The original central-station terminal loops of the two component circuits become bridges 20 of the compound talking-circuit, each extending from point z on conductor 2 to point z^2 on conductor 3 of its own main circuit. Each of these bridges includes the source of current B and the controlling and ringing relays R and R^2 of its own line, the said relays being placed on the two sides of the battery, respectively. Current is independently supplied to the transmitter of each line through the coils of its own relays. Thus placed the relays are directly in the supply-circuit, but are out of the talking-circuit. They continue excited to maintain the establishment of the through-circuit as long as is desired. It is necessary to have a considerable impedance on each side or the battery, both to individualize the line in drawing its supply from a source common also to other lines and to prevent the short-circuiting of voice-currents through the bridge 20, and another advantage of this location of the relays is that the magnet-coils are thereby enabled to economically serve as the requisite impedance appliances, such additional turns as may thus be made necessary acting incidentally to increase the efficiency of the appliances in exercising their functions as relays. The condensers K and k, included in the two sides, respectively, of the talking-circuit, act to prevent the steady current supplied to each line from passing to the other, thus insuring an independent and substantially equal supply of transmitter-current to each regardless of their respective re-

sistances. When after the establishment of a through talking-circuit, as described, and on the conclusion of a conversation disconnection is desired, it is only necessary for the substation-receivers to be replaced upon their respective switch-hooks. This action opens the metallic circuit and permits the deënergization of the relays R and R^2 and the consequent resumption of the normal or quiescent condition of both lines.

The operations whereby engaged lines are protected from intrusion or interruption and whereby a person desiring to connect his circuit with an engaged line may receive information of such engagement are now to be described. The test-relay R^3 and the tone-test-signal producer P^2 are mainly concerned in these operations. In calling a "busy" line the operation is exactly the same as has been described up to the moment when the active terminals *e* and *f* of the seeking-line have descended upon the passive or fixed terminals of the line wanted, and for the further steps of the operation we may assume a third line carrying out the functions of the calling-line L. When a call-originating line has become engaged, its shaft *s* has of course been revolved and the springs of group C have been operated by the cam Q. Spring 47 has thus been separated from spring 48 and has made contact with spring 49. The passive terminals of the testing or V series are thereby connected with the ungrounded pole of the battery B through the secondary h^3 of the busy-tone-signal apparatus induction-coil I, the resistance-coil r^5, conductor 50, contacts 49 and 47, and conductor 16, and the potential of the battery is imparted to the passive contacts *v* of line L. As soon as the new calling-line has so far carried out its process of selection as to bring its active terminal *f* into contact with the said passive terminal *v* a temporary test-circuit through winding r^3 of its own test-relay is closed and the potential upon said terminal *v* develops into a current which exciting the said test-relay brings the same into operation in the manner previously described to prevent the connection with the busy line from being completed and to establish and continue the transmission of the busy-tone signal to the calling-substation. It is, however, within the power of the attendant at the said substation to unlock or deënergize the test-relay, and thereby discontinue the connection with the test-signal apparatus whenever he may so desire. This he can do either by replacing his receiver upon the hook or by making a fresh selection. In either case his controlling-relay R suffers its armature *a* to be retracted so that the local circuit F is opened, and the test-relay R^3, being thus deprived of current, releases its armatures, disconnecting the test-signal apparatus, and the line now restored to its normal condition is ready to make another call.

A busy line may be a "call-originating" line or a "called" line—that is, a line with which connection is desired and which proves to be already engaged may be either a line which is selecting or which has selected and connected itself with another or one which has thus been selected and connected. The operation of determining and reporting the busy condition in the case of the latter does not materially differ from that of the former, which has been described; but the electrical potential of the test series *v* of fixed or passive switch-contacts is differently acquired. A busy called line is protected from intrusion from the moment it is secured by a line desiring communication with it. The active terminal member *f* on the testing side of the latter is directly in connection with the source of current through conductors 15 and 13, the winding of relay R, and conductor 12, and therefore all of the fixed or passive contacts *v* of the wanted line being permanently united to one another by the conductors 14 are brought into similar connection with the said source as soon as the active contact member of the calling-line makes contact with any one of them, the testing potential being thus established upon them all until the calling-substation disconnects.

