

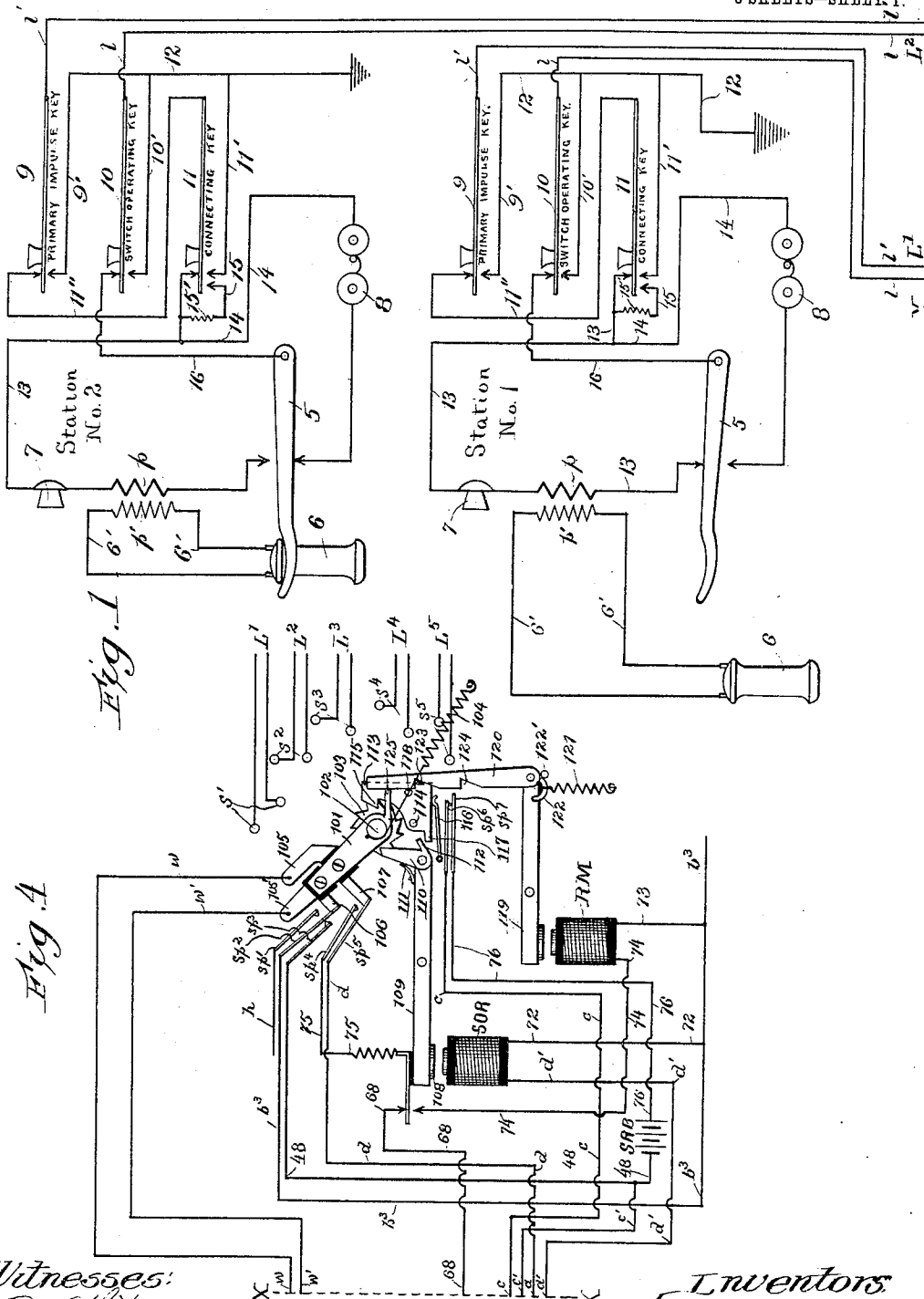
No. 784,498.

PATENTED MAR. 7, 1905.

J. K. NORSTROM & H. M. GRAIF.
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED MAY 18, 1903. RENEWED JULY 5, 1904.

3 SHEETS—SHEET 1.



Witnesses:
Ray White.
Harry B. Lovell.

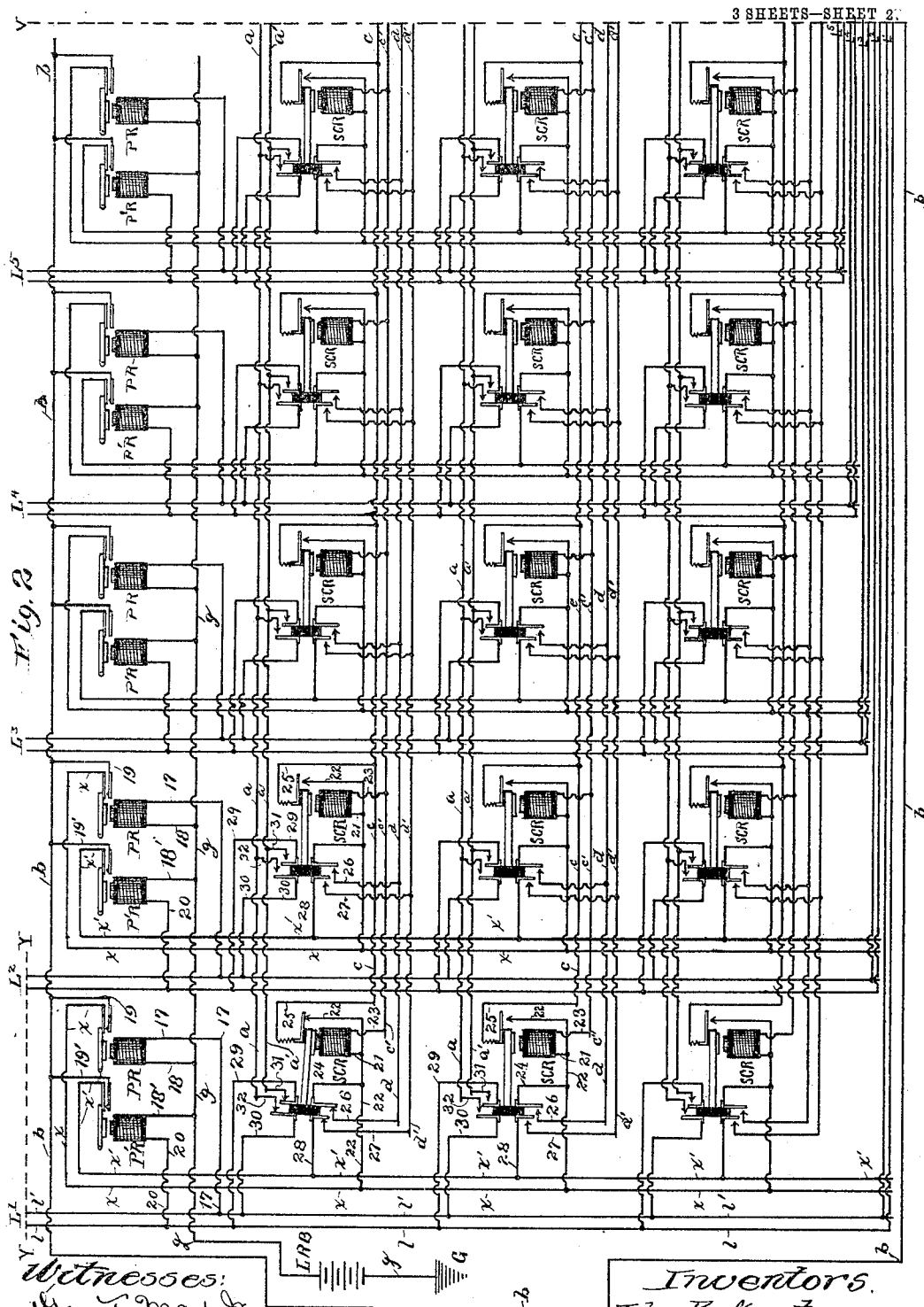
Inventors:
John K. Norstrom.
Henry M. Graif.
By J. J. Bain, Atty.

