Oct. 27, 1925.

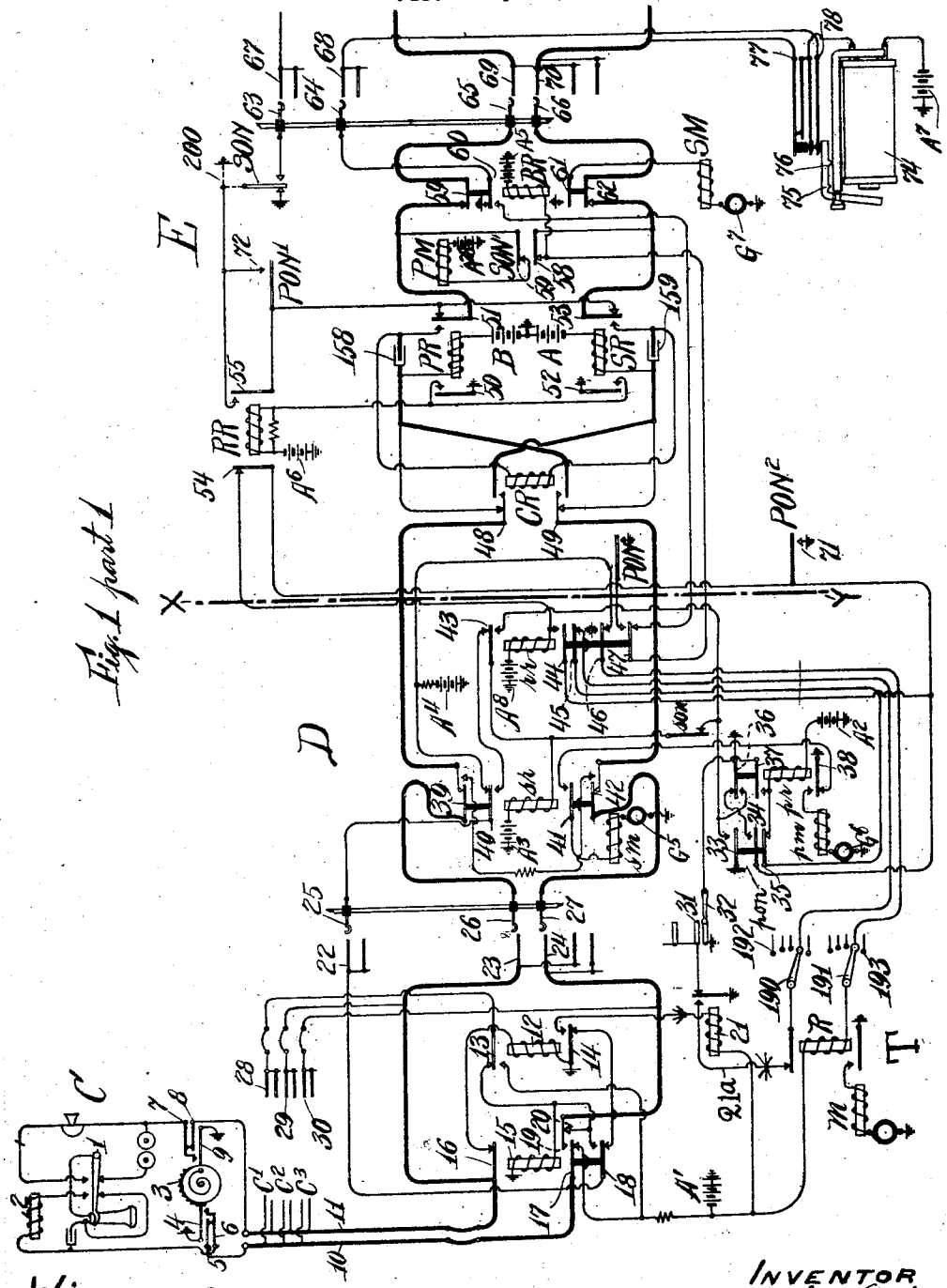
1,559,138

H. G. WEBSTER

AUTOMATIC TELEPHONE SYSTEM

Filed July 26, 1907

4 Sheets-Sheet 1



Witnesses
J. G. Kellogg
J. H. Ferguson

Inventor
Harry G. Webster
by Leroy D. Kellogg Atty.

Oct. 27, 1925. 1,559,138

H. G. WEBSTER

AUTOMATIC TELEPHONE SYSTEM

Filed July 26, 1907 4 Sheets-Sheet 2

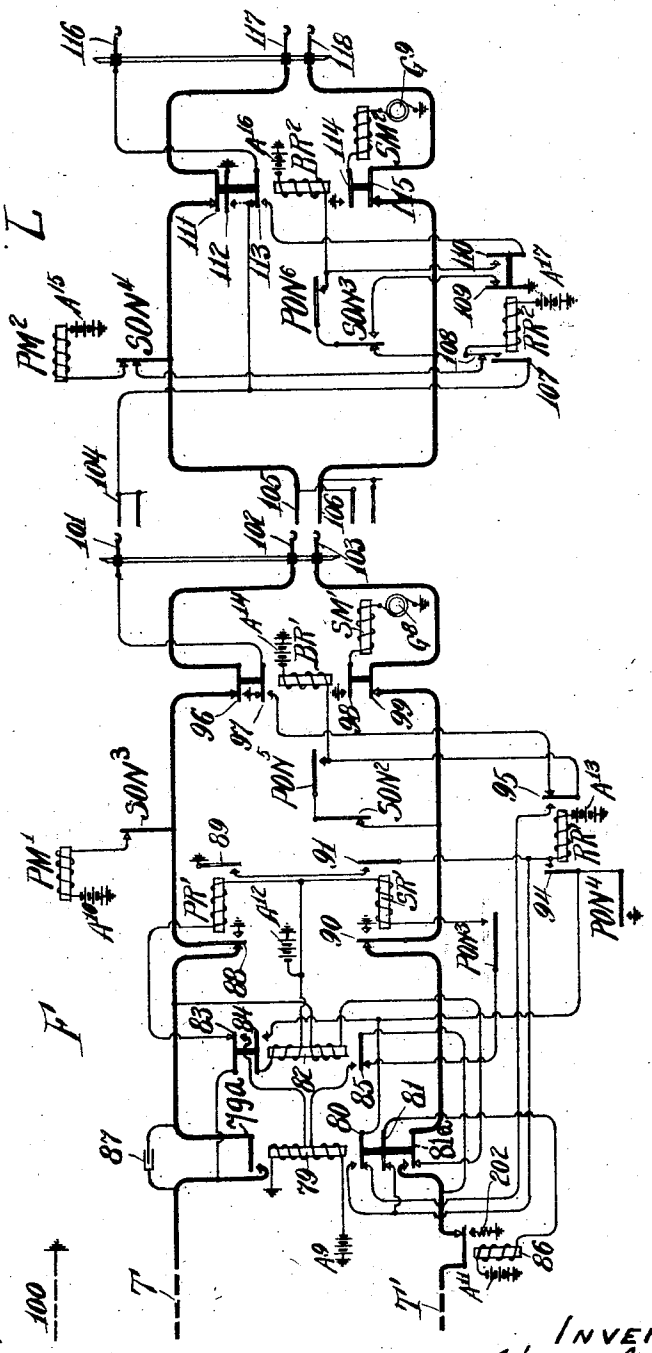


Fig. 1 part 2

WITNESSES
J. G. Kellogg
D. H. Ferguson

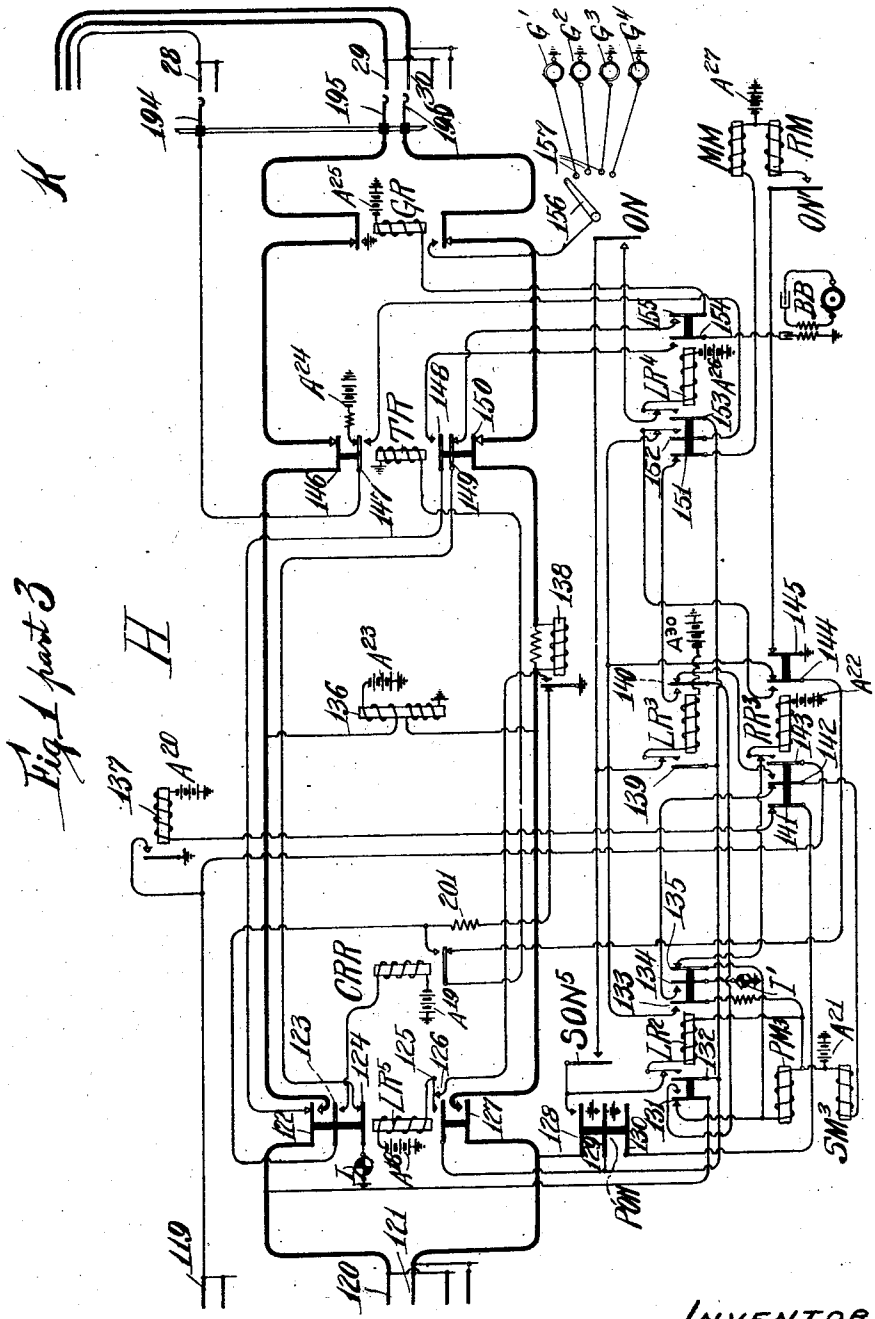
INVENTOR
Harry G. Webster
by Leroy D. Kellogg
ATTY.

Oct. 27, 1925. 1,559,138

H. G. WEBSTER

AUTOMATIC TELEPHONE SYSTEM

Filed July 26, 1907 4 Sheets-Sheet 3



WITNESSES
J. G. Kellogg
I. H. Ferguson

INVENTOR
Harry G. Webster
by Leroy D. Kellogg
ATTY.

Oct. 27, 1925. 1,559,138

H. G. WEBSTER

AUTOMATIC TELEPHONE SYSTEM

Filed July 26, 1907 4 Sheets-Sheet 4

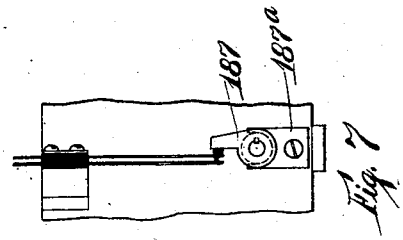


Fig. 7

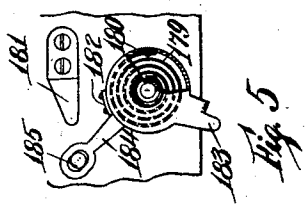


Fig. 5

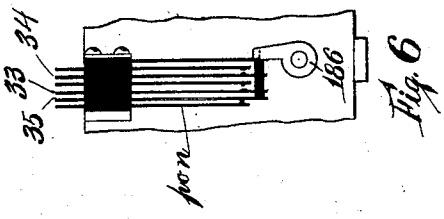


Fig. 6

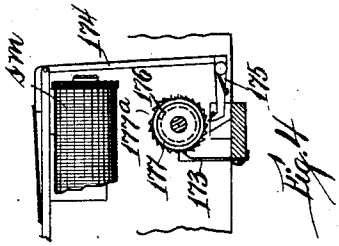


Fig. 4

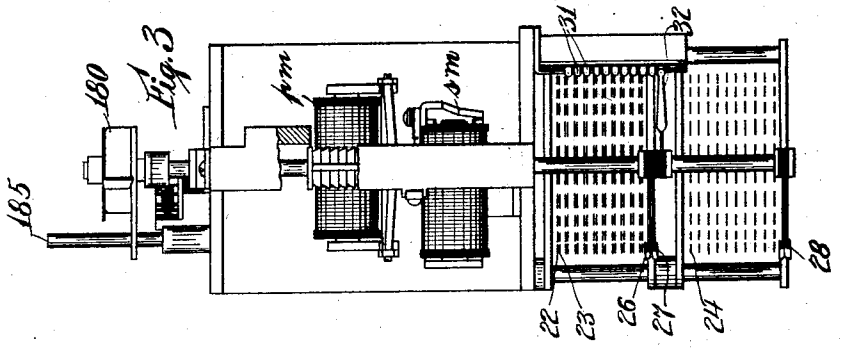


Fig. 3

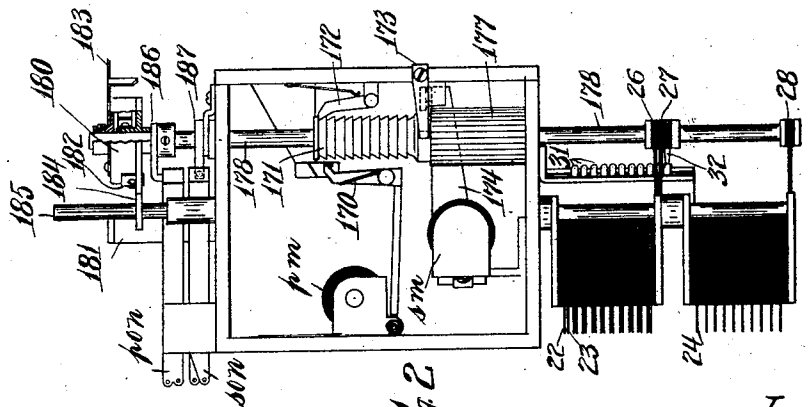


Fig. 2

WITNESSES

G. E. Mueller

J. G. Kellogg

INVENTOR

Harry G. Webster

by Leroy D. Kellogg

atty.