It occasionally happens that a called subscriber through ignorance or wilfulness refuses to answer or recognize a call transmitted to his station and proceeds instead to select another line. In these circumstances the ignored calling-substation must be advised of the fact by the busy signal; but in such case the test-relay R^3 of the latter has not been and cannot now be brought into action to connect the said busy-signal apparatus with his main circuit, and the said signal must pass by way of the branch circuit 50, which is employed to connect the passive contact members *v* of a calling-line with the ungrounded pole of the battery. It is to provide for this contingency that we connect the said branches 50 to a point of the battery-conductor outside of the induction-coil I. When the called subscriber who refusing to acknowledge his call proceeds on his own part to select another, his C-springs 47 and 49 connect the secondary winding of induction-coil I to the fixed contacts *v* of his own line; but the active or movable terminal *f* of the ignored subscriber also at that moment is resting on one of these contacts *v*, and the busy signal thus passes to the original but ignored calling-line through branch 50 and contact-points 49 and 47 of the called line and movable contact *f* and conductor 15 of the calling-line to main conductor 3 thereof, and thus to the substation. The resistance-coil r^5 comes into use in this connection. The secondary winding h^3 of induction-coil I in the conditions stated is temporarily connected in parallel with the winding of selecting-relay R of the said ignored-subscriber's

line and being in practice of very low resistance is liable to short-circuit the said relay and disarrange the motor mechanism controlled thereby; but by inserting a sufficiently high resistance-coil r^5 in the individual branch 50, leading to the C-springs 49 and 47 of each line, any such difficulty is forestalled.

In calling another substation on the same line the selecting operation must be performed exactly in the same manner as if the wanted station were on another line. This is necessary, first, because the "busy-signal" and intrusion-preventing devices must be set and, second, because the call-currents are developed by a common central-station generator which must be brought under the control of the substation signaling-key N. Calls thus made in pursuance of such selection are termed "reverting" calls. A person at any given substation of a line desiring to transmit such a reverting call and to talk with another substation of the same line operates his interrupting device or commutator, setting the same to select the line to which both of the said stations belong, and as soon as the rotary arm of the commutator returns to zero he manipulates the call-key N in accordance with the code-number signal of the station wanted.

The central-station apparatus operates as follows: The selector-arm s^2 advances and is depressed by the connecting-magnet M^3 upon the fixed terminals of its own line, which are in their appropriate place in the associated group of the fixed terminals of the several lines of the system. This particular pair of fixed terminals is connected in a manner slightly different from that of the other fixed terminals of the same line which are associated with the selectors of other lines. They are termed the "revertive fixed terminals," being employed in reverting calls only and are useful solely for the operation of ringing or sending the call to the desired station, being of course quite non-essential to the establishment of the talking-circuit. Each selector has one such pair u^2 v^2 of revertive fixed terminals, and, as shown in Fig. 1, these terminals are for each main conductor placed not beyond the separable contacts C of said conductor, but on the line side of said contacts, so that the separation of the contacts which severs the remaining fixed contacts u and v of the group from the line conductors they represent does not so sever the corresponding revertive terminals. In Fig. 2 but one of the said revertive terminals u^2 is shown as being thus connected with its line conductor; but this is simply to avoid a complicated crossing of lines, and it will be understood that though it is not necessary to so connect v^2 also, since the outgoing call-currents pass by way of u^2 only, we prefer in practice to connect both u^2 and v^2 with their respective main conductors, as shown in Fig. 1. It will be seen that when the selector-springs or active terminals e and f descend upon and make contact with the revertive terminals u^2 and v^2 the call-generator P is brought into such relations with the line which has both originated and is about to receive the call and only awaits the operation of the key N at the calling-station. When the said key is operated, the armature c of the ringing-relay R^2 falls back, and the pulsatory ringing-current from the generator P, grounded at G^4, passes out over conductor 2 of the same line through the usual lamp-resistance r^{10}, conductor g, contacts b and 6 of controlling-relay R, contacts 7 and c of the ringing-relay R^2, conductor 13, contacts 57 and 58 of springs C^2, operated by the retaining-pawl magnet, active terminal e, passive terminal u^2 of the same line, and conductor 14, which connects directly with the said line conductor 2. The ringing-current thus reaches the several substations and finding circuit at all of them (except at that which is making the call) through the respective bells D and condensers K^2 to the other main conductor 3 rings the said bells, and thus makes the required call. The main part of the ringing-current reaching conductor 3 finds its return through the earth connection G at the call-key N of the calling-station, although a negligible portion thereof finds return over conductor 3 and to the central station ground through the controlling-relay R, while still another portion leaks from the main conductor 2 at point z and through the magnet-coils of the ringing-relay R^2 to ground at G^2 on its way out, but the relay R^2 being, as before stated, biased or oppositely polarized does not respond to said ringing-current passing therethrough. When the desired substation on the same line has thus been signaled, conversation may be carried on without interruption as long as desired, the testing and lockout potential having been imparted to the fixed terminals v of said line to prevent the intrusion of other lines during the pendency of the conversation in the manner already described by the revolution of the vertical shaft s in the act of selection.