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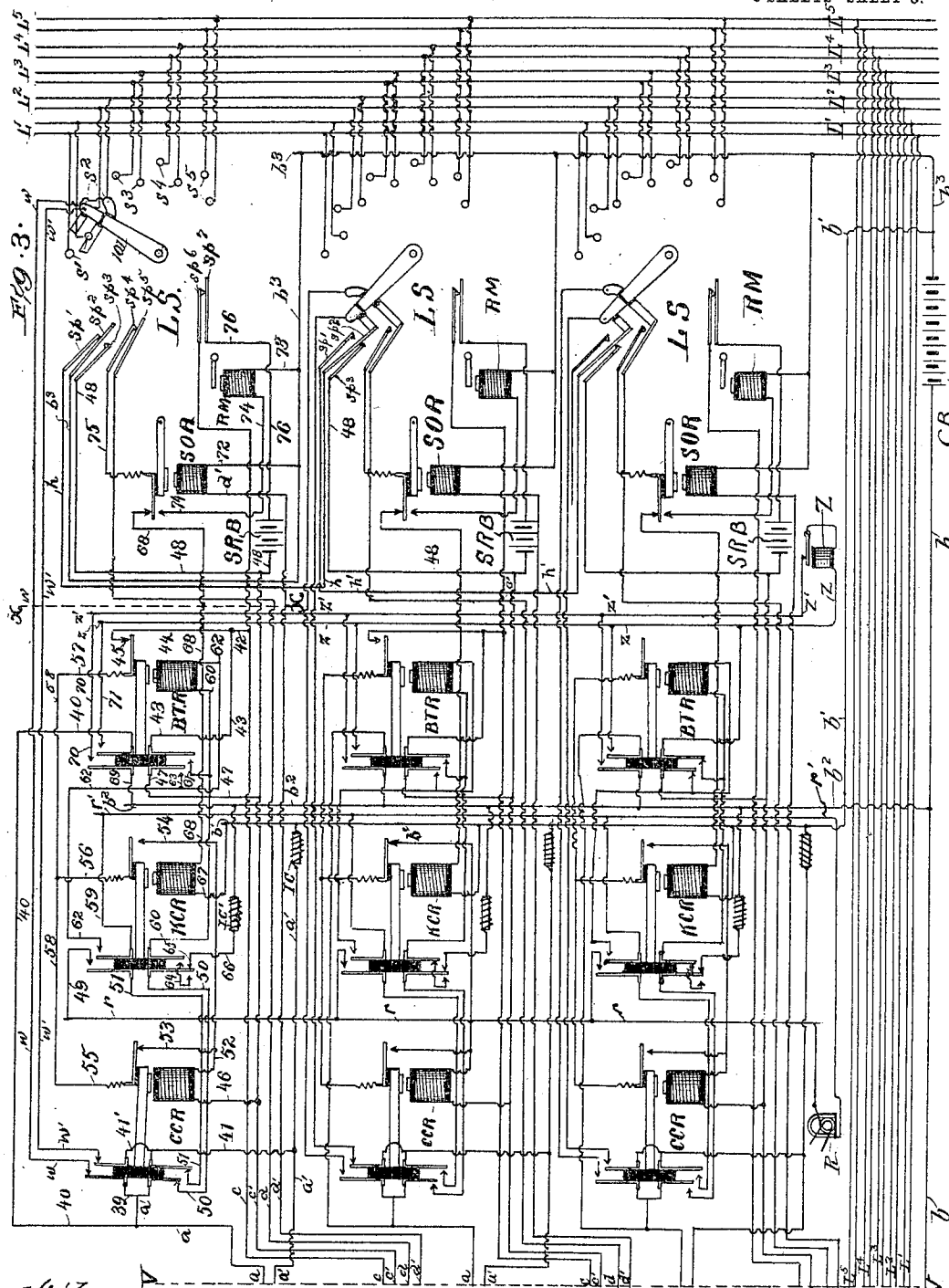
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3 SHEETS—SHEET 3.



Witnesses:
Ray White.
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UNITED STATES PATENT OFFICE.

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ASSIGNORS TO AUTOMATIC TELEPHONE COMPANY, OF CHICAGO,
ILLINOIS, A CORPORATION OF ILLINOIS.

AUTOMATIC-TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 784,498, dated March 7, 1905.

Application filed May 18, 1903. Renewed July 5, 1904. Serial No. 215,398.

To all whom it may concern:

Be it known that we, JOHN K. NORSTROM and HENRY M. GRAIF, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Automatic-Telephone-Exchange Systems; and we hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, which form part of this specification.

Our invention relates to automatic-telephone-exchange systems wherein the various functions of a telephone-exchange incident to the operation of connecting for intercommunication the lines of two subscribers are automatically performed.

One of the objects of our invention is to provide a system wherein for a switchboard accommodating a given number of subscribers—say one hundred—a relatively small number of line-selecting switches—say ten—may be employed and to so arrange the switches with reference to auxiliary devices and the lines that any switch may be controlled and actuated from any line.

A further object of our invention is to so arrange the switches and auxiliary devices relative to the lines of the subscribers that at any time any subscriber can control only the first idle or inactive switch and that when any switch is in service for one subscriber said switch is positively removed from the control of any other subscriber, the first then idle switch, however, being automatically brought within the control of the other subscribers.

A further object of our invention is to provide a system wherein the actuating mechanisms of the various devices are placed in circuits auxiliary to the talking-circuit, so that said talking-circuit when established between two subscribers' stations contains no local resistances, such as relay-coils or other impeding devices, in series in said circuit within the exchange.

Numerous other desiderata of automatic-exchange telephony are accomplished in the use of our invention which one will not here seek to enumerate, but which will become appar-

ent to those skilled in the art from the disclosure made in the following specification and claims and the accompanying drawings.

In the drawings, wherein we have illustrated our invention as applied to a central-energy telephone-exchange, Figure 1 is a diagrammatic illustration of the stations of two subscribers, the line-wires of said subscribers being so related that when the intersection-line Y Y of said figure is coincidently superposed on line Y Y of Fig. 2 said wires form connections with the corresponding wires intersected by line Y Y of Fig. 2. Figs. 2 and 3 are continuing views diagrammatically illustrating the central mechanism of an automatic-exchange system, it being understood that the wires intersected by the broken line V V of Fig. 2 are continued from the corresponding points intersected by the line V V of Fig. 3. Fig. 4 is an enlarged detail of the switch mechanism diagrammatically illustrated in Fig. 3, the wiring of Fig. 4 being so arranged that it corresponds with that of Fig. 3 when superposed upon Fig. 3 with the dotted lines X X of the respective figures coincidentally placed.

Referring now first to Fig. 1, station No. 1 and station No. 2 are illustrated as equipped with apparatus similar in every respect, so that it will be necessary only to describe a single station, it being understood that the equipment is duplicated at every other station. At station No. 1, 5 indicates a receiver-hook; 6, a receiver; 7, a transmitter; 8, a polarized bell, and 9, 10, and 11 represent three circuit-changing keys suitably associated with the subscriber's set. These keys we will for convenient reference arbitrarily designate as follows: 9 the primary-impulse key, 10 the switch-operating key, and 11 the connecting-key. The three keys are illustrated as simple circuit-changing keys, each having a spring-leaf arranged to play between an upper and a lower contact and each normally closing a circuit through its upper contact. In practice of course other mechanism may be employed; but we prefer to herein illustrate our invention in its simplest as-

pect. The subscribers' line-wires l and l' are respectively connected to the keys 10 and 9. The lower contacts of all three keys are connected to earth, as by taps 9', 10', and 11', respectively, to a common ground-wire 12.

The key 11 is connected to the upper contact of key 9 by wire 11', so that when said key 9 is in normal position the key 11 is connected to the line-wire l' .

The telephone devices are wired as follows: From the upper hook-contact extends the wire 13, including in its circuit the primary p of an induction-coil and the transmitter 7 and terminating in the upper contact-point of the key 11. A tap 14, taken from said wire 13, includes the polarized bell 8 and terminates in the lower hook-contact. The hook is permanently connected by wire 16 with the upper contact of key 10. The receiver 6 is included in a closed circuit 6', also including the secondary p' of the induction-coil inductively associated with the primary p of said coil. 15 indicates a tap from wire 13, extending to a second lower contact of key 11 and preferably including in its circuit a resistance 15'.