Patented Oct. 27, 1925. 1,559,138

UNITED STATES PATENT OFFICE.

HARRY G. WEBSTER, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE SYSTEM.

Application filed July 26, 1907. Serial No. 385,674.

To all whom it may concern:

Be it known that I, HARRY G. WEBSTER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates to automatic telephone systems wherein each connection is put up at the exchange by a plurality of successively operated selective switches, one of its objects being to secure an improved structure for returning the switches used in a connection to normal. Another feature of the invention consists in the manner in which a common return or grounded third conductor at the substations is employed in the control of the selective switches. Another feature consists in the provision made for trunking between exchanges employing but two conductors individual to each trunk. In systems heretofore proposed, a first selector has been employed to select an idle trunk leading to a distant exchange and there terminating in a second selector, a so-called "repeater" circuit being interposed at the originating exchange between the fixed contacts of the trunk circuit at the first selectors and the two trunk conductors proper. In accordance with the present invention, I do away with this repeater circuit and employ the relays used for controlling the first selector to repeat the impulses transmitted from the calling substation directly over the trunk wires to the electromagnets for controlling the second selector at the distant exchange. These, and other features of my invention will be at length explained in the detailed description wherein reference will be had to the accompanying drawings. Fig. 1 comprising parts 1, 2 and 3, to be placed in consecutive order, illustrate an organization of automatic exchange circuits constituting a preferred embodiment of my invention, all apparatus being shown at normal, the talking circuit to be established indicated by heavy lines, Fig. 2 shows diagrammatically a side elevation of a selective switch that may be employed in connection with the circuits of Fig. 1; Fig. 3 is a front elevation thereof; Fig. 4 shows a detail view of the secondary magnet mechanism of said switch; Fig. 5 illustrates certain features of the release arrangement of the said switch; Figs. 6 and 7 are respectively top views of the primary off-normal and secondary off-normal switch combinations of the said selective switch.

In the organization of the system as a whole, the subscribers' lines are preferably divided into groups of one hundred, both as calling and called lines. Each line of a group is provided with stationary multipled calling terminals appearing at the banks of a number of so-called "line selectors" having electrically adjustable contact wipers for selecting the contacts of the calling line whereby first selectors, one of which is preferably in permanent electrical connection with each line selector, are connected with calling lines, although I do not wish to be limited to this embodiment of my invention. Assuming the one hundred line line groups above referred to, which number is chosen for the sake of example, ten line selectors for each line group, on the ordinary ten per cent. basis, would be adequate to take care of the calls originating from such group. At the line selectors, the lines of the calling subscribers have their multiple terminals preferably arranged in ten groups, each of which may be placed upon a different level of the line selector in the well known manner. To control the line selector in its travel to select the calling line, the lines having their contacts upon one level are preferably provided with a group contact multipled to each line selector of the group, a group wiper being provided for the line selector to wipe over the said group contacts to select the group in which a calling line is to be found, whereon the line selector moves its wipers over the individual contacts of the lines of that group to come to rest engaging the contacts of the calling line.

The line selectors are preferably not constantly operating devices, but are normally at rest, a starting circuit common to a group of one hundred lines for starting the line selectors distributively being provided. Such starting circuit may have a selective switch T at one end to select an idle line selector,

and starts an idle line selector as soon as a call is initiated over a line of the respective group.

The first selectors have contact wipers for which are provided multiple terminals of second selectors, which second selectors are common for connection to a limited group of subscribers' lines, namely for a group of ten thousand lines in a one hundred thousand line system or for a group of one thousand lines in a ten thousand line system, in the well known manner. The second selectors have before them multiple terminals of third selectors (in the one hundred thousand line system) which are common for connection to a limited group of one thousand subscribers' lines; and in this system, the third selectors would have before their wipers, multiple terminals of connectors, each common for connection to a one hundred line group of subscribers, the connectors having before their wipers, called multiple terminals of a one hundred line group of subscribers.

More specifically taking first the one hundred thousand line system on the usual ten per cent. trunking basis; each first selector would have ten levels of ten contact sets each, the sets of each level leading to second selectors of a different ten thousand group called subscriber group, the first selector being adjusted first to select the group wanted responsive to directive impulses, and then to select the first idle contact set of the group. The second selector would have ten levels of ten contact sets each, the sets of each level leading to ten third selectors of a different one thousand group, the second selector being adjusted to first select the group of contacts wanted responsive to directive impulses, and then to select an idle third selector of the group. The third selector would have ten groups of ten contact sets each, the contact sets of each group being on a different level and connected to connectors for a different one hundred of the thousand which the third selector serves, the third selector is selecting the group wanted responsive to directive impulses, and then the idle connector, in the well known manner. The connector has the contact sets of its one hundred lines arranged in ten groups of ten contact sets each, each group being on a different level, the wipers of the connector being first adjusted to select a group in which a calling line is found, and then directively adjusted over the contact sets of the individual lines until they engage the contact set of the called line. After this occurs, the called line is tested and a busy signal transmitted to the calling subscriber if the line be busy; otherwise a ringing generator is connected to the called line to signal the subscriber.

It will be understood that in the ten thousand line system, the second selectors assigned to the ten thousand line groups are omitted and the third selectors of the one hundred thousand line system have their terminal ends at the banks of first selectors, said third selectors being then employed as second selectors.

Before proceeding to the description of the circuit, I will first describe the mechanical features of the selective switch employed in connection therewith. The switch shown in Figs. 2 to 7 inclusive is specifically a line selector although the same structure may be employed as a first, second or third selector or connector; in the latter employments, however, the group contacts 31 and the group wiper 32 being superfluous. Fig. 3 shows ten levels or groups of contact sets 22—23—24, each level including ten sets. Each set of correspondingly placed contacts 22—23—24 constitute calling terminals of an individual line. Each level of contact sets is provided with its group contact 31 as indicated at the right in Fig. 3. For engagement with the individual line contacts 22—23—24, the wipers 26—27—28 are provided, normally resting as shown in Fig. 3, their ends being at the left of the contact banks, it being understood that from left to right, the contact banks are of the usual concave form. The shaft 178 is suitably journaled to the main frame of the switch at the axis of curvature and is first lifted step-by-step so as to bring the wipers 26—27—28 fastened thereto to positions horizontal with the different levels of contacts, the shaft being then rotated in a clockwise direction, the wipers engaging at each rotary step, a different line contact set. In the case of the line selector, the primary magnet *pm* which, by means of its armature-driven pawl 170, adapted to engage ratchet 171, effects the upward stepping of the shaft 178, is controlled by the group wiper 32 moving over the group contacts 31 to find a group contact whose electrical condition has been altered on account of initiation of a call over a line having its individual contact set in a corresponding level. The retaining pawl 172 engages successive teeth of ratchet 171 on each step of the line selector and holds the shaft against back movement. It will be understood that the two ratchets 171 and 177 are rigidly secured to the shaft. For rotating the wipers 26—27—28 over the contact sets of the selected level, secondary magnet *sm* is provided, whose armature-driven pawl 175, best shown in Fig. 4, with each actuation of said magnet *sm*, drives shaft and wipers a rotary step, pawl 173 engaging the successive teeth of the ratchet 177 and holding the shaft against back movement by the tension of restoring spring 179. It will be apparent on reference to Fig. 3 that on the first ro-

tary step of shaft 178 and wipers 26—27—28, the group wiper 32 is moved away from the group contacts 31, its continued engagement therewith being no longer necessary as will be understood from the description of the circuits.

For restoring the switch to normal, additional impulses are transmitted through the secondary magnet *sm* which will continue until the wipers 26—27—28 make their eleventh step, at which time they will be beyond the right edge of their contact banks, and the shaft 178 will then be free to descend by gravity to its normal vertical level, carrying the wipers with it, because the vertical retaining pawl 172 is so disposed with respect to the vertically extending slot 176 of ratchet 171, that the eleventh step of the wipers brings said slot opposite the vertical retaining pawl 172, which then no longer supports the shaft. When the shaft descending reaches its normal level, the rotary retaining pawl 173 no longer engages the ratchet 177, the said ratchet having been brought by the descent of the shaft below the pawl, as shown in Fig. 2, and the shaft is then free to rotate, carrying with it wipers 26—27—28 and 32 in a reverse clockwise direction back to the position shown in Fig. 3, this rotation being effected by the spring 179, shown in Fig. 5.

To the end of avoiding friction of the operating parts while the shaft 178 is being adjusted vertically, the spring 179 has one end attached to the spring case 180 which is rigidly attached to the shaft 178. The other end of the spring is fastened to the arm 184, having at each end an orifice, one of which fits loosely about the shaft 178 and the other about the post 185, these parts being best shown in Figs. 2 and 5. Upon the exterior of the spring casing is fastened the arm 182 which normally presses against arm 184 at an intermediate point so that there is no tension exerted by spring 179 to cause arm 184 to press against post 185 and shaft 178, this condition continuing while the shaft is being lifted under the influence of primary magnet *pm*. As soon, however, as the first rotary step of the shaft is made, the arm 182 is carried free of the arm 184 and the tension of spring 179 tends to return the shaft, which return is prevented, as before described, by pawl 173. On the eleventh rotary step of the shaft, however, the downwardly extending portion of spring arm 183, carried by the spring case 180, passes over the top of the arm 184 to a position corresponding to that originally occupied by the arm 182. The tension of the spring is thereby again ineffective to exert pressure upon arm 184 and while the shaft descends by gravity, it has no friction to overcome. However, as it reaches its normal level, the horizontally extending end of arm 183 impacts upon the piece 181, the arm 183 is raised to clear arm 184 and the spring 179 is then effective to rotate the shaft and wipers back to normal.

In Fig. 6 is shown the primary off-normal spring combination, the arm 186 being fastened to the shaft 178, normally holding the off-normal springs *pon* in the position shown. On the first vertical step of the shaft, the arm 186 is raised so as to clear the spring engaged by it when the springs joined by the stud of insulating material shown move to the right to assume their alternate positions. The arm 187 controlling the secondary off-normal spring *son* fits loosely about the shaft 178 and is not raised therewith, the piece 187^a fastened to the frame of the switch engaging a groove in the arm 187, as shown in Figs. 2 and 7, to hold it at its normal level. The said arm 187 is, however, keyed to shaft 178, and with the first rotary movement is moved to the right to free the secondary off-normal spring, which assumes its alternate position. It will be understood that both the primary and secondard off-normal springs are restored to normal only when the shaft reaches its fully restored position at the conclusion of its back rotary travel. A tooth at 177^a is omitted to render pawl 175 ineffective to further rotate the shaft after the eleventh step.

As before indicated, when the switch is used as a selector or connector, the group wiper 32 is unnecessary, the switches for the selector and connector circuits being otherwise similar to the line selector except that the primary off-normal and secondary off-normal spring combinations will be altered to conform to the circuit diagrams. The relation of the off-normal arms 186 and 187 to the switch springs will be the same to the other switches, and mechanical illustrations of the various spring combinations are unnecessary. For a trunking first selector, a fourth wiper and set of contacts may be provided as indicated in Fig. 1.