Having now fully described our invention and its mode of operation, we claim—

1. In an automatic telephone-exchange, the combination of a metallic main or line circuit extending between a substation and a central station, and having at the latter a pair of movable or active terminals, a source of current connected in the said circuit for switching and conversations, an electromagnetic actuating mechanism for said movable terminals, a controlling-relay for said actuating mechanism and a ringing-relay or electromagnetic ringing-key connected on the two sides respectively of said source of current in said circuit, all at the said central station; with the suspension telephone-switch, a signaling-key, and an intermittent interrupting

device, all associated with the said main circuit at said substation; the said switch being adapted to close the metallic circuit and energize both relays; the said interrupter being adapted to open said metallic circuit to deënergize the ringing-relay, and to establish and intermittingly interrupt a grounded circuit composed of one side of said metallic circuit and including said source of current and controlling-relay; and the said signaling-key being adapted when depressed to steadily close the said grounded circuit to maintain the excitement of said controlling-relay, and to open said metallic circuit and deënergize said ringing-relay.

2. In an automatic telephone-exchange, metallic-circuit telephone-lines converging from substations to a central station; and an outfit at each substation comprising a telephone, a suspension-switch, a circuit-interrupter and a signaling-key; in combination with, at said central station, a common source of current for switching and conversations; and for each line, active and passive switch-terminals; electromagnetic actuating mechanism for connecting the said active terminals with the passive terminals of the same or any other line; a permanent conductive connection between the main conductors leading through said source of current, and forming the normal terminal loop of the circuit; and two relays controlling respectively call-current devices and the said actuating mechanism, and responsive to the operation of said substation devices connected in said loop or bridge one on each side of said source; the said permanent connection constituting a current-supply bridge for its own circuit, and the electromagnets of said relays constituting impedance-coils individualizing such supply, and preventing the diversion of voice-currents through said bridge when said circuit is switched to another.

3. In an automatic telephone-exchange system, the combination with each metallic-circuit substation-line; its central-station loop or bridge terminal conductor permanently uniting the main conductors thereof; an earth connection for said terminal conductor; and electromagnetic switching mechanism; of a source of current common to all lines for switching and conversations, and a controlling-relay for said mechanism in said terminal conductor on one side of said earth connection; a call-transmitting relay or electromagnetic ringing-key in said terminal conductor on the other side of said earth connection; and substation apparatus comprising means for completing said metallic circuit through said source and both relays; a periodic interrupter organized to open one side of said metallic circuit through the call-transmitting relay, and to complete and intermittingly interrupt a grounded circuit formed by grounding at the substation the other side of said metallic circuit and including said source and said controlling-relay, for the operation of said switch mechanism; and a call-key adapted when operated to reëstablish and maintain said last-named circuit, and to open and close the said metallic circuit through said call-transmitting relay, for the normal operation thereof; substantially as described.

4. In an automatic telephone-exchange, the combination of a group of main metallic telephone lines or circuits extending from their several substations to a central station; a source of current for switching and conversations connected in each of said main circuits; an electromagnetic switching mechanism for each line, whereby said line may select and connect itself with any other; a controlling-relay for said switching mechanism connected in each main circuit on one side of said source; and a ringing-relay or electromagnetic signaling-key in each main circuit on the other side of said source all at the central station; with a common central-station call-generator; and connections therefrom for each line to a rear contact-stop of said ringing-relay; substantially as set forth.

5. In an automatic telephone-exchange system, metallic-circuit main telephone lines or circuits extending between substations and a central station, each provided at said central station with a pair of active or movable switch-terminals and multiple pairs of passive switch-terminals; switching mechanism acting to bring the said pair of active terminals into connection with a pair of passive terminals of any selected line; a common battery supplying current for switching and signaling through which all lines are permanently closed; a relay for each main circuit controlling the switching mechanism thereof, and connected in the main circuit on one side of said battery; a ringing-relay or electromagnetic ringing-key also for each circuit connected on the other side of said battery, and having its armature in circuit with one of said movable switch-terminals; a common central-station call-generator adapted to supply calling-current to all lines; a connection extending from said generator to rear contacts of said ringing-relay through forward contacts of said controlling-relay, all at said central station; and a call-key at each substation adapted when operated to maintain closed the circuit through the controlling-relay, and to break the circuit through the ringing-relay, so that the forward and rear armature contacts of said relays respectively are simultaneously established to provide a conducting-path for the call-current from the generator thereof to a movable terminal of a call-originating line; substantially as set forth.

6. In an automatic telephone-exchange, a metallic telephone-line or main circuit extending between a substation and a central station; a grounded circuit formed of one of the conductors of said metallic circuit, and extending

between an attached earth connection at the central station and a normally detached earth connection at the substation; a switch-terminal for said metallic circuit; a closed conductive connection between the main conductors of said metallic circuit; a source of steady current connected therein; a switch mechanism controlling relay in both metallic and grounded circuits; a call-transmitting relay in said metallic circuit only, having an armature directly united with the said switch-terminal thereof, a forward stop therefor united with the appropriate main conductor, and a rear contact-stop; a constantly-operating call-current generator, and a conductor extending therefrom to said rear contact-stop of said call-transmitting relay, and thereby when the armature of said relay is retracted, to said switch-terminal and to any line with which the same may establish connection, all at said central station; and a calling key or switch having normally united contacts in said metallic circuit and normally separated contacts in said grounded circuit; and adapted when pressed to maintain a closed circuit through said controlling-relay, and to open the circuit through said call-transmitting relay and thereby close the circuit of the call-generator through the armature thereof to the switch-terminal of the circuit, and also to sever the connection of said switch-terminal and its own main circuit-conductor, substantially as described.