It will be apparent that with the arrangement described when the receiver is upon the hook, as illustrated at station No. 2, the bell is cut into the line-circuit and the transmitter excluded from said circuit and that when the receiver is removed from the hook, as illustrated at station No. 1, the bell is cut out of circuit and the transmitter 7 included therein. It will also be apparent that the depression of any one of the three keys 9, 10, or 11 grounds the line on one side or the other and cuts out all of the telephone instruments.

Referring now to Figs. 2 and 3, which illustrate the apparatus employed at the central station for automatically connecting the lines of any two subscribers for communication upon the proper actuation of the devices at the station of the calling subscriber, the incoming pairs of lines are indicated at $L^1 L^2 L^3$, &c., to correspond with their respective stations Nos. 1, 2, 3, &c.

We have chosen to illustrate our invention as embodied in a switchboard equipped for five subscribers; but it will be apparent that it might be extended to include any desired number of subscribers. The incoming lines are all brought upon the switchboard and are wired in multiple to corresponding pairs of contact-points (indicated by $S^1 S^2 S^3$, &c.) of a suitable number of line-selecting switches $L S$, herein illustrated as three in number. In practice it will be understood that any number of switches equal to or less than the total number of subscribers to be accommodated upon the exchange may be employed, our preference being to employ ten switches to serve each group of one hundred subscribers.

In the general arrangement of our exchange

it is our plan to employ in conjunction with each switch a group of relays to perform functions which will be hereinafter described, one group being provided for each switch, as illustrated in Fig. 3. Further, associated with each switch is a series of relays, (shown in Fig. 2,) which we will arbitrarily designate "switch-controlling" relays, equal in number to the number of lines accommodated in the exchange, all of the relays in a series being connected in multiple with the common switch and corresponding relays of the several series being connected in multiple with the corresponding subscribers' lines to form what we term "subscribers' sets" of relays, one set for each subscriber. This arrangement may be clearly seen by reference to Fig. 2, wherein the switch-controlling relays $S C R$ in any transverse line form a series associated with one of the line-selecting switches $L S$ of Fig. 3, while the vertically-aligning relays $S C R$ form sets operatively connected with the corresponding subscribers' lines $L^1 L^2$, &c. Further, associated with each subscriber's line-circuit are certain primary relays, each bridged from one side of the line to a ground-return, which act as circuit-closers for various operating-circuits, as will be disclosed, a proper complement of such primary relays being provided for and operatively associated with each subscriber's line.

It will be understood that the equipment of each subscriber's line as to its complement of primary relays, its set of switch-controlling relays, and its wiring to each switch is identical and that the equipment of every line-selecting switch $L S$, with its accompanying group of auxiliary relays and its series of the aforesaid switch-controlling relays, is identical with that of every other switch except in such particulars as may be specifically pointed out. Hence the description of one line with reference to its associated devices will suffice as description of every line, and, similarly, the description of one switch and its associated devices will suffice as a general description of all of the switches.

In the drawings the parts are illustrated in the condition assumed when subscriber No. 1, desiring to call subscriber No. 2, has taken the preliminary steps necessary to secure the connection of his line with the line of said subscriber No. 2 and has rung up said subscriber No. 2, the receiver of station No. 1 being illustrated as off its hook and proper relays of the central exchange being illustrated in the closed or active position assumed to secure the connection of station No. 1 with station No. 2.

Referring now to Fig. 2, it will be seen that with each incoming subscriber's line is associated a pair of primary relays, respectively indicated as $P R$ and $P' R$ and a set of switch-controlling $S C R$, the number of switch-con

trolling relays corresponding with the number of line-selecting switches employed in the exchange.

In Fig. 2 it will be noted that all of the primary relays upon the board are connected to a common wire g , including in its circuit a common local relay-battery L R B, and thence extending to ground at G. Further, it will be noted that one of the contact-points of each primary relay is connected to the central-battery wire b , which, as shown in Fig. 3, is connected with the central battery C B. The relay P R of each subscriber has its other contact-point connected with the wire x , which said wire has certain connections, to be hereinafter described, with each of the switch-controlling relays of the particular subscriber's set, while the other contact-point of relay P' R has a similar connection with the companion wire x' , likewise common to all the relays of a subscriber's set. The relays P R and P' R are preferably identical in construction, each preferably comprising simply an electromagnet the movement of whose armature serves to bring into contact two normally open or separated contact-springs. In detail the connections of these two relays are as follows: One terminal of the spool of relay P R is tapped by wire 17 to line-wire l' , and its other terminal is tapped by wire 18 to the wire g . One spring of the normally separated contact-springs is directly connected with wire x , while the other is tapped, as indicated at 19, to the battery-wire b . The relay P' R also has one terminal of its spool tapped by wire 18' to the wire g , its opposite spool-terminal being connected by wire 20 with the side l of the incoming line. One of the contact-springs of relay P' R is tapped by wire 19' to the common battery-wire b , and its other spring has direct connection with the wire x' . Ground-return circuits may be established through the sides of the lines to include the spools of the respective relays, as will be hereinafter fully described.

Referring now to the wiring of the switch-controlling relays S C R, it will be noted that all of the relays of a subscriber's set have similar contact connections with the sides l and l' of the line of the subscriber and with the companion wires of the auxiliary circuits x and x' . Further, certain of the contact and spool connections of each relay in a series corresponding with a switch are made to three pairs of wires common to the series and indicated as $a a'$, $c c'$, and $d d'$, the connections whereof will be hereinafter traced.

Referring now to the construction of the switch-controlling relays illustrated, it will be seen that each relay comprises an electromagnet whose armature is carried upon the extended leg of a T-shaped pivoted member. Five contact-springs adapted for cooperation with corresponding contact-points are carried by the armature-carrying member, one such

spring being carried by the extended leg, and the remaining four springs being arranged one on each side of each end of the cross-head of the armature-carrying member. The armature is so arranged that when in its normal or unattracted position all of its contacts are open.

To simplify the drawings and description, it is believed unnecessary to number each of the contact-springs; but said springs will be referred to by their relative positions, the cross-head springs being spoken of as "upper" and "lower," "right" and "left" springs, and the single springs upon the extended legs of the armature-carriers being referred to as the "end" springs. The contact-points will be correspondingly designated.

To describe now the wiring of the switch-controlling relays: One terminal of each spool is tapped at 21 to a wire 22, which is tapped to the auxiliary line x of a subscriber's set of relays. The opposite terminal of the spool is tapped by wire 23 to the wire c' , common to a series of the relays. The wire 22 is likewise tapped by wire 24 to the lower right contact-spring of the relay and has a connection to the end contact-point of the relay. The end contact-spring is tapped by wire 25 to the wire c , common to a series of relays. The lower right contact-point is tapped by wire 26 to the wire d of a relay series. The lower left contact-point is similarly tapped by wire 27 to the wire d' of the relay series. The lower left spring is tapped by wire 28 to the auxiliary wire x' . The upper right and left contact-springs are tapped by wires 29 and 30, respectively, to the line-wires l and l' , respectively. The coacting contact-points, upper right and left, respectively, are tapped by wires 31 and 32, respectively, to the wires a' and a , respectively, common to a relay series. These wires $a a'$ we will hereinafter refer to as "connecting-wires," as, together with another pair on continuing wires, they subserve practically the functions of the cord wires of a manual exchange.

Referring now to Fig. 3, it will be seen that with each line-selecting switch L S is associated a group of three relays, similar in their general construction to the switch-controlling relays and which for purposes of convenient identification we will arbitrarily designate for reference as the "circuit-closing" relay C C R, the "key-controlled" relay K C R, and the "busy-test" relay B T R. Further, each switch has an operating-relay proper, S O R, having a spring on its armature normally contacting with the upper one of two associated contact-points, and a releasing-magnet R M, movement of whose armature actuates a mechanical switch-releasing device to be described. Each switch also has in the operative relation thereto (best shown in Fig. 4) a set of three circuit-changing springs, indicated, respectively, by the numerals sp^1 , sp^2 , sp^3

and sp^3 .) a pair of circuit-making spring sp^4 and sp^5 , and a pair of circuit-breaking springs sp^6 and sp^7 . A power-driven ringing-generator for the entire exchange is indicated at R, and a busy-test buzzer or vibrator of an ordinary type, likewise for the entire exchange, is illustrated at Z. C B represent a central battery common to the whole exchange, while local batteries, one for each switch, are indicated at S R B and will be hereinafter arbitrarily designated "switch-relay" batteries.