Referring now to Fig. 1, part 1, I have there shown a subscriber's substation including the usual transmitter, receiver, condenser and call-bell, the talking and ringing circuit being of character well known in the art and requiring no specific description, it being understood that hook-lever 1 upon the removal of the receiver, leaves its lower contacts and engages its upper contacts. Contacts 5—6 and 7—8 unite the two line limbs 10 and 11 with the talking and signalling conductors of the substation. The grounded spring 9 is adapted to be actuated by the insulated teeth of diagrammatically indicated dial 3 which is rotated clockwise by the subscriber in transmitting the directive impulses until a number of teeth, corresponding to the digit to be transmitted,

have passed below the spring 9 whereon the dial being released on its return movement, connects limb 10, over contact 6—5 through impedance 2, hook-lever 1, the transmitter and contact 7—9 to ground whereafter the tooth engaging spring 9 breaks the contact 7—8. When the tooth passes beyond the extremity of spring 9, the spring is retracted and contact 7—8 is again closed and contact 7—9 opened. This will be repeated as many times as teeth have been passed below the spring 9. It is apparent that an equal number of breaks in the circuit of limb 11 will be produced while the circuit of limb 10 will be alternately shifted to ground through spring 9 and then re-established at contact 7—8, the reestablished occurring before the opening of contact 7—9.

With the return of dial 3 to normal, its tooth at the extreme left actuates spring 4 to engage spring 6 whereby circuit of limb 11 is shifted from limb 10 to ground through contact 4—6, whereafter contact 5—6 is opened, thus opening the circuit of line limb 10. When the said tooth at the left of dial 3 passes below the extremity of spring 4, said spring is retracted, contact 5—6 being closed before contact 4—6 is opened, thus re-establishing the conductive bridge between limbs 10 and 11 through transmitter, hook-switch and the impedance coil of the talking circuit. The dial 3 employed in the usual manner to transmit the directive impulses to the electromagnets of the selective switches, by making several sets of breaks in the circuit of line limb 11, as described, one set being produced for each digit of the called subscriber's number, each set being followed by a single momentary opening of the circuit of the line limb 10.

The subscriber's line is provided at the exchange with multiple called contacts 28—29—30 with which a connector makes connection when the line is used as a called line. The multiple calling contacts 22—23—24 are also provided at the banks of the line selector assigned to the one hundred line group among which the calling line is included. At 12 is shown the line relay employed for initiating travel of an idle line selector, while at 15 is a cut-off relay which, by its contact springs 16 and 17 control the talking connections of line limbs 10 and 11 to both the calling and called multiple contacts. The armature 14 of line relay 12 controls the circuit of group relay 21 which is common to the line relays of ten lines having their individual contacts on one level of the line selector banks. The said group relay controls by its armature the electrical condition of the multiple group contacts 31 and also has connection by its armature with the starting wire 21^a extending to the upper armature of master-switch relay R, and having branches to the armatures of the nine other group relays of the hundred.

The line selector D includes the primary relay *pr* initially operated over the starting wire, its circuit being then controlled over the group private wiper 32, which relay *pr* by its control of primary magnet *pm* causes the stepping of the wipers 25—26—27 and 32 up to the contact levels containing the contacts of the calling line. The secondary relay *sr* is adapted for operative connection with the individual private wiper 25 and actuates the secondary magnet *sm* to move the wipers 22—23—24 along the levels elected until wiper 25 engages the individual private contact 22 of the calling line. The primary off-normal, *pon*, springs 33—34—35, and the secondary off-normal springs *son* are actuated by the mechanism of the line selector while the primary off-normal springs, PON, and secondary off-normal springs SON to the right of the dotted line XY are actuated by the mechanism of the first selector E whose wipers are shown at 63—64—65—66.

The first selector shown at E includes the impulse transmitting relays PR and SR, adapted when the line selector has selected the calling line, to be held energized over the metallic circuit of the line, the serially disposed batteries A and B having their common point grounded and being connected across the terminals of the two relays. The said relays jointly control the release relay RR, while relay PR individually controls primary magnet PM, the secondary relay SR controlling the initial energizing circuit of busy relay BR which, when actuated, is operatively connected with private wiper 64, the relay thereby being rendered sensitive to the grounded or ungrounded condition of the private contacts 68 engaged by the wiper 64. The relay BR controls by its armature 61, the circuit of secondary magnet SM and is thus effective to cause selection of the first idle contacts 68—69—70 of a selected group in the well known manner. At F, I have shown the circuits of a trunking second selector including the wipers 101—102—103, primary magnet PM′ controlled by primary relay PR′, being provided to adjust the wipers vertically while the secondary magnet SM′ is provided to adjust them rotarily under the influence of busy relay BR′ initially operated by the secondary relay SR′ and thereafter held energized by a circuit including private wiper 101, in the well known manner, to select an idle third selector which is shown at L.

The third selector includes the wipers 116—117—118 and the primary magnet PM^2 which is operable by current impulses transmitted by primary relay PR′ after the second selector has completed its operation.

Secondary magnet SM^2 of the second selector is controlled by the busy relay BR^2 which is initially operated responsive to a current impulse transmitted by the secondary relay SR′, the circuits of the said busy relay being thereafter controlled over a connection extending to the private wiper 101 to select the first idle connector.

The connector, H, shown in Fig. 1, part 3, comprises the primary magnet PM^3 and a secondary magnet SM^3, both of which are operable responsive to directive impulses transmitted by the relay PR′, the locking relays RR^3 and LR^2 being employed to shift at the proper time the upper strand of the talking circuit of the connector indicated by the heavy line, from connection with magnet PM^3 and to connection with secondary magnet SM^3.

Associated with the connector is provided an auxiliary switch including the wiper 156 which has access to four contacts 157, each being connected to a generator of different frequency to the end that the subscribers on a party line may be selectively signaled by means of call-bells attuned to the different frequencies of the generators, in the well known manner. The magnet MM controls the wiper 156, the said magnet being arranged to be connected with the upper limb of the talking circuit by locking relay LR^3 in order that the last set of impulses transmitted from the substation may operate upon magnet MM to cause wiper 156 to select the generator of the required frequency to ring the bell of the particular subscriber wanted.

The locking relay LR^4 is actuated by an impulse transmitted by the relay SR′ immediately following the selection of the proper ringing generator, and is effective to connect the test relay TR, previously actuated in a manner hereinafter to be described, with the private wiper 194 to render the test relay sensitive to the electrical condition of the private contact 28 of the called line, the test relay TR then determining the transmission of a busy signal from busy back machine BB to the calling subscriber, or the operative connection of the selected generator to the called-for line.

A novel feature of the invention consists in this that if two subscribers have completed their conversation, the act of the called-for subscriber in replacing his receiver, while ineffective to produce the restoration to normal of any switch employed in the connection, is however, effective to actuate the mechanism of the connector in such a way that his line is free from the busy potential placed upon its contact by the connector and is available for further use as either a calling or called line whether the calling subscriber hangs up his receiver to release the switches used in the connection, or not. The busy potential upon the private contact 28 of the called line is placed there by private wiper 194 of the connector via the normal contact of armature 147 of test relay TR. The relay 138 which is provided in the path of current over the called-for line, is of course, deenergized when the called subscriber replaces his receiver and is effective to actuate the called release relay CRR, whose circuit has previously been closed at the alternate contact of armature 123 of locking relay LR^5, when relay 138 was first energized on the removal of the receiver at the called substation. The energization of relay CRR by attracting its armature establishes a circuit including the test relay TR and itself, whereby armature 147 is attracted and also armatures 146 and 150 of test relay TR in order to remove the busy potential from wiper 194 and to place the line wipers 195 and 196 on open circuit.

The remaining circuit connection will be best understood from the following description of the operation of the system.

Assuming that the calling subscriber at C desires his line to be connected with the subscriber's line indicated at K by the multiple called terminals 28—29—30 at connector H, and whose line circuit and substation connections are omitted from the drawing, it being understood that they will be connected to the called terminals in the same manner as those of the subscriber C, the subscriber at C after removing his receiver, operates his dial 3 to cause sets of breaks in the circuit of line limb 11, one set being produced corresponding in number to the units of each digit of the called subscriber's line number which is assumed to be 23456, a sixth set being produced to correspond with the position of the contact 157 of the generator G^4 of the proper frequency to ring the tuned bell of the called subscriber. This sixth set will consist of four breaks, the wiper 156 being required to make four steps to select the generator G^4.

When the subscriber C removes his receiver, a circuit is closed from the active side of battery A′ through normal contact 17, over line limb 10, contact 6—5, coil 2, through the alternate hook-lever contacts, the substation transmitter, contact 7—8, returning over limb 11, normal contact 16, the winding of line relay 12 to ground, operating the said relay 12 whose armature 13 engages its alternate contact to connect the active side of battery A′ to the private or test called multiple contacts 28 at the connectors to protect the line of the calling subscriber against in-coming calls. The attraction of armature 14 closes a circuit for the group relay 21 from battery A′ which relay attracts its armature to remove the ground from the group multiple contacts 31 at the

line selectors of the group which includes the calling line, the said armature engaging its alternate contact and completing a circuit as follows: from ground over starting conductor 21^a, normal contact of armature of relay R of the master-switch, T, through wiper 190 of the master-switch, contact 192 of the idle line selector D, the master-switch wipers 190 and 191 normally resting engaging contacts of an idle line selector, (it being understood that each line selector of a one hundred line group has its individual contacts 192, 193 before the wipers of the master-switch T of said line group) the circuit being further traced through contact 45, off-normal contact 35, primary relay *pr* of the line selector, to battery A^2. Relay *pr* attracts its armature 36 to close a circuit from ground through secondary off-normal spring *son*, secondary relay *sr* to battery A^3, operating the said secondary relay whose armatures 39 and 42 are attracted disengaging their normal contacts springs whereby a circuit is completed from the positive pole of battery B, through primary relay PR of the first selector E, through normal contact 48, alternate contact at 39, alternate contact at 42, contact 49, secondary relay SR to the negative pole of battery A, the said batteries A and B being serially connected and having their intermediate point grounded as shown. The relays PR and SR are operated to close a circuit through release relay RR of the first selector before the relay *pr* of line selector D can cause the line selector to make a step and have its armature 36 thereafter retracted whereby a premature operation of release relay *rr* of line selector D over armature 54 of relay RR is effectively prevented. When relay *pr* was energized, its armature 38 was attracted to close the circuit of primary magnet *pm*, which magnet, under the influence of impulses transmitted by generator G^6, steps the shaft and wipers 25—26—27 of line selector D upward as long as relay *pr* remains operated. The said relay *pr* in attracting its armature 37, connected the relay's winding with the group wiper 32, thereby rendering the said relay sensitive to the grounded or ungrounded conditions of the group contacts 31. I have shown in Fig. 1, the group contact 31 of the line of subscriber C as adjacent to the normally grounded rest contact of wiper 32 so that but one step of the line selector is required to bring the wipers 25—26—27 adjacent to the levels having line contacts of subscriber C. The first movement of the line selector shifts the primary off-normal springs *pon* 33—34—35, whereby the relay 37 at spring 35 is disconnected from the starting wiper 190 and is solely dependent for continuance of its energization upon group wiper 32. Thus, on the first step effected by primary magnet *pm*, the wiper 32 engages the ungrounded group contact 31, relay *pr* is de-energized and further actuations of primary magnet *pm* prevented at retracted armature 38 of the said relay *pr*.

The relay, *sr*, operated as before described, has its circuit continued through secondary off-normal spring *son* to the shifted primary off-normal spring 33 and remains energized when the armatures of relay *pr* are retracted. Hence, a circuit is completed through generator G^5, secondary magnet *sm*, contact 41, normal contact 38 to ground over which circuit current impulses flow through secondary magnet *sm*, which steps the wipers 25—26—27 rotarily over the contact sets of the selected level. With the first rotary step, secondary off-normal spring *son* disengages its contact whereby secondary relay *sr* is dependent for its continued energization solely upon a circuit extending through normal contact 43, alternate contact 40, through private wiper 25 now engaging successively the individual private contacts 22 of the lines of the selected group. Non-calling lines will have their contacts 22 grounded at normal contacts 14 of their respective line relays 12. Thus, while wiper 25 is passing over contacts 22 of such lines, the relay *sr* will continue energized and successive pulsations will flow through secondary magnet *sm*. As soon, however, as wiper 25 engages contact 22 of the line of C, said contact will be opened or ungrounded at armature 14, relay *sr* will have its circuit opened at said armature and the relay will be de-energized, armature 41 opening the circuit of secondary magnet *sm* whereby additional secondary movements of the switch are prevented and wipers 25—26—27 rest in engagement with contacts 22—23—24 of the calling line. Armature 42 is retracted, effecting closure of a substitute circuit for relay SR of switch E before the original circuit is broken, the said substitute circuit extending from battery A through normal contact of armature 42, contact 27—24, contact 19—20, cut-off relay 15 of the calling line to ground. Said relay 15 by attracting its armature 18 completes a locking circuit for itself extending through said contact, contact 22—25, normal contact 40 to the active side of battery A^4. In attracting its armature 17, a substitute circuit for relays PR and SR is completed, extending from battery B through relay PR, normal contact 48, normal contact 39, contact 26—23, over limb 11 of the line, contact 8—7, through transmitter and impedance coil, returning over contact 5—6, limb 10, contact 17—19 now closed, contact 24—27, normal contact 42, contact 49, secondary relay SR to battery A. By the make-before-break arrangement of armature 42, this substitute circuit is completed before their relays PR

and SR are deenergized and their armatures retracted.