7. In an automatic telephone-exchange system, a compound metallic conversation-circuit extending between two substations through a central station, and composed of call-originating and call-receiving substation-circuits united through movable terminals of the former circuit and fixed terminals of the latter; a signal-bell in said second circuit at the substation thereof; a central-station call-generator furnishing call-current for the operation of said bell; two bridged relays associated with said call-originating circuit at the central station, one maintaining the establishment of said compound circuit, and the other having an armature forming part of the said conversation-circuit; a call-current conductor extending to said armature through forward contacts of the former and back contacts of the latter relay, so that call-currents can be transmitted to said signal-bell, only when the armatures of said relays are respectively on their forward and back contacts, at the same time; and a signaling-key at the call-originating substation adapted to close circuit through the former relay and break circuit through the latter relay simultaneously, and thereby establish such condition of said armatures, substantially as set forth.

8. In an automatic exchange system, a metallic compound conversation-circuit extending between two substations through a central station and formed by the union at said central station of the movable terminals of a call-originating constituent circuit with fixed terminals of a call-receiving constituent circuit; telephone-transmitters at the substations of the said constituent circuits respectively; two bridges extending between the conductors of the said compound circuit at said central station; controlling and ringing relays for each constituent circuit, having their electromagnetic windings connected in series in the said bridges respectively; and a common battery included in both bridges between the said two relay-magnets thereof, to supply transmitter-current to the transmitters at the said two substations independently; substantially as set forth.

9. In an automatic telephone-exchange, a compound talking-circuit between two substations formed by uniting the line-circuits of said substations at a central station, and comprising, telephone apparatus at the said substations; two independent bridges at the central station joining the main conductors of the two constituent circuits respectively; two relays in series in each such bridge, the relays of both bridges serving as impedance-coils, and those of the call-originating constituent circuit also serving respectively to maintain the union of the two substation-circuits, and to control the transmission of call-currents over the call-receiving circuit; a central-station battery connected in both of said bridges between the said two relays thereof, and supplying current for the energization of said relays, and for the said substation telephone apparatus; and switch-conductors uniting the main conductors of each constituent circuit to the corresponding main conductors of the other at points outside of said relays; substantially as hereinbefore described.

10. In the substation apparatus of an automatic telephone-exchange system, the combination of two metallic circuit main conductors; a bridge-circuit between said circuit-conductors including an electric bell; and a condenser included also in said bridge to maintain the same normally discontinuous for steady currents, but closed for the rapidly-pulsating operating-current of said bell; with a telephone-switch adapted to close the circuit of said bridge conductively by shunting said condenser; a periodic interrupter in said bridge organized to open the circuit through one of said main conductors, and to ground and then intermittingly interrupt the other of said main conductors; and a grounded signaling-key having separable contacts in said bridge in series with said interrupter, and adapted when operated to open said bridge and metallic circuit through one of said main conductors and to establish a grounded circuit through the other; substantially as described.

11. In the substation apparatus of an automatic telephone-exchange system, the combi-

nation with two metallic-circuit main conductors; and a conductively-discontinuous bridge between said main conductors; of a telephone-switch adapted to close the circuit of said bridge; a periodic interrupting device adapted to break said circuit through one of said main conductors, and to establish and intermittingly interrupt a grounded circuit through the other of said main conductors; and a normally disconnected resistance device arranged to be included in said grounded circuit; substantially as set forth.

12. In the substation apparatus of an automatic telephone-exchange system, the combination with two metallic-circuit main conductors extending from the two poles respectively of a central-station battery; a conductively-discontinuous bridge between said conductors; and a telephone suspension-switch operating to close the circuit of said bridge and thereby unite said main conductors; of an associated interrupting device adapted when operated to break said circuit leaving one of said main conductors disconnected, and to establish and intermittingly interrupt a grounded circuit through the other of said main conductors; and a normally disconnected resistance device arranged to be included in said grounded circuit during the operation of said interrupting device in substitution for the resistance of the said disconnected main conductor; whereby the current strength developed by said central-station battery in the remaining main conductor is maintained substantially uniform.