Referring now to the general plan of wiring, it will be seen that the pairs of wires $a a'$, $c c'$, and $d d'$ of the several relay series are led into proper connection with devices of the corresponding switches, such connections being hereinafter fully described. The corresponding relays of the several groups are quite independent of each other; but the several relays of each group are similarly wired relative to each other. Certain common connections for the several groups of relays and switches are, however, provided, the following-named wires being common to all the switches and their associate devices in the exchange.

b^3 indicates a battery-wire connected to the terminal of central battery C B opposite that to which the battery-wire b is connected. b' indicates another battery-wire tapped to wire b^3 , while b^2 indicates a battery-wire common to relays of the several groups tapped to wire b . r and r' represent wires connected with opposite terminals of the ringing-generator R and having taps to like contacts of corresponding relays of the several groups, while z and z' indicate wires connected with the terminals of the buzzer Z and likewise tapped to contacts of corresponding relays of the several groups.

To take up now in detail the wiring of a single group of relays associated with a switch and the other mechanism of such switch, we will first trace the six wires $a a'$, $c c'$, and $d d'$. The wire a is connected by a suitable split tap 39 to both the upper and lower left springs of the circuit-closing relay C C R and is also tapped by wire 40 to the upper right spring of the busy-test relay B T R. The wire a' is tapped by wire 41 to a common connection 41' between the right upper and lower springs of the circuit-closing relay C C R and from the point of said tap extends through an impedance-coil I C to tap the wire b' , connected to the battery, as heretofore specified. The wire c is tapped by wire 42 to the busy-test relay B T R, the tap being split and one branch, 43, connected with the lower right spring of said relay, while the other branch, 44, terminates in the end contact-point 45 of the busy-test relay. It will be noted, however, that the end contact-point 45 is so disposed relative to its spring that it contacts with said spring when the relay is deenergized. In this point alone the busy-test relay differs in mechanical construction from the switch-control-

ling relays. From the point where the tap 42 is taken the wire c extends to and terminates in the circuit-closing spring sp^6 . The wire c' is tapped at 46 to one terminal of the spool of the circuit-closing relay C C R. Again, it is tapped by wire 47 to the lower left spring of the busy-test relay B T R. From the last-mentioned tap it extends to and is connected with the wire 48, which forms the connection between one terminal of the switch-relay battery S R B and the lower circuit-changing spring sp^3 . The wire d is direct-connected to the lower spring sp^5 of the pair of circuit-making springs. The wire d' is direct-connected with one terminal of the spool of switch-operating relay S O R.

Referring now to the circuit-closing relay C C R, the upper pair of contact-points are connected by wiper-wires w and w' , which in operation are complementary to the connecting-wires $a a'$, to the two wipers or contact-springs of the operating-arm 101 of the line-selecting switch L S. The lower left and right contact-points are connected, respectively, by wires 50 and 51 with the left lower and upper springs of the key-controlled relay K C R. The spool-terminal of the circuit-closing relay opposite that connected by wire 46 with line c' is connected to wire 52, from which taps 53 and 54 respectively extend to the end contact-points of the circuit-closing and key-controlled relays. The end contact-springs of the three relays C C R, K C R, and B T R are all connected together, being respectively tapped by wires 55, 56, and 57 to a common connecting-wire 58.

Examining now the connections of the key-controlled relay K C R, not heretofore stated, the right upper spring is tapped by wire 59 to the ringer-wire r' . The lower right spring forms a terminal for wire 60, which extends thence to one terminal of the spool of the busy-test relay B T R and is tapped at 61 to the lower right contact-point of said relay. The upper right point of relay K C R forms a terminal of wire 62, connected with the other terminal of the spool of busy-test relay B T R, said wire being tapped by wire 63 to the lower left contact-point of said busy-test relay. The two usual lower contacts for the lower right and left springs of the key-controlled relay K C R are connected together by wire 64. In addition to these usual contact-points an additional contact-point 65, arranged for contact with the lower left spring when the relay is deenergized, is provided. A wire 66, terminating at one end in said contact-point 65, includes an impedance-coil I C' and is tapped to the battery-wire b^2 . One terminal of the spool of the key-controlled relay K C R is tapped at 67 to the battery-wire b' , and its other terminal is connected by wire 68 with the upper contact-point associated with the spring carried by the armature of switch-operating relay S O R.

Referring now to the busy-test relay B T R, its upper left spring is connected by wire 69 with the battery-wire b^2 . Its upper right spring is tapped by wire 40 to the connecting-wire a , as heretofore described. The coacting contact-points are tapped by wires 70 and 71, respectively, to "buzzer-wires" z' and z of the buzzer Z. The remaining connections of the busy-test relay have been heretofore described.

Referring now to the connections of the switch mechanism proper, which may be best seen in Fig. 4, the terminal of the operating-spool opposite that connected to wire d' is tapped by wire 72 to the battery-wire b^3 , which, as heretofore stated, extends to the circuit-changing spring sp^2 . One side of the spool of the releasing-magnet R M is tapped by wire 73 to the aforesaid battery-wire b^3 , and the other spool-terminal is wired, as indicated at 74, to the lower contact-point of the armature-carrying lever of the switch-operating relay. The contact-spring of said switch-operating relay S O R is connected by wire 75 to the circuit-closing spring sp^4 . The terminal of the switch-relay battery S R B opposite that to which wire 48 is connected, as heretofore described, is connected with the lower circuit-breaking spring sp^7 by wire 76. The upper circuit-changing spring sp^1 is connected by wire h with the middle spring sp^2 of the circuit-changing group of the next succeeding switch, while the upper spring sp^1 of said second group is similarly connected by wire h' with the middle spring sp^2 of the circuit-changing group of the third switch, and so on, it being understood that a battery-wire b^3 is connected to the central movable spring sp^2 of a circuit-changing set for one switch and the upper spring sp^1 of said group for each switch being wired to the spring sp^2 of the group of the next succeeding switch throughout the entire exchange.

For purposes of illustration we have herein shown a simple form of switch which might be used in the practice of our invention, and the mechanical arrangement of said switch we will now describe.

Referring particularly to Fig. 4, 101 indicates a rotary switch-arm mounted upon a rotatable shaft 102. Said shaft likewise carries a ratchet 103 and is connected with a spring 104, arranged to exert a pressure upon the shaft, tending to hold it in the inactive position illustrated in Fig. 4. The switch-arm 101 is provided with two contact-springs or wipers 105 and 105', adapted when the arm is moved to sweep over the corresponding pairs of contact-points s' s^2 , &c., into which the incoming subscribers' lines are led, as heretofore described. The switch-arm is also provided with two insulated projections 106 and 107, adapted when the switch is in inactive position to respectively engage the springs sp^2 and sp^5 . The spring sp^2 is held by

its projection 106 in contact with the lower spring sp^3 of the circuit-changing set, but is so arranged that when released by the movement of the switch-arm it springs into contact with the uppermost spring sp^1 of the circuit-changing set. The insulated projection 107 serves to hold the spring sp^5 out of contact with the spring sp^4 , such contact being made as soon as the switch-arm is moved. 108 indicates the armature of the switch-operating relay S O R, mounted upon one end of a pivoted lever 109, the opposite end of which extends into proximity to the ratchet 103. 110 indicates a pawl pivoted on the free extremity of the lever 109 and normally held by a spring 111 in engagement with the ratchet 103. 112 indicates a pin or finger projecting from the pawl 110, so that when struck upward it will throw the pawl out of engagement with the ratchet 103. It will be apparent now that whenever the spool of the switch-operating relay is energized to attract its armature the ratchet-and-pawl connection will serve to rotate the shaft forward a distance corresponding with one tooth of the ratchet. The parts are so proportioned that this movement also just suffices to bring the wipers 105 and 105' into contact with the corresponding terminals of the next preceding line, one movement of the lever serving to make connection between the wipers and the contacts s' , two movements to move the wipers into contact with termini s^2 , &c.