The master-switch wipers 190 and 191 are now caused to move over contacts 192—193 of the ten line selectors such as D which the master-switch is assumed to serve, in search of an idle line selector, the relay R having been energized by a circuit extending from battery A′, through said relay, contact 191—193, normal contact 46 through normal contact 40, contact 25—22, alternate contact 18 to ground through relay 15. The relay R thus attracts its armature to close circuit through magnet *m* which drives the wipers by any approved mechanical connections. It is obvious that as long as wiper 191 is wiping contacts 193 of line selectors in engagement with the calling lines, the relay R will be energized over a succession of locking paths similar to that just described, but when the wiper 191 reaches a contact 193 belonging to a line selector at rest, the said contact 193 will be open at wiper 25, relay R de-energized, and also magnet *m* of the master-switch whereafter the wipers 190 and 191 rest in engaging the contacts of the idle line selector ready to start the same responsive to the initiation of a call. The conductor 21^a is a common conductor, a branch thereof extending to each group relay 21 of the ten ten-line groups.

When cut-off relay 15 was energized, its armature 16 opened the circuit of line relay 12 whose armature 14 falling back deenergized the group relay 21 so that as soon as the calling line was selected, the starting ground was removed from conductor 21^a and the ground restored to the group contact 31 so that the level of contacts at the line selectors including that of subscriber C will remain unselectable until another subscriber of that level initiates a call.

The first selector E is now operatively connected with the calling subscriber's line and he proceeds to operate his calling device 3 actuating the same a first time to effect two breaks in the circuit of conductor 11 followed by one break in the circuit of conductor 10. As before explained, each tooth of dial 3 in the return of the actuated dial closes contact 9—7 before breaking contact 7—8. Thus relay SR is held energized over a circuit extending over limb 10, contact 6—5, the impedance coil, 2, the transmitter and contact 7—9 to ground, while the relay PR is de-energized by the breaking of contact 7—8, while with the return of spring 9 after a tooth of dial 3 passes beyond it, a metallic circuit through contact 7—8 is re-established before contact 7—9 is broken. Two de-energizations of primary relay PR caused by the the first actuation of dial 3, are effective to transmit two current impulses from ground through secondary off-normal spring SON, through attracted armature 55 of release relay RR, through retracted armature 51, secondary off-normal spring SON′ and primary magnet PM to battery A^{28}, said primary magnet PM then stepping wipers 63—64—65—66 two vertical steps to positions horizontal with terminal contacts 67—68—69—70 pertaining to second selectors assigned for connections to subscribers' lines numbering from 20,000 to 29,999. With the first vertical step of the switch E, the primary off-normal springs PON′ and PON^2 are shifted to engage their alternate contacts.

Following the second de-energization of primary relay PR, secondary relay SR is de-energized by a break caused in the circuit of limb 10 of the line of subscriber C by the last tooth of dial 3 in its return to normal, the said dial operating upon spring 4 to first close contact 4—5 and then open contact 5—6 whereby relay PR is maintained energized while relay SR is de-energized, as before explained. The de-energization of relay SR caused an impulse of current to flow from grounded secondary off-normal spring SON through attracted armature 55, retracted armature 53, secondary off-normal, SON′, contact 58, busy relay BR to battery A^5, energizing the said relay, which attracts its armatures 59 and 62 to place line wipers 65—66 on open circuit, armature 61 to close a circuit from generator G^7 through secondary magnet SM to ground, which magnet is now effective to move the wipers 63—64—65—66 step-by-step over the contacts of the selected level. Armature 60 of busy relay BR completed a circuit for said relay from battery A^5 extending through normal contact 47, attracted armature 60 to wiper 64 and to the multiple private contacts 68 engaged by said wiper. Such contacts 68 as pertain to busy second selectors F will be grounded, and relay BR will be locked over a series of successive locking circuits until wiper 64 engages a contact 68 pertaining to an idle second selector, at which time relay BR will be de-energized, and its armatures retracted; whereof 60 will place a busy ground upon wiper 64 then engaging multiple contacts 68 of the selected idle second selector, while armature 61 opens the circuit of secondary magnet SM, whereby wipers 63—64—65—66 rest engaging contacts 67—68—69—70 of the idle second selector assumed to be F.

In the present description, it is assumed that the conductors T and T′ connected to the contacts 69 and 70 are connected to a trunking second selector F located at a distant exchange, under which circumstances of course, a two-conductor trunk is very desirable. The conductor 100 shown as extending from the multiple contact 67 to ground at the second selector F in the dis-

tant exchange is not an individual conductor but is intended to indicate merely a common return conductor which may be common to all second selectors F of the distant exchange having conductors T—T′ extending to first selectors E in the first exchange. This conductor 100 is only employed when there is a sufficient difference of earth potential between the two exchanges to affect unfavorably the working of the relays of the system, notably the relays PR′ and SR′. By means of secondary off-normal spring SON at the first selector E, which spring is shifted on the first secondary movement of the first selector, the wiper 63, connected, on selection made, to the multiple contact 67 provided for the common return 100, is connected through armature 55 and the primary off-normal contact PON′ 72 to the back contacts of the armatures 51 and 53 so that the next impulses transmitted by said relays which will pass over conductors T—T′ as hereinafter explained, will be from a ground local to the battery A^{12} by way of the common return 100 or from a ground having a potential within operating limits like that of the ground return of the distant exchange battery.

With the first secondary movement of the first selector E, the secondary off-normal springs 58 and 59 were shifted to disconnect magnet PM and the busy relay BR from the armatures 51 and 53, which armatures will then be connected over a clear circuit extending through contacts 65—69 and 66—70 to the trunking conductors T—T′.

The conductors 200 and 100 are for alternative employment and in the present description, it will be understood that the conductor 200 is to be left disconnected. If, however, there was no operative difference of ground potential between the two exchanges, the common return 100 would not be provided at all and the local ground conductor 200 would be used. I consider the use of a wiper as 63 employed in connection with a selector to pick out a special return conductor according to the exchange to be connected with, to be new in the art.

The calling subscriber C now actuates his calling device 3 to produce three breaks in the circuit of conductor 11 followed by a break in the circuit of conductor 10. Three de-energizations of primary relay PR are thereby caused, and each transmits a current impulse from ground over common return 100, contact 67—63, secondary off-normal switch SON, off-normal contact PON′ 72, normal contact 51, contact 59, contact 65—69, trunk conductor T, contact 83, primary relay PR′ to battery A^{12}, energizing and de-energizing relay PR′ thrice whereby three current impulses are transmitted from ground through alternate contact 88, contact SON^3, primary magnet PM′, to battery A^{10}, the said magnet PM′ being actuated three times to lift wipers 101—102—103 three steps opposite a level of multiple contacts 104—105—106 belonging to third selectors assigned for connection to a group of subscribers having numbers from 23,000 to 23,999. With the first primary movement of the switch, primary off-normal springs PON^3, PON^4 and PON^5 were shifted whereon PON^3 operatively connected secondary relay SR′ with trunk conductor T′. The single de-energization of relay SR following the three of relay PR, transmits an impulse of current from common return 100 over the before traced path, through normal contacts 53 and 52, contact 66—70, over trunk conductor T′ through armature of relay 86, thence through normal contact 85, primary off-normal contact PON^3, secondary relay SR′, to battery A^{12}, operating the said relay which through attracted armature 90 transmits a current impulse from ground through secondary off-normal contact SON^2, primary off-normal contact PON^5, now shifted, busy relay BR′ to battery A^{14}. The said relay BR′ attracts armatures 96—99 to place line wipers 101—102—103 on open circuit while wiping over contacts 105 and 106 of busy third selectors L, while armature 98 completes a circuit for generator G^8 through secondary magnet SM′ to ground; armature 97 completes a circuit for relay BR′ extending from battery A^{14} through normal contact 95, alternate contact 97, wiper 101 and to the multiple private contacts 104 engaged by said wiper, such contacts as pertain to busy third selectors such as L, being grounded at normal contacts 97 of the second selectors rendering them busy. Thus, relay BR′ will continue energized, holding its armature 98 attracted and causing successive actuations of magnet SM′ until the wiper 101 engages contact 104 which is ungrounded, that is, one pertaining to an idle third selector. When this occurs, relay BR′ will be de-energized, its armatures retracted, 97 placing ground upon multiple contacts 104 of the idle third selector L; and 98 opening the circuit of secondary magnet SM whereby wipers 101—102—103 remain engaging the contacts 104—105—106 of the selected third selector. On the first secondary movemnet of second selector F, the secondary off-normal springs SON^2 and SON^3 were shifted whereby magnet PM′ and busy relay PR′ were cut-off from armatures 88 and 90 and said armatures provided with clear circuits extending through to contacts 102 and 103.

The third set of breaks caused by subscriber C in limb 10 consisting of four, are effective to cause four de-energizations of primary relay PR which effects four energizations of relay PR′ in the manner before described. The said relay PR′ transmits

four impulses from ground through normal contact 96, contact 102—105, the first current impulse transmitted then dividing, a part flowing through release relay RR^2 via secondary off-normal contact SON^4 and contact 108. Release relay RR^2 thereon attracts its armature 107 to complete a locking circuit through contact 104—101 to ground at armature 97, the attraction of armature 107 opening contact 108 and disconnecting the relay RR^2 from contact 105. The rest of the first impulse passes through magnet PM^2 which steps the shaft up one step. The three other impulses of the four pass through magnet PM^2 only, the switch wipers being thus raised to positions horizontal with their fourth levels of contacts forming terminals of connector switches assigned for connection to lines numbered from 23,400 to 23,499.

A break in conductor 10, following the four breaks in the conductor 11, produced the de-energization of secondary relay SR which transmits an impulse to secondary relay SR′ in the before described manner, which relay attracts armature 90 to transmit an impulse from ground through normal contact 99, contact 103—106, secondary off-normal contact SON^3, primary off-normal contact PON^6 shifted with the first primary movement of third selector L and through busy relay BR^2 to battery A^{16}, which relay attracts armatures 111—115 to disconnect line wipers 117—118, armature 114 to cut in secondary magnet SM^2, and armature 113 to complete a locking circuit for relay BR^2 extending through the attracted armature 110 of release relay RR^2, and alternate contact 113 to private wiper 116 and multiple private contacts 119 of the connectors of the selected level. Contacts 119 of busy connectors will be grounded and relay BR^2 will continue energized until wiper 116 engages an ungrounded contact 119, one pertaining to an idle connector H, whereon relay BR^2 will be de-energized and its armatures retracted, wipers 116—117—118 being left resting in engagement with contacts 119—120—121 of the selected idle connector H. With the first secondary movement of the third selector L, secondary off-normal springs SON^3 and SON^4 were shifted whereby primary magnet PM^2 and relay BR^2 were disconnected from the armatures 88 and 90 of relays PR′ and SR′ and the said armatures connected through by a clear circuit to wipers 117—118, as soon as armatures 111—115 of relay BR^2 were retracted. The fourth set of breaks caused in limb 11 of the line of subscriber C, consisting of five breaks, are effective to operate the relays PR and PR′ in the before described manner to transmit five impulses from ground through armature 88, contact 96, 102—105, 111, 117—120, through normal contact 131, a portion of the current then passing to the right through normal contact 135, and through release relay RR^3, which relay locks itself by its armature 143 from battery A^{22} over private contact 119, wiper 116, normal contact 113, contact 104—101, and the ground at normal contact 97, the busy ground for contact 119 being traced to said contact 97. The other portion of the current flowing over contact 117—120 and normal contact 131, this being the first impulse, passes through primary magnet PM^3 to battery A^{21} actuating said magnet, and the remaining four impulses pass through said magnet only, armature 143 of relay RR^2 having disconnected the relay winding from the normal contact of armature 131. Thus the wipers 194—195—196, of the connector are stepped up to their fifth contact level, comprising contacts of lines numbering from 23,451 to 23,459 followed by contacts of line 24,450, it being understood that zero is represented by ten impulses in automatic telephone systems.

The break in limb 10 of the line of C following the five breaks in limb 11, de-energizes relay SR which energizes relay SR′ which transmits an impulse from ground through alternate contact 90, contact 99, contacts 103—106, 115, 118—121, through primary off-normal contact 128 of the connector H, shifted on the first primary movement thereof, and through locking relay LR^2 to battery A^{21}, the said relay locking itself by armature 132 to ground at shifted off-normal contact 129. Attracted armature 133 of relay LR^2 completes a circuit from battery A^{21} through armature 133, through the normal contact at armature 152 of relay LR^4, through attracted armature 144, armature of relay CRR, test relay TR to ground operating the said test relay which continues energized until the transmission of the last subsequent impulse. The set of breaks representing the next digit of the called subscriber's number caused in limb 11 by subscriber C, consisting of six breaks, de-energizes relay PR six times and energizes relay PR′ six times, whereby six impulses pass through armature 88 over the before traced circuit, through contact 117—120, through alternate contact 131 of the now energized relay LR^2, through normal contact 140, through alternate contact 142 of the energized relay RR^3 and through secondary magnet SM^3 to battery A^{21}, whereby magnet SM^3 is energized and de-energized six times, and causes wipers 194—195—196 to engage the contacts 28—29—30 of the called subscriber's line being line numbered 23,456, the line wipers 195 and 196 being on open circuit at contacts 146 and 150 while wiping over multiple contacts 29—30 of lines not wanted. The break in line limb 10 caused by dial 3 following the last of the six impulses mentioned, is effec-

tive, by the de-energization of relay SR and the consequent energization of relay SR′, to transmit a current impulse from ground over the before traced path through contact 118—121, shifted contact 128, secondary off-normal contact SON^5, shifted on the first secondary movement of connector H, through the winding of locking relay LR^3 to battery A^{30}, the said relay attracting its armatures and locking itself by armature 139 to ground at primary off-normal spring 129.