13. The combination in each circuit of an automatic exchange system, of the metallic-circuit main conductors permanently united at the central station; a battery or like source of steady current connected therein; a switch-mechanism-controlling relay, and a call-signal-transmitting relay, connected in said circuit on different sides of said battery; and a ground connection between said battery and said call-signal-transmitting relay, all at said central station; and a grounded call-key at a substation, normally detached from said circuit-conductors and organized when operated to establish a grounded circuit through one of said main conductors, the controlling-relay and the source of current, and to open the circuit through the other main conductor and the call-transmitting relay, whereby the attraction of the controlling-relay armature and the retraction of the call-transmitting-relay armature may be effected simultaneously with each operation of said key; substantially as and for the purposes set forth.

14. A system for call-signaling for an automatic telephone-exchange, comprising a group of telephone main circuits or lines each extending between one or more substations and a central station, and each composed of two main conductors serving respectively as the outgoing and return call-current conductors; an electromagnetic bell at each substation of all of said circuits; a common call-current generator at said central station; means associated at said central station with each main line when acting as a call-originating circuit for establishing an incomplete circuit connection between said call-generator and the call-current main conductor of the said call-originating circuit or of any desired other line of the group; a transmitting call-key at the substation of said call-originating circuit; and two relays in the said call-originating circuit at said central station, responsive to the operation of said substation-key, one acting to maintain the establishment of such incomplete circuit connection, and the other acting to complete the same and to thereby close the circuit of the said call-generator through the said outgoing conductor and substation-bells of the selected line; whereby with a single call-transmitting key, call-signals may be transmitted from any substation to any other substation on the same, or on any other line at will; as set forth.

15. The combination in an automatic telephone-exchange, of a metallic substation-circuit; a second substation-circuit with which the first has established connection to constitute a through talking-circuit; a central-station battery furnishing current for switching operations and talking, to both circuits; a circuit-controlling key at the substation end of said first-named circuit; a switch-mechanism-controlling relay, and a call-transmitting relay in said first-named circuit on opposite sides of said battery, the connection between the said two circuits being established through the armature of said call-transmitting relay, and the said relays being responsive by the attraction and retraction of their armatures respectively to the operation of said key; a central-station call-current generator; and a conductive connection therefor leading through the armature of the controlling-relay and its forward contact, and the armature and rear contact of said call-transmitting relay, to the appropriate main conductor of said second substation-circuit; substantially as and for the purposes described.

16. In an automatic telephone-exchange, a temporary signaling-circuit extending between a central station and a substation; a call-current generator included therein at said central station and organized to develop and deliver thereto successive current pulsations of single direction; an electromagnetic bell included in said circuit at the substation and polarized to be responsive to said current impulses; and a relay controlling said signaling-circuit, connected in a branch thereof at said central station, and oppositely polarized to remain unaffected by said current impulses; substantially as and for the purposes set forth.

17. In an automatic telephone-exchange, a

number of metallic main telephone circuits or lines, each extending between one or more substations and a central station; an individual switching device at the central station for each circuit; a common call-current generator at the central station organized to develop and deliver to its external circuit a pulsatory or intermittent current of single direction; an electromagnetic call-bell at each of the substations of said lines, polarized in a direction to be responsive to the successive current pulsations of said call-generator; a temporary but incomplete signaling-circuit established between the said call-generator and the call-bell of a wanted substation by the action of the switching device of a call-originating substation-circuit; a call-key at said call-originating substation; and a polarized relay responsive to said key and acting to complete said signaling-circuit for the operation of said call-bell, the said relay being in the circuit of said call-originating substation, and also in a branch of said signaling-circuit, and being polarized to remain unaffected by the current pulsations of said call-generator; substantially as set forth.

18. In an automatic telephone-exchange system, the combination of a number of metallic main telephone circuits or lines each extending between one or more substations and a central station, and the two main conductors of each serving respectively as call-current-supply and call-current-return conductors; an individual switching mechanism at the central station for each circuit; a common call-current generator at the central station organized to develop and to deliver to any external circuit which may be established for it, a pulsatory or intermittent current of single direction; an electromagnetic call-bell at each of the substations of said lines polarized in such manner as to be responsive to said pulsatory call-current; a temporary but incomplete signaling-circuit established between the said call-generator and the call-bell of a wanted substation by the action of the switching mechanism of a call-originating substation-circuit; a call-key at said call-originating substation; and two polarized relays at the central station responsive to said key, both in the call-originating main circuit and also in said signaling-circuit or a branch thereof, one being adapted to control said switch mechanism for the establishment and maintenance of said incomplete signaling-circuit, and the other acting to complete the said signaling-circuit for the operation of the call-bell at said wanted substation; substantially as set forth.

19. In the central-station switching mechanism individual to each telephone main line of an automatic exchange, the combination substantially as hereinbefore described, of a main-line relay; a local circuit leading through contacts of said relay and having a portion of its conductor divided into two parallel branches; selecting and retaining-pawl electromagnets in one of said branches; a connecting-relay in the other of said branches; and a vibratory resistance in the connecting-relay branch actuated by the selecting-relay, and consisting of contact-points mounted respectively upon a spring, and the armature-lever of said selecting-relay, and adjusted to vibrate upon each other when said lever is in operation, but to rest in firm contact with each other on the cessation of such operation.