The holding and releasing means may be arranged as follows: 113 indicates a dog pivoted at 114 and provided, as at 115, with a tooth adapted to engage the ratchet to prevent its return to inactive position under the tension of its spring 104. A spring 116 serves to maintain the dog in operative or holding position. 117 indicates a lug projecting from the dog 113 and normally lying immediately below the projection 112 from a pawl 110. 118 indicates a pin projecting from the dog on the same side of the pivot as the tooth 115. 119 indicates a pivoted lever at one end carrying the armature of the release-magnet R M and at its other end carrying a pivoted releasing-arm 120. The arm 120 extends up beside and overlies the dog 113, its front edge normally resting in contact with the pin 118, carried by said dog, and a finger 125, projecting from the switch-arm. A spring 121, connected to a hook 122 of the arm 120, projecting on one side of its pivot-point, serves to both hold the arm normally down in contact with the stop 122' and to maintain its bearing with a constant pressure against the stud 118. Notches 123 and 124 are provided on the side of the arm 120, said notches being so arranged that when said arm 120 is elevated and moved inward the pin 118 of the dog and the end of the circuit-breaking spring sp^7 respectively rest therein.

The operation of the release mechanism so

arranged will be as follows: When the spool of the magnet R M is energized to attract the armature carried by lever 119, the arm 120 will be raised. If now the switch-arm 101 be in advanced position, so that the finger 125 is removed from the path of the arm 120, the last said arm will be moved inward by the tension of its spring 121, so that its notches 123 and 124 respectively engage the pin 118 and the end of the spring sp^7 . When now the magnet is deenergized, the spring 121 pulls down the arm 120, holding it constantly, however, toward the engaged stud and spring and pulling with it the said instrumentalities. Consequently any circuit established through springs sp^7 and sp^6 will be broken, and the dog 113 will be moved so that its tooth 115 is disengaged from the ratchet 103. At the same time projection 117 of the dog strikes the projection 112 of the pawl 110, throwing the pawl out of connection with the ratchet. The ratchet being now entirely freed, the shaft rotates to return the arm 101 to its normal position under tension of the spring 104. When the arm 101 reaches its normal or inactive position, its finger 125 strikes the arm 120 of the release mechanism and moves it to the right against the tension of its spring, thereby releasing the stud 118 of the dog 113 and spring sp^7 from the engaging notches in the arm 120 of the release mechanism. At the same time the projection 117 of the dog is removed from the path of the projection 112 of the pawl, allowing the pawl to return under tension of its spring 111 into engagement with the ratchet. The parts are now restored to their initial position, as illustrated in Fig. 4.

Having thus described minutely the present illustrative embodiment of our invention, we will now describe the operation of the system. Assuming that the subscriber at station No. 1 is desirous of calling subscriber No. 2, his actions and their results will be as follows: The removal of the receiver 6 from the hook 5, as indicated at station No. 1 in Fig. 1, cuts the bell 8 out of the line and the telephone instruments into operative connection with the two line-wires, the circuits therethrough being traced in through line-wire l' , key 9, wire 11" to key 11, thence by wire 13 to the transmitter 7, through the primary p of the induction-coil to the receiver-hook 5, and thence by wire 16 and key 10 back to the line-wire l . Now the primary impulse-key 9 is depressed by the calling-subscriber, grounding the side of the line l' through the wire 12. A circuit is thereby completed, which we may trace from the ground in Fig. 1 through the primary impulse-key 9 to the wire l' , thence, in Fig. 2, by wire 17 to the spool of primary relay P R, back from the spool of said relay by wire 18 to the wire g , and by said wire through the local battery L R B to ground. It will be noted that the above circuit includes

the spool of the primary relay P R, the armature of which is accordingly attracted, closing its associated contact-springs. This establishes a circuit which may be traced from the lower spring of primary relay P R through wire 19 to the battery-wire b , which, it will be remembered, connects with left end of the central battery C B (shown in Fig. 3) and, on the other hand, extending from the upper spring of the relay P R by wire w and wires 22 and 21 to the spool of the first switch-controlling relay S C R of the first subscriber's set, thence from the other terminal of the spool by tap 23 to wire c' , continuing, on Fig. 3, past taps 46 and 47 to the wire 48, thence upward to the lower spring sp^3 of the circuit-changing set, which (it being assumed that the uppermost switch L S is not in use) contacts with spring sp^2 and from the latter spring by battery-wire b^3 to the right terminal of the central battery C B. Thus it will be seen that a closed circuit is established which includes the central battery C B and the spool of the first switch-controlling relay S C R. The armature of said relay S C R is accordingly attracted to the position illustrated in Fig. 2, and a local circuit, including the spool, is established to hold the armature indefinitely in closed or active position. The local circuit is traced as follows: from the end contact-point of the relay by wires 22 and 21 to the spool, thence by wire 23 to the series wire c' , thence continuing on, in Fig. 3, to the wire 48, connected to the left side of the local switch-relay battery S R B. On the other hand, the circuit extends from the end spring of the relay by wire 25 to series wire c , thence, in Fig. 3, along to the spring sp^6 , which is closed upon spring sp^7 , and thence by wire 76 to the right terminal of the switch-relay battery S R B, completing the closed local circuit. It will be noted that as long as the subscriber maintains the primary impulse-key 9 in closed position the spool of the switch-controlling relay S C R will be energized both by the central battery C B and the local battery S R B. It is necessary, therefore, that the wires 48 and b^3 be connected to like terminals of the two batteries to prevent the occurrence of a short circuit. It will be understood, however, that the primary impulse-key 9 need be closed only momentarily to send a single impulse through the primary relay P R and may be then released. The switch-operating key 10 is now depressed by the calling subscriber a number of times corresponding with the number of the subscriber whom he desires to call, in the present instance two movements of the key being necessary to call subscriber No. 2. Upon each depression of the key 10 a circuit is established through the primary relay P R as follows: from the ground, in Fig. 1, by wire 12 and tap 10' to key 10, thence to the line-wire l , continuing on, Fig. 2, by the tap 20 to the one side of the spool

of relay P' R, thence by wire 18 to wire *g*, through the local battery L R B, and to ground again. Consequently the armature of relay P' R will be now attracted to close its contact-springs as many times as the switch-operating key 10 is depressed. With each movement of the armature of said relay P' R a circuit is closed through the spool of the switch-operating relay S O R as follows: beginning at the upper spring of the contact pair of the relay P' R by wire *a'* and tap 28 to the lower left spring of the switch-controlling relay S C R, (which, it will be remembered, is being maintained in active position,) thence by tap 27 to wire *d'*, which continuing (in Fig. 3) extends direct to the spool of the relay S O R, thence back by wire 72 and battery-wire *b'* to the right side of central battery C B, and, on the other hand, from the lower contact-spring of the primary relay P' R by tap 19' to the battery-wire *b*, connecting with the opposite terminal of central battery C B. It will thus be apparent that the spool of the switch-operating relay S O R will be energized and deenergized as many times as the switch-operating key 10 of the subscriber's station may be depressed.