The next set of breaks caused by subscriber C in limb 11 sent for the purpose of selecting the desired generator G^4, which breaks will be four in number, by de-energizing relay PR and energizing relay PR′, causes transmission of four current impulses from ground at armature 88 over the before traced path through contact 117—120, the impulses now passing through alternate contact 131, alternate contact 140, normal contact 151, motor magnet MM of the generator switch to battery A^{27}, said magnet MM being energized four times and being effective, by a well known mechanical arrangement, to move wiper 156 four steps to rest engaging contact 157 of generator G^4. This generator, as before indicated, delivers current of a frequency to ring the bell of the particular subscriber wanted on the called-for line, the party line system preferably operating on the well known tuned reed principle. The four substations on the called-for line will be connected in multiple, as indicated at the line of C, the wires C′, C^2, C^3 indicating the taps to the other substations' telephones.

A final break in line limb 10 causes the transmission of an impulse, as before described, traversing contact 118—121, thence through primary off-normal contact 128, shifted secondary off-normal spring SON^5, off-normal spring ON of the generator switch which was shifted on the first movement thereof and through the locking relay LR^4 to battery A^{26}, the said relay by armature 153 locking itself to ground via primary off-normal spring 129. The said relay LR^4 attracts its armatures whereon 152 now connects test relay TR with the test wiper 194 over a circuit extending from relay TR through armature of called release relay CRR, alternate contact 144, attracted make-before-break armature 152, the attracted armature 147, and thence to said wiper 194. If the called line is busy, relay TR remains energized; while if idle, the said relay becomes de-energized, because if the line is idle (it being remembered that the line circuit of the called line K is identical with that of the calling line of C), the private contact 28 will be connected to ground through normal contact 13 and cut-off relay 15. (See line circuit of C.)

It will be assumed first that the called line is idle, the busy line features being hereinafter explained. The relay TR having thus the two ends of its winding grounded, becomes de-energized and its armatures are retracted to engage their normal contacts, whereof 147 connects battery A^{24} through a suitable resistance to wiper 194 and the private multiples 28 of the called line rendering the line busy by raising the potential at said contact, and also causing the operation of cut-off relay 15 of the called line which disconnects the line relay 12 so that it will remain inert when the called subscriber answers. Said relay 15 of the called line by armature 17 completes the talking circuit of limb 10 of the called subscriber's line to the talking multiple contact 30, as will be understood by inspecting the line circuit of C. On the retraction of armature 149, grounded interrupter I, a constantly rotating device, is connected through armatures 124, 149 and 155 with generator relay GR and battery A^{25} so that the relay GR is alternately energized and de-energized, periodically ringing the bell of the called substation by current from generator G^4 which passes through contact 157—156, lower armature of relay GR when attracted, contact 196—30, attracted armature 17 of cut-off relay 15 of the called line, over the line limb and through the substation, ringing the call bell, returning over limb 11 of the called line through contact 29—195 and to ground at the attracted upper armature of relay GR.

The called subscriber answering the call removes his receiver, establishing a conductive bridge of the line limbs at his substation whereon as soon as relay GR is de-energized, a circuit is completed from battery A^{23} through the upper winding of impedance 136, contact 146, upper armature of GR, contact 195—29, over limb 11 of the called line through transmitter and impedance coil at the substation, energizing the transmitter for talking, returning over limb 10, alternate contact 17, contact 30—196, lower armature of GR, armature 150, relay 138, and its non-inductive shunt, to ground through the lower winding of impedance 136. The attracted armature of relay 138 energizes locking relay LR^5 which is locked by armature 126 to ground at contact 129, whereon the said relay attracts its armatures, 124 disengaging its contact to prevent the further operation of generator relay GR whereby ringing current is kept excluded from the called line while armatures 122 and 127 complete the talking circuit of connector H, indicated by the heavy lines, by engaging their alternate contacts. Current now flows from battery A^{23} through alternate contact 122, contacts 120—117, 111, 105—102, 96, normal contact 88, through the lower wind-

ing of relay 82, armature 81^a, normal contact 90, contacts 99, 103—106, 115, 118—121, 127 and to ground through the lower winding of impedance 136. By attracted armature 84, relay 82 thereon unlocks itself to ground via primary off-normal contact PON^4. Armatures 83 and 85 disconnect relays PR′ and SR′ from the upper and lower talking conductors of switch F, and by engaging their alternate contacts bridge the windings of relay 79 across trunk conductors T—T′ whereby current is caused to flow from battery A^9, over limb T′, through contacts 70—66, 62, alternate contact 53, control relay CR, alternate contact 51, contacts 59, 65—69, trunk conductor T′ to ground through alternate contact 83 and relay 79. Control relay CR at switch E is thereby operated, its make-before-break armature switches reversing the connections of batteries A and B to the calling line, the system being thereby adapted for use in connection with polarized pay stations or call counters connected with the talking conductors of the subscriber's line, such structures being well known in the art. Armature 80 engaging its alternate contact completes a circuit from battery A^{13} through release relay RR′, alternate contact 80 and to ground through primary off-normal contact PON^4, the said relay locking itself at said ground by armature 94, while armatures 79^a and 81^a complete the circuits of the upper and lower talking conductors of the switch F whereby a complete talking circuit between the calling and called station is produced which may be traced from the substation C over the line limbs and throughout the exchange by the heavily marked conductors, talking current being supplied to the transmitter of the subscriber C from the series batteries A and B through the inductive resistances of relays PR and SR, and to the called subscriber's line through the inductive resistances of the windings of impedance 136 from battery A^{23}.

It is to be understood that the multiplicity of batteries indicated throughout the drawings by the letter A with different exponents may be, and preferably are, in case all the apparatus is in one exchange, the same source of current, the plurality of symbols referring actually to but one instrumentality. The source B having its opposite pole grounded from that of source A is, of course, a separate battery. In the just preceding description however, it being assumed that the trunk lines T—T′ interconnect two distant exchanges, there would be two sources of current A, these sources having their positive poles grounded, one being at each exchange. In such case, the battery symbols A to the left of reference letters T—T′ would refer to one source and those to the right of the said conductors would refer to a second source.

It will, of course, be observed that the calling subscriber C has current supplied to his line from a source including the series batteries A, B of double potential as compared with the single battery A^{23} supplying current to the called line, the distribution of the proper amounts of current to calling and called lines being effected by suitable proportionings of resistances for relays PR, SR and for the windings of impedance 136.

When the subscribers have finished their conversation they replace their receivers upon the hook lever thus opening the conductive bridges of limbs 10 and 11 at their substation. Assuming the called subscriber K does this first, relay 138 is de-energized and its armature retracted to close a circuit from ground through resistance 201, alternate contact 123, called release relay CRR to battery A^{19}, which relay by attracting its armature causes the energization of test relay TR over a circuit extending through the attracted armature of CRR and to battery through said relay CRR, the resistance 201 being provided to prevent the shunting of relay TR at the grounded armature of relay 138. The energization of relay TR places wipers 195—196 on open circuit and also the private wiper 194 whose circuit will be found open at the attracted armature of called release relay CRR. Battery is thus removed from the private contacts 28 of the called line and its cut-off relay 15 is de-energized so that the called line is now in position to initiate a call or be called by some other subscriber, although the wipers of connector H have not been disconnected from the contacts 28—29—30 of said called line. The replacing by the called subscriber of his receiver thus frees his line without causing the restoration of the connector to normal. This is believed to be a novel feature in automatic telephone exchange systems.

When now the calling subscriber C hangs up his receiver, opening his line circuit, the relays PR and SR are de-energized, the armatures 50 52 are retracted simultaneously now for the first time and relay RR is de-energized, its armature 54 closing a circuit from battery A^8, release relay *rr* of the line selector D to ground through primary off-normal contact 34 of the line selector and armature 36. Armature 43 energizes secondary relay *sr* by connecting it to ground at contact 33, which relay *sr* operatively connects in circuit secondary magnet *sm* which rotates the wipers of the line selector to their releasing position, when they descend and are rotated back to normal, at which time primary off-normal contacts 33—34—35 are shifted to normal and secondary relay *sr* de-energized by contact 33. Release relay *rr*, however, which by armature 44 was locked to ground at spring 34

of the line selector D and spring PON² at the first selector E, will remain energized until the first selector also reaches normal. By armature 47 release relay *rr* completed a circuit from grounded primary off-normal spring PON through busy relay BR, which relay attracting its armature 61, brings secondary magnet SM into play which rotates the wipers 63—64—65—66 to their restoring positions whereon the first selector E is restored and when it reaches zero, by opening contact PON², de-energizes release relay *rr* in case the line selector is already restored. Armature 46 of relay *rr* places a ground upon contact 193 of the line selector, so that it will render it busy to the master-switch T while being restored. Armature 43 de-energized cut-off relay 15 by leaving its normal contact. It will be understood that when the switches D and E reach normal, all the off-normal contacts are shifted back to the positions shown at Fig. 1, and the apparatus will then be at normal.

The restoration of the trunking second selector F is effected by the energization of busy relay BR of switch E opening the circuit of limbs T—T′ which de-energizes relay 79 whose retracted armature 80 completes a circuit for busy relay BR′ extending through attracted armature 95, normal contact 80 to ground through primary off-normal spring PON⁴; armature 81 in falling back, completes a circuit from battery A¹¹ through relay 86, normal contact 81, attracted armature 94 of relay RR′, primary off-normal contact PON⁴ to ground so that relay 86 will be energized until the switch F reaches normal. The operation of relay BR′ operatively connects the secondary magnet SM′, which rotates the switch F until the wipers reach their restoring position when the shaft falls and is rotated to normal, at which time the off-normal contacts are restored and the switch is ready for further use.

The relay 86 just referred to, is provided for holding the multiple contact 68 at the distant exchange busy, while the switch F is being restored, co-operating in so doing with the double-acting relay 74. This relay 74 may include the circuit-changing springs 77 and 78 and an angular armature having two fulcrums 76 and 75. When a relatively slight flow of current passes through the winding of relay 74, it will be energized sufficiently to rotate the armature about the fulcrum 76 and will then cause spring 78 to engage its contact springs, but the operating end of the armature will not be raised sufficiently to shift the spring 77 by this limited flow through relay 74. As soon as fulcrum 75 strikes the longitudinally extending heel iron, the efficiency of the armature lever is obviously very materially decreased by the increased length of the load arm and the armature stops in an intermediate position. If, however, a heavy flow of current is caused through the relay 74, the armature will continue to be attracted after fulcrum 75 strikes the heel iron and in addition to closing contact 78, the armature will be attracted sufficiently to open contact 77. After the first selector has selected the trunking second selector and as soon as the first current impulse is transmitted, responsive to a de-energization of secondary relay SR, through contact 66–70, a portion of this current will pass through contact 77 and relay 74 to battery A⁷ whereby the relay will be energized to close contact 78; whereon a low resistance circuit from ground at contact 60 and through contact 64–68 will immediately come into play, fully operating relay 74 so that contact 77 will be opened and the relay winding 74 disconnected from the trunk limb T′. When relay BR was energized to release the first selector E, it not only de-energized relay 79 of switch F, but by armature 60, de-energized relay 74. As soon however, as the relay 86 of switch F attracted its armature as before described, it connected ground through resistance 202 with limb T′ and through contact 77 with the winding of relay 74 and battery A⁷. Resistance 202 being so proportioned as to allow only the operation of the armature of relay 74 upon fulcrum 76, the ground at resistance 202 will be connected over trunk limb T′ through contacts 77 and 78 with the private contacts 68, and this condition will continue until the switch F reaches normal and relay 86 is de-energized whereby the ground at 202 renders the multiple contact 68 busy during release of switch F.

Returning now; when busy relay BR′ was energized, its armature 97 opened the circuit of wiper 101, since armature 95 was then attracted, and caused the de-energization of release relay RR² of third selector L and of release relay RR³ of connector H, these relays having been locked in parallel to ground at armature 97; both relays become de-energized, RR² closing a circuit for relay BR² at retracted armature 109; relay BR² then operatively connects secondary magnet SM² which rotates the wipers of switch L to the restoring position when they fall and are rotated back to normal shifting the primary off-normal and secondary off-normal springs to their positions of rest as shown at L, whereby relay BR² is de-energized, and switch L is at normal. While switch L is restoring, armature 112 holds multiple contacts 104 busy.

Relay RR³ at switch H has its armatures retracted whereon 142 completes a circuit from battery A²¹ through secondary magnet SM³ and attracted armature 134 through constantly traveling interrupter I′, which

transmits impulses to secondary magnet SM^3 until the wipers 194—195—196 r ach their restoring positions, when they descend and are rotated back to normal at which time the opening of the primary off-normal springs PON and the secondary off-normal springs SON cause all the locking relays and apparatus of the connector to assume their usual inert conditions, the circuit of relays CRR and TR being opened at armature 123. The retraction of armature 141 of relay RR^3 operated relay 137 by current to ground at off-normal spring 130, relay 137 attracting its armature to hold ground upon multiple contacts 119 to prevent selection of the connector H until the switch reaches normal, when relay 137 becomes de-energized. The retraction of armature 145 connected ground through off-normal spring ON′ of the generator switch through release magnet RM to battery A^{27}, the magnet RM withdrawing a retaining dog from association with the ratchet of wiper 156, when this wiper is restored to normal by a suitable restoring spring, in the well known manner, at which time off-normal springs ON and ON′ will be shifted to normal.