20. The combination in an automatic telephone-exchange switch apparatus, with a substation telephone-circuit having its main conductors provided with movable terminals to select and connect with the fixed terminals of other circuits and with multiple fixed contact-terminals to be selected and connected with by the movable terminals of other circuits; a selecting and connecting device for bringing the said movable terminals into juxtaposition to any predetermined pair of fixed terminals and uniting them therewith; and selecting, retaining-pawl, and connecting electromagnets for operating and maintaining the operation of the said selecting and connecting device; of a branched local circuit including said electromagnets, the selecting and retaining magnets being in one and the connecting-magnet in the other branch of said local circuit; a relay in the main circuit controlling said local circuit and itself responsive to appropriate substation apparatus; and a vibratory contact resistance device in the connecting-magnet branch of said local circuit actuated and controlled by the armature of the selecting-magnet; as and for the purpose described.

21. The combination in an automatic telephone-exchange switch apparatus, with a substation telephone-circuit having its main conductors provided with movable terminals to select and connect with the fixed terminals of other circuits, and with multiple fixed contact-terminals to be selected and connected with by the movable terminals of other circuits; a selecting and connecting device for bringing the said movable terminals into juxtaposition to any predetermined pair of fixed terminals and for uniting them thereto; and selecting, retaining-pawl, and connecting electromagnets for operating and maintaining the operation of the said selecting and connecting device; of a branched local circuit including said electromagnets, the selecting and retaining magnets being in one and the connecting-magnet in the other branch of said local circuit; a relay in the main circuit controlling said local circuit and itself responsive to appropriate substation apparatus; a vibratory contact resistance device in the connecting-magnet branch of said local circuit, actuated and controlled by the armature of the select-

ing-magnet, to prevent the operation of the connecting-magnet during selection and to permit the same after selection; and a normally open short-circuiting shunt around said vibratory resistance adapted to be closed by and pursuant to the operation of said connecting-magnet; substantially as hereinbefore described.

22. In an automatic telephone-exchange, the combination of a number of metallic substation-circuits or telephone-lines each extending from one or more substations to a central station; an automatic switching mechanism for each line at the central station, comprising the ringing and testing active switch-terminals representing respectively the two main conductors of said line, and fixed or passive switch-terminals for all lines of the system including its own, the said switching mechanism being controlled from any substation of the line to connect the said active terminals with any desired pair of said passive terminals; an electromagnetic ringing-key or ringing-relay at the central station for each line controlling the ringing active terminal thereof; a common call-generator at said central station, and a call-current conductor leading therefrom to a contact of said ringing key or relay, and adapted to be switched by the operation thereof to the active line-terminal controlled thereby and thus connected with the call-bell at the substation of any line with whose fixed terminal said active terminal may be in contact; and a key at each substation controlling the said electromagnetic relay or ringing-key of its own line; whereby call-signals may be transmitted through the agency of a single call-key from any substation to any other substation, on the same or on another line, substantially as set forth.

23. In an automatic telephone-exchange, a system of call-signaling between stations on the same line or main circuit by means of call-currents developed by a central-station source, comprising a metallic polystation telephone-circuit having outgoing and return call-current main conductors provided at a central station with a pair of movable or active terminals and a pair of reverting fixed terminals; a common central call-current generator; a central-station selecting and connecting mechanism appropriated to said telephone-circuit and adapted to move said movable terminals into juxtaposition to and into connection with said reverting fixed terminals in response to action taken at a call-originating substation; an incomplete ringing-circuit from said call-generator through one of said movable terminals and the corresponding reverting fixed terminal thus connected, to the outgoing call-current conductor; an electromagnetic call-bell bridged in series with a condenser between the said outgoing and return main conductors at each substation; a signal-transmitting call-key at the call-originating substation; and two central-station relays (in a permanently-closed connection including a battery between the said two main circuit-conductors) responsive to the operation of said call-key, one controlling said selecting and connecting mechanism and acting therethrough to maintain the said connection between the movable and reverting fixed terminals, and the other acting to complete the said call-generator ringing-circuit; whereby the operation of the call-key at any one of the several substations of a polystation-circuit acting through the medium of a relay at the central station is enabled to ring the bells of the other substations of said circuit; substantially as described.