Referring now to Fig. 4, it will be apparent and it has heretofore been explained that each impulse sent through the spool of the switch-operating relay causes the wiper-carrying arm 101 to be advanced over one pair of terminal contact-points of the subscribers' lines. Thus two impulses transmitted through said spool bring the wipers in contact with the terminals *s*² of the line L² coming in from the station of subscriber No. 2. In Fig. 3 the wiper-arm is illustrated in such position. The movement of the arm 101, as heretofore stated, releases the spring *sp*², which leaves its lower spring *sp*³ and contacts with spring *sp*¹ for a purpose to be described. It will be noted now that the line-wires *l*¹ of subscriber No. 1 are connected, respectively, by taps 29 and 30 to connecting-wires *a'* and *a*, which, as shown in Fig. 3, are led in by taps 41 and 39, respectively, to the right upper and lower and left upper and lower springs of the circuit-closing relay C C R. It will also be noted that the wipers of a switch-arm are connected by "wiper-wires" *w* and *w'* to the upper left and right contact-points of said circuit-closing relay C C R. As no circuit has yet been established through the spool of said relay C C R, however, the lines of the subscribers 1 and 2 are not yet connected, but are open at that point. A single operation upon the part of subscriber No. 1 now secures for him the connection of the two lines and either rings subscriber No. 2 or, if the latter subscriber's line be busy, gives the calling subscriber No. 1 the busy signal and disconnects his line from the line already busy. The results enumerated follow the depression of the connecting-key 11, which closes a local circuit

through the primary relay P R as follows: from the ground by wire 12 through the connecting-key 11, wire 11'', and key 9, to the line-wire *l*¹, thence by tap 17 to the coil of relay P R, back by tap 18 to the ground-wire *g*, and thence through the local battery L R B to ground at G. As long as the said connecting-key 11 is maintained closed the armature of the primary relay P R maintains connection between the springs of said relay, establishing the following circuit: from the lower contact-spring of relay P R by wire 19 to the battery-wire *b*, connected to the left-hand side of the central battery C B, and, on the other hand, extending from the upper spring of the pair of relay P R by wire *a* and taps 22 and 24 to the lower right spring of the switch-controlling relay, thence by tap 26 to wire *d*, thence direct to spring *sp*⁵ on to the upper spring *sp*⁴, thence by wire 75 to the spring of the switch-operating relay S O R, (which is now deenergized,) and from said spring by wire 68, through the spool of key-controlled relay K C R; thence by tap 67 to the battery-wire *b'*, which connects with the right terminal of the central battery C B. Accordingly the relay K C R is energized, attracting its armature and closing its various contacts. It will be apparent, however, that the relay K C R remains energized only while the key 11 is held depressed. The closing of the key-controlled relay K C R primarily serves to close a circuit through the spool of circuit-closing relay C C R, such circuit being traced as follows: on the one hand, from the end spring of the relay K C R by wires 56 and 58 to end spring of relay B T R, end spring-contact 45, wire 44, and tap 42 to the wire *c*, through the springs *sp*⁶ and *sp*⁷ and wire 76 to the right end of the battery S R B, and, on the other hand, from the end contact-point of relay K C R, tap 54, wire 52, to the spool of relay C C R, thence from the other side of the spool by tap 46, wire *c'*, and wire 48 to the left end of battery S R B. The armature of relay C C R is accordingly attracted and is held in such position irrespective of the key-controlled relay by the closing of the end spring of the relay C C R upon its point, giving a connection (through wires 55 and 53) between wires 58 and 52 of the circuit last traced parallel with the connection between such circuit-wires 58 and 52 established by the key-controlled relay through wires 54 and 56. The closing of the circuit-closing relay serves, primarily, to establish a direct connection between the lines of the calling and called subscribers, including no local resistances, such as relay-coils or like impedances, within the line-circuit in the exchange. Further, the closing of said relay serves to bridge the ringer, "buzzer," and central-battery wires onto the connected lines, so that upon the closing of circuit through any one of said instrumentalities it is enabled to perform its

functions. The ringing and "busy-signal-
 ing" devices are first brought into operation
 only if both the key-controlled relay K C R
 and circuit-closing relay are simultaneously
 5 closed, while the central battery is bridged
 onto the connected lines only when the relay
 K C R is deenergized. We will first trace the
 line-circuit through from station to station,
 presuming that the station instruments are in
 10 the conditions illustrated in Fig. 1 of the
 drawings. Commencing now with the hook
 5 at station 1: by wire 13, including primary
 p of the induction-coil, and transmitter 7 to
 the upper contact of the connecting-key 11,
 15 thence through the key 11, wire 11'', and key
 9 to the line-wire l' , continuing, Fig. 2, to the
 energized switch-controlling relay by tap 30
 to the upper left spring thereof, thence by tap
 32 to connecting-wire a , continuing, Fig. 3, to
 20 the circuit-closing relay C C R, through tap 39
 and upper left spring, thence by complement-
 ary connecting-wire w to the wiper, and on to
 the terminal of line L^2 , corresponding with
 line-wire l' , thence (returning) through wire l'
 25 of pair L^2 in Fig. 2 up to station 2 in Fig. 1, in
 through the key 9, wire 11'', key 11, wire 13,
 and tap 14, including the bell 8, to the re-
 ceiver-hook 5, out over wire 16 and key 10 to
 line l , returning to the corresponding termi-
 30 nal of the central switch, through the wiper
 to wire w' , onto upper right spring of the re-
 lay C C R, thence by taps 41' and 41 to the
 connecting-wire a' , back to the upper right
 spring of the energized switch-controlling re-
 35 lay S C R, and by tap 29 to line-wire l of line
 L' and in through key 10 and wire 16 of sta-
 tion No. 1 to the receiver-hook 5. Assuming
 now that the key 11 is, when depressed to en-
 40 ergize the key-controlled relay K C R, as here-
 tofore described, maintained in such position
 for a suitable time, the ringing-generator R
 is bridged upon the connected lines of sub-
 scribers 1 and 2 to ring the bell of subscriber
 2 and energizing the primary p of the induc-
 45 tion-coil and the transmitter of subscriber No.
 1, the circuit being as follows: from one ter-
 minal of the generator by wire r and tap 49 to
 the upper left spring of the key-controlled re-
 lay K C R, thence by wire 51 to the lower
 50 right spring of the circuit-closing relay C C R,
 which, it will be remembered, forms part of the
 connection of one side of the line of subscrib-
 ers 1 and 2. From the other terminal the cir-
 cuit is traced from the ringing-generator R,
 55 through wire r' , wire 59, to upper right spring
 of the key-controlled relay K C R, thence by
 wire 62 to the spool of the busy-test relay B
 T R, returning by wire 60 to the lower right
 60 spring of the key-controlled relay, thence by
 the connection 64 to the lower left spring, and
 thence by wire 50 to the lower left contact-
 point of the circuit-closing relay C C R and
 its corresponding contact-spring. As the last-
 65 mentioned spring is connected to the other
 side of the circuit of subscribers 1 and 2, it

will be seen that the ringer is bridged on the
 two lines, so that it transmits its impulses
 both ways. In tracing the foregoing circuit
 it will have been noticed that the spool of the
 busy-test relay B T R was included therein. 70
 It will be understood, however, that the said
 spool is so wound that its armature is not re-
 sponsive to the current supplied by the ring-
 ing-generator, which for purposes of illustra-
 tion we will say is designed to develop about 75
 one-tenth ampere, but that said armature is
 responsive to a heavier current of, say, one-
 fifth ampere. If the central battery be also
 designed to furnish a tenth ampere of current
 with the working resistance (which may by 80
 proper balancing of the lines be made uni-
 form for all subscribers' lines) it will be ap-
 parent that if a circuit be established to con-
 nect both the battery and the ringing-genera-
 tor to jointly supply current to the spool 85
 of the busy-test relay the latter will be en-
 ergized to attract its armature when the direc-
 tions of current from both sources coincide.
 Assuming now that line called—that is to say,
 the line of subscriber No. 2—is already busy, 90
 it is obvious that any circuit closed across the
 wiper-lines w and w' will receive the battery-
 current from the busy line. If now the key-con-
 trolled relay is actuated to bridge the ring-
 ing-generator across the connected lines of the sub- 95
 scribers by the circuit including the spool of
 the relay, as above described, it will be ap-
 parent that current from both the central bat-
 tery and the generator will pass through the
 spool of the busy-test relay. Consequently the 100
 battery-current of, say, one-tenth ampere is
 alternately reinforced and opposed by the im-
 pulses generated by the ringing-generator, so
 that a pulsating current of one-fifth ampere is
 developed in the relay-spool. Consequently 105
 with the first such impulses the armature of
 said relay is attracted, breaking the circuit-
 controlling relay-circuit as the end contact-
 spring of the relay leaves its point 45, and so
 by the restoration of the circuit-controlling 110
 relay to inactive position breaking the ring-
 ing-circuit. The busy-test relay is now main-
 tained closed by a local circuit, which may be
 traced from the spool of the relay B T R by
 wire 60 and tap 61 to lower right contact- 115
 spring, thence by wire 43 and tap 42 to wire
 c , thence through the circuit-making springs
 sp^6 and sp^7 to the right side of the local relay-
 battery S R B, returning by wire 48, wire c' ,
 tap 47, lower left spring of relay B T R, tap 120
 63, and down by wire 62 to the opposite side
 of the spool of relay B T R. It is well known
 that when an electromagnet is once energized
 to attract its armature but little current is
 required to retain the armature in attracted 125
 position, and the local battery need not be of
 great strength to accomplish this result. The
 actuation of the busy-test relay B T R in
 breaking the ringing-circuit by moving its end
 contact-spring from contact-point 45 also de- 130