Such switches as the generator switch comprising a rotary shaft having a ratchet and wiper and a motor magnet to drive the ratchet and a release magnet controlling a restoring pawl, are well known and illustration of the mechanical features of such are unnecessary. The same is true of the master-switch mechanism which may include a rotary shaft provided with ratchet and wipers driven by an armature actuated pawl of magnet *m*, no retaining dog or release magnet being required as the switch is not provided with a restoring spring, the wipers always being rotated in one direction.

If, at the time test relay TR, by the operation of locking relay LR^4, was connected to wiper 194, the called line was busy because some other subscriber has already established connection thereto, the multiple contact 28 engaged by connector H would have been connected to battery through retracted armature 147 of test relay TR of the connector already connected to the line. If the line of the called subscriber had been busy because it was a calling line, its multiple contact 28 would have been connected through normal contact 13 of line relay 12 of the called line through alternate contact 18, and contact 22—25 of the line selector connected with said line and normal contact 40 of said line selector with the active side of battery A^4, as will be understood from an inspection of Fig. 1, part 1. In either of the above cases, the multiple contact 28 would be at a potential other than ground, test relay TR would have continued energized owing to the development of the potential upon the multiple contact 28 engaged by wiper 194 of connector H into current circulating through alternate contact 147, alternate contact 152, alternate contact 144, armature of relay CRR and through relay TR to ground. The armatures of said relay TR continuing attracted, busy back machine BB would remain connected in operative relation with the calling subscriber's line over a circuit extending through alternate contact 154, attracted armature 148, normal contact 122, contacts 120—117, 105—102, through condenser 87 over limb T, contacts 69—65, alternate contact 51, condenser 158, normal contact 48, contact 26—23, over line limb 11, and through the substation giving the busy signal in the receiver, returning over limb 10, contact 17—19, 24—27, normal contact 49 and to ground through relay SR and battery A. The calling subscriber hearing the signal, replaces his receiver and the release of the apparatus employed in the connection, proceeds, so far as line selector D and the first selector E are concerned, in the manner as that before described. The release of the second selector F, however, is accomplished in a different manner. It will be observed that release relay RR of switch E is provided with a non-inductive shunt which renders it slow to release its armatures. Therefore, after relays PR and SR are de-energized, and before relay RR can release its armatures, (which will result in the energizations of relay *rr* and BR as before described), armatures 51 and 53 of relays PR and SR will have transmitted impulses simultaneously over the trunk conductor T—T′ from ground at conductor 100 and through relays PR′ and SR′ over the before traced path, it being remembered that owing to the failure of a response at the called substation, relays 79 and 82 have remained inert. Relays PR′ and SR′ being thus simultaneously energized, now first close circuit from ground through attracted armatures 89—91 and release relay RR′ to battery A^{13}. The release relay being now energized and relay 79 being de-energized, circuit is closed through busy relay BR′ and the release of second selector F, first selector L and connector H, proceeds as before described.

It will be remembered that as soon as the line selector D has selected the calling line, the relays PR and SR are connected in circuit with said line. If before the calling subscriber actuates his calling device 3, he replaces his receiver, the de-energization of relays PR and SR will restore the line selector D as will be understood from the preceding description. Similarly, if at any time during the process of putting up a connection, the calling subscriber replaces his receiver, the de-energization of relays PR

and SR will cause whatever switch he may have set from normal to be released and restored.

If the calling subscriber should remove and replace his receiver, thus transmitting a flash signal only so that the group relay 21 was energized to start the selector D but did not remain energized until group wiper 32 selected the group contact 31, then the primary relay *pr* will continue energized until the switch has made an eleventh vertical movement, at which time, group wiper 32 will pass beyond the topmost group contact 31 and relay 37 will be de-energized. Immediately thereafter, the secondary magnet *sm* will be operatively connected through retracted armatures 38 of relay *pr*, and the line selector D will be rotated eleven steps to its restoring rotary position and be automatically restored.

As before indicated, the ground conductors 100 and 200 are not for simultaneous use, but are alternatives, that is to say, if the ground conductor 200 is used, the wiper 63, contact 67 and the common return 100 are superfluous, as would also be the secondary off-normal contact SON at switch E, all impulses whether for the local or for the distant exchange work being then transmitted from ground from a local common return 200. I believe it to be novel in automatic telephone systems to use the wiper of a switch to pick up a particular common return conductor such as 100 which, of course, leads preferably to a point having an earth potential about the same as the earth where the battery of the exchange containing the switch F is located. In case there were a series, say three or four distant exchanges, each having second selectors F with multiple terminals appearing at different levels in the banks of the first selector E of the exchange of subscriber C, then the contacts 67 in each level, containing terminals of the second selector of one exchange, may be connected to the particular common return for that exchange so that the wiper 63 may pick out a return conductor of a plurality of predetermined potentials, the conductor picked out in any case being of a potential especially suited for efficient operation of the apparatus of the exchange to which it may be assigned.

It is to be stated that for local work, the second selectors may, if desired, be of the same character as that shown at F; that is to say where a very great amount of trunking is expected to be done, it may be considered preferable for the purpose of securing conformity in apparatus, to have all second selectors of the character of that shown at F, although for local calls, the second selectors would contain more apparatus than would be absolutely necessary.

In case for local business such second selectors as F were not desired, a duplicate of the structure shown at L may be employed as second selectors for local business, that is to say, the first selector structure of E is so arranged that the wipers 64—65—66 and the other apparatus of switch E will work preferably in connection with contacts 104—105—106 of the third selector L, no change whatever being required. For instance, let it be assumed that the switch F is omitted and that L is a second selector to be selected directly by the first selector E, the second selector L selecting the connector H in the before described manner. In such case, a ten thousand line system would of course be had. The de-energizations of primary relay PR would transmit impulses from ground at connector 200 and through contacts 65—105, through primary magnet PM^2, the first impulse energizing release relay RR^2. The de-energization of relay SR would transmit an impulse through contact 66—106 to energize busy relay BR^2 of switch L in the before described manner. The primary magnet PM^2 and busy relay BR^2 would be cut off in the described manner. Successive sets of impulses would be transmitted by armatures 51 and 53 or relays PR and SR to the circuit of the connector operating it, as before described. When the called subscriber answers the call, a circuit for the reversing control relay CR at first selector E would be completed directly from battery A^{23} through contact 105—65, returning through contact 66—106. When the calling subscriber replaced his receiver, release relay RR^2 of line selector L and RR^3 of connector H which during conversation would have been locked over contact 104—64 to ground at normal contact 60 would be de-energized as soon as busy relay BR of the first selector was energized, and the selector L and connector H would be restored as before described.

It is apparent that my invention is not limited to the precise circuit structures shown and described, nor to operation with selective switches of the character shown. Those skilled in the art will find the structures of my invention readily applicable in general automatic exchange practice. It is my intention not to be limited in what I claim in the above respects, but what I do claim is:

1. An automatic telephone system including a subscriber's line extending by its limbs to the exchange, a pair of serially connected sources of electrical energy at the exchange, a connection from one pole of each source to one limb of said line, a relay for each said connection having its winding in circuit with a line limb, and the respective connection, a third or return conductor connected at the junction point of said sources, switching mechanism at the sub-

station of said line including a connection to said third or return conductor, means for closing the metallic circuit of said line at the substation whereby said relays are energized over said metallic circuit, circuit changing members for said switching mechanism, an actuating device for said members included in said mechanism for operating said members to connect one of the line limbs to said third conductor, whereby the relay of said limb is maintained operated, and thereafter opening the circuit of the other line limb whereby the second relay is de-energized link-circuits, and a selective switch responsive to said relays jointly serving to connect an indifferent idle link-circuit with said telephone line.

2. An automatic telephone system including a subscriber's line extending by its limbs to the exchange, a pair of serially connected sources of electrical energy at the exchange, a connection from one pole of each source to one limb of said line, a relay for each said connection having its winding in circuit with a line limb, and the respective connection, a third or return conductor connected at the junction point of said sources, switching mechanism at the substation of said line including a connection to said third or return conductor, means for closing the metallic circuit of said line at the substation whereby said relays are energized over said metallic circuit, circuit changing members for said switching mechanism, an actuating device for said members included in said mechanism for operating said members to connect one of the line limbs to said third conductor, whereby the relay of said limb is maintained operated, and thereafter opening the circuit of the other line limb whereby the second relay is de-energized, means for subsequently re-establishing the metallic circuit of said line, whereby said second relay is re-energized, before disconnecting said third conductor, said switching mechanism also including means for effecting the complementary operation with respect to said line limbs and relays link-circuits at the exchange arranged in groups, a primary switch adjusting magnet responsive to de-energizations of one relay, the other remaining energized to select a desired group of link circuits, and a secondary switch controlling electromagnet responsive to de-energization of said other relay, the first remaining energized to cause automatic selection of an idle link-circuit of the selected group.

3. An automatic telephone system including a subscriber's line extending by its limbs to the exchange, a pair of serially connected sources of electrical energy at the exchange, a connection from one pole of each source to one limb of said line, a relay for each said connection having its winding in circuit with a line limb, and the respective connection, a third or return conductor connected at the junction point of said sources, switching mechanism at the substation of said line including a connection to said third or return conductor, means for closing the metallic circuit of said line at the substation whereby said relays are energized over said metallic circuit, circuit changing members for said switching mechanism, an actuating device for said members included in said mechanism for operating said members to connect one of the line limbs to said third conductor, whereby the relay of said limb is maintained operated, and thereafter opening the circuit of the other line limb whereby the second relay is de-energized, means for subsequently re-establishing the metallic circuit of said line, whereby said second relay is re-energized, before disconnecting said third conductor, said switching mechanism also including means for effecting the complementary operation with respect to said line limbs and relays, a connector at the exchange, a primary connector adjusting magnet responsive to the first described operation of said relays, a secondary connector adjusting magnet, and a circuit changer responsive to the complementary operation of said relays to render said secondary magnet thereafter responsive to the first described operation of said relays.

4. A telephone system comprising a telephone line having a pair of conductors, a source of current at the exchange in series with said conductors, a relay connected between each pole of said source and one of said conductors, a connection at an intermediate point of said source to a third or common return conductor, a calling device at the substation of said line including contact members, a connection from said device to said return conductor, means for connecting said line limbs at the substation to operate said relays over the metallic circuit of the line, actuating means for said contact members for operation to connect one line limb to said return conductor and thereafter open the circuit of the second line limb, said members on return movement re-establishing the metallic circuit of the line and thereon breaking the connection to said return conductor link-circuits, and a selective switch responsive to said relays jointly serving to connect an indifferent idle link-circuit with said telephone line.

5. A telephone system comprising a telephone line having a pair of conductors, a source of current at the exchange in series with said conductors, a relay connected between each pole of said source and one of said conductors, a connection at an intermediate point of said source to a third or common return conductor, a calling device at the substation of said line including con-

tact members, a connection from said device to said return conductor, means for connecting said line limbs at the substation to operate said relays over the metallic circuit of the line, actuating means for said contact members for operation to connect one line limb to said return conductor and thereafter open the circuit of the second line limb, said members on return movement re-establishing the metallic circuit of the line and thereon breaking the connection to said return conductor, mechanism included in said actuating means for effecting the complementary operation, whereby in the operation of said calling device said relays, after de-energization, receive actuating current over the metallic circuit, said return conductor being employed to hold an already operated relay energized, link-circuits at the exchange arranged in groups, a primary switch adjusting magnet responsive to de-energizations of one relay, the other remaining energized to select a desired group of link circuits, and a secondary switch controlling electromagnet responsive to de-energization of said other relay, the first remaining energized to cause automatic selection of an idle link-circuit of the selected group.

6. A telephone system comprising a telephone line having a pair of conductors, a source of current at the exchange in series with said conductors, a relay connected between each pole of said source and one of said conductors, a connection at an intermediate point of said source to a third or common return conductor, a calling device at the substation of said line including contact members, a connection from said device to said return conductor, means for connecting said line limbs at the substation to operate said relays over the metallic circuit of the line, actuating means for said contact members for operation to connect one line limb to said return conductor and thereafter open the circuit of the second line limb, said members on return movement re-establishing the metallic circuit of the line and thereon breaking the connection to said return conductor, mechanism included in said actuating means for effecting the complementary operation, whereby in the operation of said calling device said relays, after de-energization, receive actuating current over the metallic circuit, said return conductor being employed to hold an already operated relay energized, a connector at the exchange, a primary connector adjusting magnet responsive to the first described operation of said relays, a secondary connector adjusting magnet, and a circuit changer responsive to the complementary operation of said relays to render said secondary magnet thereafter responsive to the first described operation of said relays.

7. A telephone system comprising a telephone line having a pair of conductors, a source of current at the exchange in series with said conductors, a relay connected between each pole of said source and one of said conductors, a connection at an intermediate point of said source to a third or common return conductor, a calling device at the substation of said line including contact members, a connection from said device to said return conductor, means for connecting said line limbs at the substation to operate said relays over the metallic circuit of the line, actuating means for said contact members for operation to connect one line limb to said return conductor and thereafter open the circuit of the second line limb, said members on return movement re-establishing the metallic circuit of the line and thereon breaking the connection to said return conductor, mechanism included in said actuating means for effecting the complementary operation, whereby in the operation of said calling device said relays, after de-energization, receive actuating current over the metallic circuit, said return conductor being employed to hold an already operated relay energized, other telephone lines, link-circuits at the exchange, a selector and a connector at the exchange, and means for successively operating said selector and connector responsive to said relays to connect by a link-circuit said telephone line and a wanted one of said other lines.