24. In an automatic telephone-exchange, the combination of a polystation main telephone-circuit having its main conductors provided with a pair of movable terminals, multiple fixed terminals one pair for each other main circuit of the system, and a pair of reverting fixed terminals, the said movable terminals being adapted to select and connect with the fixed terminals of other circuits or the reverting fixed terminals of their own circuit, the said multiple fixed terminals to be selected and connected with by the movable terminals of other circuits, and the said reverting-terminals to be selected and connected with exclusively by the movable terminals of their own circuit for ringing between two stations of the same line; a selecting and connecting device associated with said circuit and adapted to connect the movable terminals thereof with said reverting-terminals or with the fixed terminals of any other selected circuit; a common call-generator; an incomplete ringing-circuit from said call-generator through one of the said movable terminals to the conductor represented by the fixed terminal with which it has established connection; and two relays in a closed loop of said main circuit including a common battery, one acting to control said selecting and connecting device and to maintain the connection established thereby, and the other to complete said ringing-circuit; with electromagnetic call-bells and signal-transmitting call-keys, one of each at each substation of said main circuit and of other circuits; the said relays being both responsive to the operation of the call-key of any one of the substations of their own circuit which has previously operated its said selecting and connecting device to establish connection between its movable switch-terminals, and a selected pair of reverting or other fixed terminals; and the said substation-bells of any circuit represented by said selected fixed terminals being responsive to the action of said last-mentioned relay; substantially as set forth.

25. The combination in an automatic exchange system, of a substation-circuit having

movable or active terminals; selecting and connecting apparatus actuated by electromagnets in a local circuit for connecting the said terminals with fixed terminals of another substation-circuit; a busy-test relay associated with said selecting apparatus controlling the local circuit thereof, said relay being adapted when energized to open said local circuit and thereby prevent the operation or further operation of said selecting and connecting apparatus; a normally incomplete test-circuit containing the exciting-coil of said relay; and means actuated by said selecting apparatus for completing said test-circuit and for causing a current to flow therein for the operation of said relay when the said other substation-circuit is already engaged.

26. In an automatic exchange system, the combination substantially as described herein, of a substation-circuit having movable or active terminals; selecting and connecting apparatus actuated by electromagnets in a local circuit for connecting said terminals with fixed terminals of another circuit; a busy-test relay having actuating and maintaining exciting-coils, said relay being adapted when energized to open said local circuit thereby preventing the operation or further operation of said connecting apparatus, and to divert the current thereof through its own maintaining-coil, a normally incomplete test-circuit including the actuating-coil of said relay; a commutating device actuated by said selecting and connecting apparatus to transiently sever one of said active terminals from its main conductor and to complete said test-circuit therethrough; and means for establishing current through said test-circuit for the operation of said busy-test relay, when, and as long as the said other substation is engaged.

27. In an automatic exchange system, the combination of a call-originating substation-circuit having a movable or active switch and test terminal; selecting and connecting apparatus therefor actuated by electromagnets in a local circuit for connecting said terminal with a fixed terminal of another or wanted substation-circuit; an intrusion preventing test-relay having actuating and maintaining or locking exciting-coils, said relay being adapted when energized to open said local circuit thereby preventing the said connecting apparatus from effecting the desired connection, and to divert the current of said local circuit through its own maintaining-coil; a normally incomplete test-circuit including the actuating-coil of said relay; means for impressing a potential upon the multiple fixed terminals of the said other or wanted substation-circuit when the same is busy; and a commutating device actuated by said selecting and connecting apparatus to sever the said active test-terminal from its main conductor during the process of selection, and to connect said incomplete test-circuit therewith; whereby when contact is made between the active test-terminal of a call-originating circuit and a passive terminal of a busy line, current is caused to flow from the latter through the former, and through the actuating-coil of said intrusion-preventing test-relay; substantially as and for the purposes described.

28. In the central-station apparatus of an automatic telephone-exchange, the combination of a call-originating substation-circuit having movable or active terminals; automatic switching apparatus for connecting the said terminals with fixed terminals of another substation-circuit; a busy-test relay associated with said switching apparatus, having actuating and maintaining exciting-coils; a normally incomplete test-circuit including the actuating-coil of said relay; means actuated by said switching apparatus for completing said test-current circuit and for causing a current to flow therein for the operation of said relay when the said other substation is already engaged; and an audible busy-signal-producing device in a conductor leading through normally separated contacts of said relay to a main conductor of said call-originating circuit; the said relay being adapted when operated to establish the circuit of said audible signal device through said contacts, and to close and direct current through the circuit of its own maintaining-coil; substantially as and for the purposes set forth.

29. In an automatic telephone-exchange system, the combination at the central station, of a call-originating or calling substation-circuit, and a call receiving or wanted substation-circuit, both provided with a pair of active terminals and multiple pairs of passive switch-terminals; switching mechanism actuated by electromagnets in a local circuit for said calling-circuit adapted to connect the active terminals thereof to the passive terminals of said called circuit; a busy-test relay with actuating and maintaining exciting-coils; a normally open locking-circuit through the maintaining-coil thereof; a tone-current-producing device in a normally open busy-signal circuit; means as indicated for impressing a testing-potential upon the multiple passive contacts of the wanted substation-circuit when said circuit is busy; and a temporary testing-circuit including the actuating-coil of said test-relay established by the operation of said switching mechanism through the active and passive terminals of said calling and wanted circuits respectively when said terminals are brought into connection; the said relay normally maintaining the said switching-mechanism local circuit, and adapted when energized, to disestablish the same, to close the said maintaining-coil or locking-circuit and

divert the current of said local circuit thereto, and to close the said busy-signal circuit through the appropriate main conductor of the calling-circuit and the substation-receiver thereof; whereby the engaged condition of the wanted line may be announced to the substation of said call-originating line; as set forth.