destroys the connection between the two subscribers' connecting-lines, as it will be recalled that the local circuit maintaining the circuit-closing relay C C R in energized condition included therein said spring and point of the busy-test relay, so that said local circuit is broken by the actuation of the said busy-test relay. In addition to its circuit-breaking functions the busy-test relay also serves to bridge upon the line of the calling subscriber the "busy" vibrator or buzzer Z. The buzzer-circuit, it will be seen, is made direct through wire z on the one side to upper right spring of the busy-test relay B T R and thence by tap 40 to the wire a , while on the other side it includes line z' , upper left spring of the busy-test relay, tap 69, battery-wire b^2 , which is tapped to the battery-wire b , and thence through the central battery C B, returning by the opposing battery-wire b' up to the point where said wire is tapped by wire a' , thence through the impedance-coil I C, and returning along the wire a' . It will be remembered that the connecting-wires a and a' are connected at the switch-controlling relay S C R by taps 32 30 and 31 29, respectively, with the subscriber's line-wires l' and l , and it will therefore be apparent that a circuit including the central battery C B and the vibrator Z will be bridged upon the calling-subscriber's line. It may here be noted that when once the busy signal is started it continues indefinitely, irrespective of whether the line desired remains busy or not, until the calling subscriber takes proper steps to restore the whole system to normal condition, and the contact at point 45 of relay B T R remaining broken the calling subscriber is unable to actuate the circuit-closing relay C C R for any purpose.

Referring now for a moment to the ringing operation heretofore described, when the ringing-generator is bridged upon the connected lines of two subscribers it will be obvious that an arrangement whereby the calling subscriber is apprised of the fact that the called subscriber is being rung may be advantageously employed. We provide, therefore, a closed circuit through the calling-subscriber's line and the primary winding of his induction-coil in order that the alternating generator-current flowing therethrough may inductively occasion the magnet in his receiver to assume alternately opposite polarities, causing its diaphragm to vibrate with a series of clicks, assuring him that his line is working properly and the desired party is being called. It will be remembered that in ringing the connecting-key 11 is depressed, and with such understanding the circuit may be traced from the line l' , through the key 9, wire 11'', to connecting-key 11, thence to the second contact-point of said connecting-key, and by tap 15 through the resistance 15' (if included) and wire 13 to the transmitter and primary of the induction-coil to the upper hook-contact,

thence returning through the hook 5, wire 16, and key 10 to the line l . It is essential that in this circuit just traced there be considerable resistance, for reasons to be hereinafter stated, and the inclusion of the resistance 15' will only be necessary when the resistance of the transmitter 7 is insufficient for the purpose to be disclosed. Assuming now that the called subscriber is not busy, but that the ringing operation has been concluded and the key 11 released by subscriber No. 1, the system is in the condition illustrated in the drawings, the circuit-closing relay C C R being closed and the key-controlling relay K C R being open. Now it will be apparent that the central battery C B is bridged upon the connected-subscriber's lines, as in an ordinary central-energy exchange. The circuit in detail is as follows: starting from the left side of central battery C B, by battery-wire b and wire b^2 tapped thereto, through taps 66, including the impedance-coil I C', to lower left spring of relay K C R, thence by wire 50 to the lower left spring of relay C C R, and by tap 39 onto the side a of the pair of connecting-wires. On the other hand, starting from the right side of the battery, the circuit is traced by battery-wire b' direct to wire a' , the latter wire including the impedance-coil I C and forming part of the remaining side of the connecting pair of wires. Now to complete the talking-circuit it only remains for the subscriber at station No. 2 to remove his receiver from the hook, cutting his transmitter and induction-coil primary into circuit, as heretofore described.

It will be noted from the foregoing statement of operation that the line of the calling subscriber is not directly connected to the wipers of the switch until the operation of actuating the switch-arm to advance it to the terminal contact-points of the line of the subscriber desired to be called has been accomplished and the lines prepared for the final step of ringing the called subscriber or notifying the calling subscriber that the line desired is busy. Further, it will be noted that the operation of connecting the line of the calling subscriber with the wiper is performed by an instrumentality distinct from that employed in operating the switch. This arrangement results in many distinct advantages, as it is apparent that entire secrecy is insured any two subscribers engaged in conversation, as the now calling subscriber cannot have his line bridged upon the connected lines before he operates the connecting-key and as soon as his connecting-key is depressed he will get the busy-signal and the momentary connection of his connecting-wires with the wiper-wires will be broken. Further, such an arrangement obviates the possibility of calling subscriber by any improper manipulation of his actuating devices from bridging the ringing generator upon the wiper-line and then in ac-

tuating the switch, momentarily connecting said ringer with each of the lines over which its wiper-contacts travel.

When the connected subscribers have finished their conversation and it is desired to restore the switch and the other instrumentalities to their normal or inactive positions, the keys 9 and 11 are simultaneously depressed and both maintained closed for an instant. As a result circuits are established as follows: Both line-wires l and l' being grounded by the depression of the keys a ground return-circuit is established through each of the primary relays P R and P' R, as heretofore described. Consequently the contact-springs of relay P' R are brought together, establishing a circuit, which has heretofore been traced, through the central battery CB, the spool of the switch-operating relay S O R, and back by way of the lower left spring of the switch-controlling relay S C R and the auxiliary line x' . The armature of the switch-operating relay being attracted, its end spring is brought down into contact with the lower contact-point, and (the relay P R being energized and its contact-springs accordingly connected) the attraction of the armature of the switch-operating relay establishes a circuit which may be traced from the upper spring of the relay P R by the line x , through the lower right spring of the switch-controlling relay S C R by tap 26 to wire d , thence up to the lower spring sp^5 of the circuit-closing pair of the line-selecting switch, by wire 75 to the end spring of the switch-operating relay, lower contact, and wire 74, to the spool of the release-magnet, returning by tap 73 to the battery-wire b^3 , thence to the right end of the battery, and from the left terminal of the battery, by wire b and tap 19, to the lower spring of the primary relay P R. The release-magnet is accordingly energized, and the releasing-arm 120 is raised to operatively engage the stud 118 of the switch-arm-retaining dog 113 and the contact-making spring sp^7 , as heretofore described. When now the keys 9 and 10 are released, the release-magnet is deenergized and, as heretofore described, frees the switch-arm 101, so that it is enabled to return under tension of its spring 104 to inactive position while the circuit-breaking springs sp^6 and sp^7 are parted, so destroying the continuity of the local circuits serving to maintain the switch-controlling relay S C R and the circuit-closing relay C C R energized. Consequently all of the operating-circuits being now broken the parts are all restored to their normal or inactive positions, the return of the switch-arm serving, as heretofore described, to disengage the releasing-arm 120 from the dog and the spring and permitting the return of these mechanical instrumentalities to their normal position.

Reverting now to the description of the wiring of the stations whereby the calling subscriber is apprised of the fact that the ring-

ing operation is being successfully consummated, it will be noted that the connections are such that ground-circuits for both primary relay P R and P' R are established. The path from line-wire l' (with which relay P R is connected) to ground through key 11 has been fully traced; but it will be noted that during the time the connecting-key 11 is depressed the line-wire l (connected with relay P' R) is grounded through key 10, wire 16, hook 5, line 13, (including coil p and transmitter 7,) wire 15, (with resistance $15'$, if present,) key 11, wires 11' and 12 to ground. The last-described restoring operation does not follow from this connection, however, on account of the high resistance interposed between relay P' R and ground. The circuit just traced contains the transmitter 7 and coil p , which in most cases suffice to prevent the flow of sufficient current through relay P' R to attract the armature to said relay. Obviously, however, enough resistance may be included at $15'$ to prevent the possibility of the relay P' R becoming operatively energized, and so inopportunately working simultaneously with relay P R to restore the devices to inactive position.