8. An automatic telephone system including a pair of telephone lines, a plurality of step-by-step selective switches having individual motor driven means for linking said lines together, said switches including a non-numerical switch operable over the two sides of one of said lines in series for extending a connection from said line, a release circuit extending to a plurality of switches linking said lines, electromagnetic release mechanism for each of said plurality of switches, and means for closing said circuit long prior to the time of release and thereafter maintaining it continually closed and for opening said circuit when release is desired to de-energize said mechanism to cause restoration of their respective switches.

9. An automatic telephone system including a pair of telephone lines, a plurality of step-by-step selective switches having individual motor driven means for linking said lines together, said switches including a non-numerical step-by-step switch operable over the two sides of one of the lines in series for extending a connection therefrom, a release circuit extending to a plurality of switches linking said lines, electromagnet release mechanism for each of said plurality of switches, contacts of said switches included in said circuit serving to

protect the talking circuit against intrusion, and means for closing said circuit long prior to the time of release and for opening said circuit when release is desired to de-energize said mechanisms to cause restoration of their respective switches.

10. An automatic telephone system including a pair of telephone lines, a plurality of step-by-step selective switches having individual motor driven means for linking said lines together, said switches including a non-numerical switch operable over the two sides of one of said lines in series for extending a connection therefrom, a release circuit extending to a plurality of switches linking said lines, electromagnetic release mechanism for each of said plurality of switches, contacts of said switches included in said circuit serving to protect the talking circuit against intrusion, relay mechanism controllable from the substation of one of said lines, means for altering the operative condition of said mechanism when disconnection is desired, and switching mechanism responsive to said altered condition to open said release circuit to de-energize said electromagnetic release mechanisms whereby the respective switches are released.

11. An automatic telephone system including a pair of telephone lines, a plurality of step-by-step selective switches provided with individual driving magnets linking said lines together, said switches including a non-numerical step-by-step switch controllable over the two sides of one of said lines in series for extending a connection therefrom, a release circuit extending to a plurality of switches linking said lines, electromagnetic release mechanism for each of said plurality of switches, relay mechanism controllable from the substation of one of said lines, means for altering the operative condition of said mechanism when disconnection is desired, and switching mechanism responsive to said altered condition to open said release circuit to de-energize said electromagnetic release mechanisms whereby the respective switches are released.

12. A telephone system including a pair of telephone lines, a link-circuit connecting said lines, multiple contacts for the called line at the exchange, a connector included in said link circuit having electrically adjustable terminals in connection with contacts of the called line, rendering said line busy, and mechanism responsive to currents controlled at the substation of said called line to render said line idle without altering the selective position of said connector.

13. A telephone system including a pair of telephone lines, a link-circuit connecting said lines, multiple contacts for the called line at the exchange, a connector included in said link-circuit having electrically adjustable terminals in connection with contacts of the called line, rendering said line busy, mechanism responsive to currents controlled at the substation of said called line to render said line idle while maintaining said connector in its antecedent progressive position, and release means responsive to currents controlled at the calling substation to restore said connector to normal.

14. A telephone system including a calling telephone line, directive switching means at the substation thereof, a non-numerical switch, a directively controlled step-by-step selector connected with said line via said non-numerical switch, operating relays for said selector responsive to said means, driving magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector, operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, and releasing means for said switches controllable by the opening of a subscriber's line circuit.

15. A telephone system including a calling telephone line, directive switching means at the substation thereof, a non-numerical switch, a selector connected with said line via said non-numerical switch, operating relays for said selector responsive to said means, magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector, operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, release mechanism for restoring said last-mentioned selector, relay apparatus individual to said first-mentioned selector for rendering said mechanism effective by current changes produced in said individua

trunk conductors, and releasing means for said switches controllable by the opening of a subscriber's line circuit.

16. A telephone system including a calling telephone line, directive switching means at the substation thereof, a non-numerical switch, a selector connected with said line via said non-numerical switch, operating relays for said selector responsive to said means, magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector, operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, means for simultaneously energizing said trunk relays responsive to current impulses transmitted over said conductors by said selector relays when disconnection is desired, a release circuit for said trunk selector operated responsive to the simultaneous energization of said trunk relays, and releasing means for said switches controlled by the opening of a subscriber's line circuit.

17. A telephone system including a calling telephone line, directive switching means at the substation thereof, a selector connected with said line, operating relays for said selector responsive to said means, magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector, operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, other telephone lines, link-circuits associated with said trunk conductors having selective switches operable responsive to said trunk relays in completing connection to a called line, means for simultaneously energizing said trunk relays responsive to current impulses transmitted over said conductors by said selector relays when disconnection is desired, a trunk release circuit extending from said trunk selector to the selective switches employed in a connection, and connections altered responsive to the simultaneous energization of said relays to render said circuit effective to release the switches.

18. A telephone system including a calling telephone line, directive switching means at the substation thereof, a selector connected with said line, operating relays for said selector responsive to said means, magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector, operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, other telephone lines, link-circuits associated with said trunk conductors having selective switches operable responsive to said trunk relays in completing connection to a called line, means for simultaneously energizing said trunk relays responsive to current impulses transmitted over said conductors by said selector relays when disconnection is desired, a trunk release circuit extending from said trunk selector to the selective switches employed in a connection, and connections altered responsive to the simultaneous energization of said relays to render said circuit effective to release the switches, an electromagnet associated with said trunk selector, means effective on the response of the called subscriber to operate said electromagnet over the metallic circuit of said trunk conductors whereby the control of said release circuit is removed from said trunk relays and shifted to said electromagnet, and a circuit changing electromagnet at said first-mentioned selector thereafter effective at the will of the calling subscriber to open the metallic circuit of the trunk conductors to de-energize said electromagnet associated with said trunk selector whereby said release circuit is rendered effective to release the switches.

19. A telephone system including a calling telephone line, directive switching means at the substation thereof, a selector connected with said line, operating relays for said selector responsive to said means, magnets for adjusting said selector responsive to said relays, a trunk circuit including a pair of individual trunk conductors only, multiple contacts at one end of said circuit at

said selector and selectable thereby when said circuit is idle, trunk relays connected with said conductors at the other end of said circuit, armature switch mechanism of the relays of said selector conductively connected with said last-mentioned relays on selection made of said circuit, whereby the relays of said selector operating responsive to said substation means, directly control said trunk relays, a trunk selector for said circuit at said other end having operating electromagnets controllable by said trunk relays, other telephone lines, link-circuits associated with said trunk conductors having selective switches operable responsive to said trunk relays in completing connection to a called line, a trunk release circuit extending from said trunk selector to the selective switches employed in a connection, an electromagnet held energized over the metallic circuit of said trunk conductors during conversation and controlling said release circuit, and a circuit changing relay at said first-mentioned selector operable at the will of the calling subscriber to deenergize said electromagnet to render said release circuit effective.

20. A telephone system including a calling line, a directively controlled step-by-step selector at the exchange having operating relays connected with, and responsive to directive currents over said line, a non-numerical switch for connecting said selector to said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having driving magnets connected with armature switches of said link-circuit relays and operable thereby, a release circuit for said switch responsive to current changes produced at said selector in said individual conductors to release said selective switch when disconnection is desired, and means controlled over the two sides of the said line in series for controlling said release circuit.

21. A telephone system including a calling line, a directively controlled step-by-step selector at the exchange having operating relays connected with, and responsive to directive currents over said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having driving magnets connected with armature switches of said link-circuit relays and operable thereby, other telephone lines, auxiliary selective switches operable responsive to said link-circuit relays to complete a talking circuit from said calling line to a called line, a trunk release circuit extending from said link-circuit switch to an auxiliary switch and produced in the process of connection, and means for opening the circuit of said link-circuit conductors at said selector when disconnection is desired to render said release circuit effective.

22. A telephone system including a calling line, a selector at the exchange having operating relays connected with, and responsive to directive currents over said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having adjusting magnets connected with armature switches of said link-circuit relays and operable thereby, other telephone lines, auxiliary selective switches operable responsive to said link-circuit relays to complete a talking circuit from said calling line to a called line, a trunk release circuit extending from said link-circuit switch to auxiliary selective switches employed in establishing a connection, electromagnet release means for said selective switches and branch connections from said release circuit energizing said means during connection, means for opening the circuit of said conductors at said selector when disconnection is desired, and apparatus responsive thereto at said link-circuit switch for opening the circuit of said trunk release circuit to render effective said release means.

23. A telephone system including a calling line, a selector at the exchange having operating relays connected with, and responsive to directive currents over said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having adjusting magnets connected with armature switches of said link-

circuit relays and operable thereby, other telephone lines, auxiliary selective switches operable responsive to said link-circuit relays to complete a talking circuit from said calling line to a called line, a trunk release circuit extending from said link-circuit switch to auxiliary selective switches employed in establishing a connection, a contact for said link-circuit switch for connection with a contact of an auxiliary switch, included in the connection, to protect the talking circuit from intrusion, said contacts being included in said release circuit, and means for opening the circuit of said link-circuit conductors at said selector when disconnection is desired to render said release circuit effective.

24. A telephone system including a calling line, a directively controlled step-by-step selector at the exchange having operating relays connected with, and responsive to directive currents over said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having driving magnets connected with armature switches of said link-circuit relays and operable thereby, other telephone lines, auxiliary selective switches operable responsive to said link-circuit relays to complete a talking circuit from said calling line to a called line, a trunk release circuit extending from said link-circuit switch to auxiliary selective switches employed in establishing a connection, and means for opening the circuit of said link-circuit conductors at said selector when disconnection is desired to render said release circuit effective.

25. A telephone system including a calling line, a selector at the exchange having operating relays connected with, and responsive to directive currents over said line, traveling contact-makers for said selector, a link-circuit having two individual conductors only for conductive connection to the contact-makers of said selector, said conductors being selectable by said selector responsive to said relays, link-circuit relays conductively connected with said conductors and operable responsive to currents transmitted by said operating relays on selection made, a selective switch for said link-circuit having adjusting magnets connected with armature switches of said link-circuit relays and operable thereby, other telephone lines, auxiliary selective switches operable responsive to said link-circuit relays to complete a talking circuit from said calling line to a called line, a trunk release circuit extending from said link-circuit switch to auxiliary selective switches employed in establishing a connection, a contact for said link-circuit switch for connection with a contact of an auxiliary switch, included in the connection, to protect the talking circuit from intrusion, said contacts being included in said release circuit, electromagnet release means for said selective switches and branch connections from said release circuit energizing said means during connection, means for opening the circuit of said conductors at said selector when disconnection is desired, and apparatus responsive thereto at said link-circuit switch for opening the circuit of said trunk release circuit to render effective said release means.

26. In telephony, a trunk circuit for automatic telephone systems including a pair of trunk conductors only, multiple terminals of said conductors, a directively controlled step-by-step selector at a first exchange for selecting said terminals, driving magnets for said selector and operating relays for controlling the same, trunk relays for said trunk circuit at an exchange at the distant end of said conductors, armature switches of said operating relays conductively connected to said trunk relays when said selector selects said terminals whereby said trunk relays are rendered directly controllable by said operating relays, a selective switch operable by said trunk relays, means for restoring said switch responsive to circuit changes produced in said trunk conductors at said selector, and means controlled over the two sides of a line in series for controlling said restoring means.

27. A telephone system including telephone lines arranged in groups, said groups being divided into sub-groups, multiple terminals of said lines similarly arranged and divided, line relays, one for each line and energizable over the two sides of the line in series, a sub-group relay common to and operable by the line relays of a sub-group, a common starting conductor with branches to the sub-group relays of a line group whereby any sub-group relay of a line group may control the electrical condition of said conductor, selective switches for selecting the multiple terminals of calling lines, means for interchangeably operatively connecting idle ones of said switches with said starting conductor, and release means for said switches controllable by the opening of a subscriber's line circuit.

28. In an automatic telephone system, the combination with a link-circuit having talking contacts and a private or test contact, of a double-acting relay having an armature provided with an efficient point of leverage and a less efficient point, means for

partially energizing said relay by current over one of the talking contacts, a low resistance locking circuit for said relay thereon effective to fully energize the same including the private contact, whereby said relay is cut off from the said talking contact, a selective switch for said link-circuit, switching means therefor effective when said switch is restoring to partially energize said relay over a circuit connected with said contact to connect said circuit with said test contact to maintain said test contact in an abnormal electrical condition while said switch is restoring.

29. An automatic telephone system including a pair of telephone lines, a plurality of link-circuits interconnecting said lines, a number of directively controlled step-by-step selective switches and a non-numerical switch provided with individual driving means included in the connection, said switches being first connected to the calling subscriber's line and then operated to extend the connection in the direction of the called subscriber's line, said non-numerical switch being operated over a line circuit including the two sides of a line in series, an electromagnet, one for each of said switches for use in restoring the same, said electromagnets being held energized while connection exists, switching means responsive to the opening of the metallic circuit of one of said telephone lines for de-energizing and restoring said electromagnets and means responsive to any restoration of said electromagnets to restore the switches.

30. An automatic telephone system including a pair of telephone lines, a plurality of link-circuits having step-by-step selective switches and a non-numerical switch provided with individual driving means for interconnecting said lines, means controlled over the two sides of one of said lines in series for operating said non-numerical switch, a talking circuit extending through said switches, a release circuit extending therethrough and separate from the talking circuit, electromagnets for the respective switches for use in releasing the same, said electromagnets being connected with said release circuit and held energized while connection continues, and means for altering the connections of said release circuit when disconnection is desired to de-energize said electromagnets to release the switches.