30. In an automatic telephone-exchange system, the combination at the central station, of substation circuits or lines having one set of movable terminals and multiple sets of fixed terminals, any of which lines may be a line calling for another or a line wanted by another; switching mechanism for each line actuated by selecting and connecting electromagnets and operating to unite the movable terminals of said line when calling, to the fixed terminals of a wanted line; a controlling-relay in each line; a local circuit containing said actuating-magnets and extending through forward or working contacts of said controlling-relay; a normally detached branch of said local circuit alternative to the magnet-containing portion thereof; a battery or like source of current adapted to be attached to the fixed terminals of an engaged line by the normal operation of the switching mechanism establishing such engagement; an incomplete and temporary testing or non-intrusion circuit to be completed through the said attached battery and fixed terminals of any engaged line when the movable terminals of said calling-line are connected therewith by the switching mechanism of said calling-line; a normally discontinuous busy-signal circuit and a tone-signal current-producing apparatus included therein; a test or intrusion-preventing relay for each line having actuating and maintaining exciting-coils in said non-intrusion circuit and detached branch circuits respectively; and two switching armature-levers therefor, adapted one to move between back and front contact-stops to control the local actuating-magnet circuit through said magnets and the alternative normally detached branch thereof through said maintaining-coil, and the other between a back non-contact stop and a front contact-stop to control the connection of said normally discontinuous busy-signal circuit with the conductors of said calling-line, the normal connection of said local circuit being through said back contact, and the connections of said branch and busy-signal circuits being through said front contacts respectively; substantially as described.

31. In an automatic telephone-exchange the combination substantially as herein described, of a polystation main telephone-circuit having at each substation a bridged call-bell, and at the central station active and passive terminal contacts; a selecting and connecting switch mechanism for said circuit with actuating-magnets in a local circuit; a source of current in a permanent central-station connection between the two main conductors of said main circuit; a periodic interrupting device at a call-originating substation of said main circuit; a controlling-relay responsive to said interrupting device for said local circuit and the switch-mechanism actuating-electromagnets contained therein, included in said permanent connection on one side of said source; a ringing-relay also in said permanent connection on the other side of said source; an earth conductor attached to said permanent connection between said source and ringing-relay; an impedance device in said permanent connection between said ringing-relay and said earth conductor; and a shunt-circuit for said impedance device controlled by said ringing-relay; substantially as and for the purposes set forth.

32. In an automatic telephone-exchange system, the combination at the central station, of substation circuits or lines having active and multiple passive switch-terminals, any of which lines may be a line calling for another, or a line called or wanted by another; switching mechanism for each line adapted to connect the active terminals of said line when calling, to the passive terminals of a wanted line; a test-relay for each calling-line; means for exciting said relay when connection is made by the active terminals of the said calling-line with the passive terminals of a busy called line; a common busy-signal-producing device; a normally open busy-signal circuit containing said device, and branching to switch-contacts of the said test-relays of the said lines respectively; and a resistance device in each of the said relay branches of said busy-signal circuit; the said relays being each adapted when excited to complete said busy-signal circuit through the branch thereof appropriated to said relay and its individual resistance, and through the said calling-line; substantially as and for the purposes specified.

33. In an automatic telephone-exchange system, the combination with two or more metallic substation-circuits leading to a central station; of selector mechanism at the central station for connecting a calling with a called substation-line, said mechanism comprising terminals representing the substations, and a movable connector adapted to connect terminals of the calling and any called substation-line; ringing and controlling relays in the conductors of the calling-circuit respectively; electromagnetic actuating means for advancing the connector; a selecting-circuit through said electromagnet closed upon the simultaneous deënergization of one relay and energization of the other relay; selecting means under control of the calling-substation for simultaneously grounding

a circuit by way of one conductor of the calling-substation circuit through one relay and opening the circuit through the other relay; a ringing-circuit closed by the simultaneous energization of the controlling-relay and de-energization of the ringing-relay, said ringing-circuit extending through the terminals connected by the connector of the called line; and signaling means under control of the calling-substation for simultaneously grounding a circuit by way of one conductor of the calling-substation through one relay and opening the circuit through the other relay.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 21st day of January, 1904.

ALBERT M. BULLARD.

Witnesses:
HARRY B. THAYER,
ALBERT L. SAER.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 22d day of January, 1904.

LOUIS A. FALK.

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