The foregoing statement of operation is predicated on the assumption that the call is made and connection established on a switch-board whereon no lines are busy; but let us now assume that with lines L' and L^2 connected subscriber No. 3 desires to call subscriber No. 5. Of course the personal operations of subscriber 3 are just as described in connection with subscriber No. 1 and the relay P R of line L^3 is actuated. The relay S O R of the first or upper series cannot, however, respond, as the primary actuating-circuit of all of the relays in said series, it will be remembered, included a path across the springs sp^3 and sp^2 dependent upon the closed condition of the latter. The springs sp^3 and sp^2 of the first switch being parted when the switch is in use, as heretofore described, prevents positively the completion of an actuating-circuit for any relay of the first series. A corresponding primary actuating-circuit traced through the second series, however, shows the lower spring sp^3 to be closed on the middle spring sp^2 , which is connected through wire h , springs sp' and sp^2 of the first or upper switch with the battery-wire b^3 . Any one of the switch-controlling relays of a series, it will be remembered, controls both the energizing-circuit of the switch-operating relay of such switch and the connection of the calling subscriber's line with the connecting-wires a and a' of the series. Thus every subscriber when using a switch is protected against interference, the switch-controlling relays of the corresponding series being absolutely removed from the control of any other subscriber, while the series of switch-controlling relays corresponding with the first

then idle switch are automatically brought within the control of any other subscriber.

For purposes of a full disclosure of our invention we have illustrated and described in some detail an embodiment thereof which we deem suitable for illustration; but we do not desire to be understood as limiting ourselves to such disclosure in detail, as our invention contemplates a broad system susceptible of many variations in specific embodiment without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central group of line-selecting switches adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, switch-actuating means operatively associated with each switch, such means, for each switch, including a series of devices each adapted and arranged to control the corresponding switch, one of such devices in each series being operatively associated with each subscriber's line for control by the subscriber.

2. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central group of line-selecting switches, each adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, switch-actuating means, including a switch-circuit, and a series of switch-circuit-controlling devices, operatively associated with each switch, one of such circuit-controlling devices of each series being provided for and operatively associated with each subscriber's line, and means within the control of each subscriber for operating the switch-circuit-controlling devices associated with his line.

3. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central group of line-selecting switches each having terminal contact connections with all of the lines and each having also a movable member adapted to be brought into contact with the contact-terminals of any line, and adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, means, for each switch, for actuating the movable member thereof, and a series of devices associated with each switch adapted and arranged to control such actuating means, one such controlling device of each series being operatively associated with each subscriber's line for control from the subscriber's station.

4. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central group of line-selecting switches, each having terminal contact connections with all of the lines and each having also

a movable member adapted to be brought into contact with the contact-terminals of any line, means associated with each switch for actuating the movable member thereof including a circuit and a series of circuit-controlling devices, one device in the series for each switch being operatively associated with each subscriber's line for control from the subscriber's station and each device comprising circuit-closing means, and normally open circuit connections between the line of each subscriber and the movable contact member of each line-selecting switch, each of said open circuits being adapted and arranged to be closed by the circuit-closing means of the switch-controlling device of the corresponding subscriber's line included in the actuating means of the corresponding switch upon the actuation thereof, to connect any subscriber's line to the movable contact member of any switch.

5. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central group of line-selecting switches, each switch having a set of terminals to which all of the lines are respectively connected, and a contact member adapted to make contact with the terminals of any line, means for establishing connection between any two lines through said switch-contact member including series of switch-controlling relays, one series being operatively associated with each switch and each series having a relay operatively associated with each subscriber's line for control from the subscriber's station, and suitable circuits for the relays.

6. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central set of line-selecting switches, each switch having contact-terminals connected with each line and a movable contact member adapted to contact with the terminals of any line, and adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, means associated with each switch for actuating the moving contact member thereof, such means for each switch comprising a series of relays each adapted to control the corresponding switch, one of such relays in each series being associated with each subscriber's line for control by the subscriber, means for placing the relays of one switch normally within the control of all subscribers, and means for automatically removing the relays of each actuated switch from the control of any other than the actuating subscriber, and placing the relays of the first then idle switch within the control of such other subscribers.

7. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a central set of line-selecting switches, each having a series of contact-points forming terminals of all the subscribers' lines, and a movable contact member, means for actuating said contact member including an elec-

tric circuit, a series of switch-controlling relays for each switch, each relay being arranged and adapted to control the circuit of the actuating means of its switch, means within the control of each subscriber for actuating a switch-controlling relay of each series, and means for automatically removing the relays of the first-actuated switch from the control of any other than the actuating subscriber and placing within the control of such other subscribers the relays of the first then idle switch.

8. In an automatic-telephone-exchange system, the combination of the lines of the subscribers, a plurality of switches each adapted and arranged to be instrumental in connecting the lines of any two subscribers, means for actuating each switch, a series of relays for each switch, each relay being adapted and arranged to control the actuating means for its switch, one relay of each series being provided for and operatively associated with the line of each subscriber, a normally open circuit normally including one series of relays, means within the control of each subscriber for closing said circuit to render operable the switch-actuating means of the switch corresponding with said series, and means controlled by the switch, for cutting out of the normally open circuit the series of relays of the first-actuated switch, and cutting into said normally open circuit the relays of the first then idle switch.

9. In an automatic-telephone-exchange system, the combination with the lines of the subscribers, of a plurality of line-selecting switches, each adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, actuating means for each switch including a normally open circuit, a series of switch-controlling relays associated with each switch, each relay being adapted to close said actuating-circuit, and a relay of each series being provided for the line of each subscriber, and an auxiliary circuit including means within the control of each subscriber for energizing the subscriber's switch-controlling relay of the series of relays associated with any switch whereby the actuation of the corresponding switch is brought within the control of the subscriber.

10. In a telephone-exchange system, the combination with the lines of the subscribers, of a line-selecting switch having a series of contact-terminals to which the subscribers' lines are respectively connected, and a contact member adapted to make contact with any of said terminals, actuating means for said contact member including a normally open circuit having therein devices within the control of any subscriber, adapted and arranged when the circuit is closed to actuate the switch, a series of relays for said switch, one relay being provided for the line of each subscriber, circuit connections for the lines of the respective subscribers and the contact member of the switch open at the respective relays and

adapted to be closed by the energizing of any relay to bring the switch within the control of the corresponding subscriber, a normally open relay-energizing circuit, and means within the control of each subscriber for closing said circuit through his corresponding relay.

11. In combination, a plurality of telephone-lines, a switch having contacts arranged to form the termini of the lines, and a contact member adapted to sweep over said termini, electromagnetic devices for operating said switch, a circuit for the electromagnetic devices, a series of relays, one for each subscriber's line, arranged to control the circuit of the switch-actuating electromagnet, connecting-wires arranged and adapted to be connected to any line by the actuation of its relay, complementary connecting-wires terminating in the contact member of the switch, a relay adapted when energized to connect said complementary wires, and means associated with the switch arranged to be brought into operation by the movement of the latter for bringing the circuit-closing relay within the control of the subscriber, whereby the talking-circuit may be established by the subscriber.

12. In combination, a plurality of telephone-lines a line-selecting switch provided with a contact member adapted and arranged to be instrumental in connecting for communication the lines of any two subscribers, means for operating said switch-contact member arranged for control by any subscriber, and means for connecting the line of the calling subscriber with the switch-contact member arranged to be operated subsequently to the switch-operating means.

13. In an automatic-telephone-exchange system, the combination with the subscribers' lines adapted to be connected, and means for supplying energy to said lines when connected for conversation, of means within the control of each subscriber for connecting any two subscribers' lines, a ringing-circuit including a ringing-generator adapted to be connected to the connected lines of the subscribers, whereby when the called line is busy and already energized current from the energized line is received in the ringing-circuit, a busy-test circuit including a signaling device and means for connecting said device with the line of the calling subscriber, comprising a relay having its coil arranged to receive current from the ringing-circuit, said relay being inoperable by the ringing-generator current, and operable by the current transmitted thereto when said ringing-circuit is disconnected to a busy line.

In testimony that we claim the foregoing as our own we affix our signatures in presence of two witnesses.

JOHN K. NORSTROM.
HENRY M. GRAIF.

In presence of—

GEO. T. MAY, Jr.,
MARY F. ALLEN.