31. An automatic telephone system including telephone lines, a selecting switch, a release controlling magnet for said switch, a local circuit for said magnet, means for operating said switch for connecting a calling line with the terminals of a called line, switching mechanism effective in the selecting operation thereof to close said local circuit and hold it permanently closed during use of the switch whereby said magnet is held operated during conversation, with means for de-energizing said magnet to restore said switch when disconnection is desired.

32. In a telephone system, the combination with trunk lines, of common return conductors, some of said trunk lines having associated with them one such conductor and others another such conductor, electrically adjusted switch contacts for selecting and connecting with said trunk lines, said apparatus including means whereby, on connection to a trunk line, connection is made to the particular associated return conductor.

33. A telephone system including trunk lines divided into groups, a common return conductor for a group, a second common return conductor for another group, multiple terminals for said trunk lines, each terminal of a line of a group including a contact connected to the respective return conductor, a selector adapted to be directively adjusted to select a group and thereafter to automatically select an idle terminal of the group, said selector including a contact adapted to register with the contact of the return conductor of the group.

34. In a telephone system, the combination with relays divided into groups, of trunk lines one for each relay, common return conductors for said trunk lines, one for the lines of each group of relays, terminals for said trunk lines, each such terminal including a switch contact connected with the return conductor of the appropriate group, an electrically controlled selector, means for transmitting directive impulses to said selector to select a group of trunk lines, means for operating said selector to select a particular trunk line, said selector including a switch contact registering, on selection of a trunk line, with a contact connected to the return conductor of the respective group.

35. In a telephone system, a plurality of groups of trunk lines, a plurality of common return conductors for said trunk lines connected to points of different potential, some of said trunks having associated with them one conductor and others another conductor, an electrically adjusted selector adapted to select any of said trunk lines, and means whereby said selector in selecting a trunk line makes connection with the appropriate return conductor.

36. In a telephone system, the combination with two groups of trunk lines, of a return conductor for each said group, selective mechanisms electrically adjustable to select a group of trunk lines and then an idle line with means for connecting said mechanism with the return conductor of the group of lines selected.

37. A telephone system including a tele-

phone line, selective switches adapted to select said line, a selector common to said switches, a contact for each said switch at said selector, a source of current, a cut-off relay for said line, and a circuit for rendering the contact of an operated switch busy at said selector by connecting a particular pole of said source to the contact, the connection to said pole being traced through said cut-off relay.

38. A telephone system including a telephone line, selective switches adapted to select said line, a selector common to said switches, a contact for each said switch at said selector, a source of current, a cut-off relay for said line, and means effective by the final selecting movement of a selective switch in connecting with said line serving to connect a pole of said source over a connection traced through said cut-off relay to the contact of the respective switch at said selector to render it busy.

39. A telephone system including a telephone line, multiple terminals therefor, selective switches adapted to select terminals of said line as a calling line, a master-switch for initiating travel of an idle selective switch, a contact for each said selective switch at said master-switch, and means for connecting the contact of any selective switch to a multiple terminal of said line to render said contact busy upon connection of such switch with the line.

40. A telephone system including a telephone line, multiple terminals therefor, selective switches adapted to select terminals of said line as a calling line, a master-switch for initiating travel of an idle selective switch, a contact for each said selective switch at said master-switch, and means effective on a final selecting movement of a selective switch in connecting with said line to unite said contact with a terminal of said line to render said contact busy.

41. A telephone system including a telephone line, multiple terminals therefor, selective switches adapted to select terminals of said line as a calling line, a master-switch for initiating travel of an idle selective switch, a contact for each said selective switch at said master-switch, and means effective on a final selecting movement of a selective switch in connecting with said line to unite said contact with a terminal of said line to initiate travel of said master-switch.

42. A two-dimension progressively movable selector for automatic exchanges including a pair of talking conductors, an electromagnet adapted when energized to place said conductors on open circuit, a trunk release conductor separate from the talking conductors, a release controlling electromagnet for said selector, connected to said trunks release conductor means for energizing said magnet during selection, means for de-energizing said magnet when disconnection is desired, and a circuit closed by such de-energization to energize said first magnet.

43. A selector for automatic exchanges including a pair of talking conductors, an electromagnet adapted when energized to place said conductors on open circuit, a trunk release conductor separate from the talking conductors, a release controlling electromagnet for said selector connected to said trunk release conductor, means for holding said last-mentioned magnet energized during conversation, apparatus for de-energizing said magnet to restore said selector, and an armature controlled switch for said magnet effective on such de-energization to close circuit through said first-mentioned magnet during a restoring movement of said selector.

44. A selector for automatic exchanges including a pair of talking conductors, an electromagnet and contacts controlled thereby effective on its energization to open the circuits of said conductors, a second electromagnet for operation to restore said selector to normal, a trunk release conductor separate from the talking conductors, a release control relay for said selector connected to said trunk release conductor, and means controlled over the talking conductors for opening the circuit of said relay when disconnection is desired, said relay then serving to cause energization of both said magnets to restore said selector and open the circuit of said talking conductor.

45. A progressively movable directively controlled selector for automatic exchanges including a pair of talking conductors, an electromagnet and contacts controlled thereby effective on its energization to open the circuits of said conductors, a second electromagnet for operation to restore said selector to normal, a trunk release conductor separate from the talking conductors, a release controlling relay for said selector connected to said trunk release conductor, means for maintaining said relay energized during conversation, apparatus for de-energizing said relay at conclusion of conversation, and a contact of said relay closed on its de-energization to cause operation of both said magnets.

46. A selector for automatic exchanges including a pair of talking conductors, an electromagnet for said selector adapted to control the connections of said conductors, a relay for said selector, a circuit for said magnet including a branch with a contact closed when said relay is energized, a second branch of said circuit having a contact closed when said relay is de-energized, and means for energizing and de-energizing said relay.

47. A selector for automatic exchanges

including switch wipers, an electromagnet adapted to control travel of said wipers, a release control magnet for said selector, a circuit for said first-mentioned magnet, a branch of said circuit including a normally open switch contact of said second magnet and a locking contact of the first magnet, and a second branch of said circuit including a normally closed contact of said second magnet.

48. A selector for automatic exchanges including switch wipers and off normal contacts, an electromagnet adapted to control travel of said wipers, a release control magnet for said selector, a circuit for said first-mentioned magnet, a branch of said circuit including a normally open switch contact of said second magnet and a locking contact of the first magnet, and a second branch of said circuit including an off-normal contact of the selector.

49. A selector for automatic exchanges including an impulse wire, a selector adjusting magnet connected to said wire, a selector releasing magnet connected to said wire, means for transmitting a current impulse over said wire to simultaneously energize said magnets, and a local locking circuit effective upon energization of the releasing magnet to lock said magnet energized while said adjusting magnet is de-energized responsive to cessation of said impulses.

50. A selector for automatic exchanges including an impulse wire, a selector adjusting magnet connected to said wire, a selector releasing magnet connected to said wire, means for transmitting a current impulse over said wire to simultaneously energize said magnets, and a switch actuated responsive to said impulse to disconnect said releasing magnet from said wire while leaving said switch adjusting magnet connected thereto.

51. A selector for automatic exchanges including an impulse wire, a selector adjusting magnet connected to said wire, a selector releasing magnet connected to said wire, means for transmitting a current impulse over said wire to simultaneously energize said magnets, a switch actuated responsive to said impulse to disconnect said releasing magnet from said wire while leaving said switch adjusting magnet connected thereto, and a second switch for thereafter disconnecting said adjusting magnet from said wire.

52. A telephone system including a pair of telephone lines, a non-numerical device controlled over the two sides of one of said lines in series for extending a connection from said line in the direction of the other of said lines, step-by-step selective switches having individual motor means for connecting said lines, a release electromagnet for each of said switches connected in parallel to a trunk release conductor, means for energizing said electromagnets and maintaining them continually energized during the progress of connection and while connection exists, and switching means responsive to the opening of the metallic circuit of one of said lines for de-energizing said electromagnets to effect restoration of said switches.

53. A telephone system comprising a pair of telephone lines, selector and connector switches having motion in one plane to select groups of lines and in another plane to select lines, means for operating said switches to connect a calling one of said lines with a called one of said lines, a release electromagnet for each of said switches, means for effecting and maintaining a continuous energization thereof during the progress of connection, and switching means controlled over the connected telephone lines for causing de-energization of the said electromagnets whereby any de-energization thereof will restore the switches.

54. A telephone system including telephone lines, a selector switch, a release electromagnet for said switch, means for operating said switch to extend connection of a calling line, means for energizing said electromagnet during the progress of operation of said switch, a local locking circuit for said magnet closed responsive to its energization, and switching means controlled at the calling substation for de-energizing said electromagnet to effect restoration of said switch.

55. In a telephone system the combination with a subscriber's telephone line connected to an automatic switch circuit, of a second subscriber's telephone line, a terminal for said automatic switch circuit for connecting with said second telephone line, and means under the sole control of the substation connected to the second of said lines for automatically disassociating said telephone line from said automatic switch circuit prior to the disconnection of the terminal of said automatic switch circuit from said telephone line.

56. A telephone system comprising subscriber's telephone lines, an automatic switch circuit, terminals for said automatic switch circuit included in a conversational circuit between said lines, means controlled at the substation of one of the connected lines independent of the other connected line for automatically disassociating said first line from said automatic switch circuit prior to the disconnection of said terminal from said line thereby rendering said line non-busy.

57. In a telephone system the combination with a pair of connected subscribers' telephone lines, of an automatic switch circuit provided with terminals for inclusion in said connection, and means under the sole control of one of said connected subscribers

for automatically disassociating his line from said automatic switch circuit prior to the disconnection of said terminals from said subscriber's line.

58. In a telephone system the combination with a pair of connected subscribers' telephone lines, of an automatic switch circuit provided with terminals for inclusion in said connection, and means under the sole control of one of said connected subscribers for automatically disassociating his line from said automatic switch circuit prior to the disconnection of said terminals from said subscriber's line whereby said line is rendered non-busy.

59. In a telephone system the combination with an automatic switch circuit connected to a telephone line, a second telephone line, a terminal for said automatic switch circuit for connecting with said second telephone line, and means controlled over the said second line independent of the other of said lines for automatically disassociating said second telephone line from said automatic switch circuit without disconnecting said terminal from said line whereby said line is rendered non-busy.

60. In an automatic telephone system, the combination with a pair of telephone lines connected for conversation, of a plurality of switches associated with said connected circuit, release relays at each of said switches, means to energize said release relays when the switches are taken for use, a pair of bridges across said circuit located at different switches, one or more intervening switches free from bridged electromagnets, the release of the switches depending upon the de-energization of their release relays, means whereby the bridge nearest the calling subscriber's station controls the release of all switches intervening between said switch and the switch containing the other bridge.

61. In a telephone exchange system, the combination of a calling subscriber's line, a called subscriber's line, means for interconnecting the lines including first selector, trunk selector and connector switches, means for directing the action of the automatic switching mechanism including an impulse sending device, a trunk line connecting the first selector and second selector switches and comprising only two wires over which the impulse may be transmitted, and means for restoring the switches including means for rendering the trunk line busy during the restoration of the trunk selector switch.

62. In a telephone exchange system, the combination of calling and called subscribers' lines, means for interconnecting the lines including groups of selector switches, impulse sending means for directing the action of the switches to interconnect the lines, a trunk line comprising only two wires for connecting two groups of selector switches and over which the impulses are transmitted, means for restoring the switches on the conclusion of a call including means for rendering the trunk line busy during the restoration of the switches.

63. In a telephone exchange system, the combination of calling and called subscribers' lines, mechanism for interconnecting the lines including automatic selector and connector switches, and a two-wire trunk line between two sets of said switches, means for directing the action of the switches including an impulse sending means, and means for restoring the switches including mechanism timed for preventing the selection of the trunk line until after the restoration of the trunk selector switch.

64. In an automatic exchange trunking system, a calling line and a called line, a plurality of step-by-step switches for establishing connection between said lines, including a non-numerical switch, means operated over the two sides of a line in series for operating said non-numerical switch to extend the calling line in the direction of the called line, releasing apparatus for a plurality of said switches, a release relay for controlling each releasing apparatus, one of said switches comprising means for supplying the talking circuit with talking current, said one switch also comprising means for maintaining all of said release relays energized.

65. In an automatic telephone exchange trunking system, a calling subscriber's line and a called subscriber's line, means including a non-numerical switch, a step-by-step selector switch and a step-by-step connector switch for connecting the two lines, said non-numerical switch being operable over the two sides of said calling line in series, a releasing mechanism for each switch and a releasing relay for controlling each releasing mechanism, parallel circuits for said release relays, and a line relay for one switch, said line relay adapted to control the parallel circuits of all of said release relays after the two lines are connected.

66. In an automatic telephone exchange trunking system, a calling line and a called line, a plurality of step-by-step switches having individual motor magnets for connecting the calling line with the called line, including a switch individual to the calling line, said switches being controlled over the two sides of the calling line in series, contact springs for the said individual switch included in the connecting line circuit, and automatic means whereby if said springs are separated all of the switches are released.

In witness whereof, I hereunto subscribe my name this 24th day of July, 1907.

HARRY G. WEBSTER.